ENHANCE CAPACITIES OF NATIONAL CONSULTANTS IN ECOSYSTEM-BASED ADAPTATION (EBA) APPROACH IN RWANDA

Product 1. Scoping Assessment of Knowledge and Capacity Needs on Ecosystem-based Adaptation

Revised Version 3

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TABLE OF CONTENT

List of tables

List of figures

Climate variability and change has been experienced in many parts of the world and add to the challenges that face livelihoods and ecosystems. Rwanda is one of the most vulnerable countries and adaptation of human and natural systems has become a growing priority, recognizing the urgency. However, there is no single approach to adaptation to climate change, but rather a series of strategies and processes according to the context and spatio-temporal decision scale. One of these approaches is Ecosystem-based Adaptation (EbA). This approach is based on the management of ecosystems in order to support the people and society that depend on these ecosystems adapt to the adverse effects of climate change.

A vast array of information and knowledge have been generated over the years through completed and ongoing research on climate related impacts and risks, vulnerability and adaptation to climate variability and change. In light of this, it is essential to assess the current state of knowledge available and what specific information is still required in order to identify areas that require attention and research to further our understanding. This information is useful to inform policy and decision-makers on viable and appropriate adaptation options.

Given the relatively recent introduction of the EbA approach and the limited evidence of implemented actions and their effectiveness in Rwandas, many knowledge gaps and needs need to be addressed. As EbA is context-specific, this means that the knowledge gaps will be context specific as well, as in the case of Rwanda.

Although Rwanda demonstrates a greater development of knowledge in the area of meteorology and vulnerability assessment regarding the multiple aspects of adaptation in itself, this does not mean that these investigations have already covered all the knowledge needs. The key identified knowledge gaps on EbA include: (i) low to moderate level of knowledge on locally-specific climate risks and vulnerability of people and ecosystems; (ii) gaps in the understanding of the link between climate change, nature conservation and adaptation of people and their livelihoods; (iii) gaps in the organizational and individual capacity to develop and use tools to monitor and evaluate the performance of adaptation projects and programs; (iv) moderate level of organizational and individual capacity to plan and implement EbA strategies and actions; (v) low knowledge on developing mechanisms for including adaptation in current planning tools. They must be covered in order to have the necessary knowledge tools plan and implement EbA at a large scale in Rwanda.

To close the identified knowledge gaps on EbA it is needed the generation of specific information needs to support processes for planning and implementation of such adaptation measures. Key information needs include: (i) Climate services: Methods to handle results from multiple scenarios for future development and to harmonise climate projections for adaptation on the local level without prescribing data; (ii) Territorial information (subnational): referred to impacts and vulnerability on ecosystems and their services and how this affects human livelihoods, and national public policy instruments at different administrative levels. The potential climate-induced

impacts on specific habitats and species; (iii) Information for implementation: different options for adaptation measures with EbA approach, including their effectiveness, socioeconomic and environmental impact. Information regarding financing and analysis based on cost-benefit; (iv) Information for the construction of monitoring and evaluation indicators, and for the development of baselines. These allow to measure and monitor the impact of the implementation of public policies and climate actions on the vulnerability (social, economic, institutional, ecological) of the country and local territories.

Awareness raising, capacity-building and training of trainers on methods and tools for EbA planning and implementation is essential, however it has to be specifically designed to address the identified knowledge gaps. Therefore, it is proposed that the capacity-building activities focus on some of the following topics: (1) Methodology for evaluation of climate risk and vulnerability to climate change tailored to inform EbA planning; (2) Tools to support planning processes and decision making for the implementation of appropriate EbA measures; (3) Monitoring and evaluation of EbA measures; and (4) Guidance for land use-related EbA measures with landscape approach.

1. INTRODUCTION

1.1 BACKGROUND

Climate variability and change has been experienced in many parts of the world and add to the challenges that face livelihoods and ecosystems. The significant impacts of climatic changes and climate-related extreme events across regions, the natural environment and human livelihoods are projected to amplify and create new risks.[1] Countries in East Africa are particularly exposed to prolonged droughts and more erratic rains causing landslides and extensive soil erosion. Rwanda is one of the most vulnerable countries and adaptation of human and natural systems has become a growing priority, recognizing the urgency.

In view of that, adapting to climate variability and change has become a priority for many countries and regions, both developing and developed. Adaptation has started to incorporate potential adaptation strategies into their overall development planning processes through national adaptation strategies and action plans (i.e. National Climate Change Adaptation Plans – NAPA's).

There is no single approach to adaptation to climate change, but rather a series of strategies and processes according to the context and spatio-temporal decision scale. One of these approaches is Ecosystem-based Adaptation (EbA). This approach is based on the management of ecosystems in order to support the people and society that depend on these ecosystems adapt to the adverse effects of climate change. This approach uses a range of measures for the sustainable management, conservation and restoration of ecosystems that facilitates the reduction of social and ecological vulnerability in the future and allows generating social, economic and cultural benefits in a more cost-effective manner.

A vast array of information and knowledge have been generated over the years through completed and ongoing research on climate related impacts and risks, vulnerability and adaptation to climate variability and change. In light of this, it is essential to assess the current state of knowledge available and what specific information is still required in order to identify areas that require attention and research to further our understanding. This information is useful to inform policy and decision-makers on viable and appropriate adaptation options.

Effective institutional capacity to identify and integrate climate change adaptation actions within sectoral planning and budgeting processes is a key step towards design, implementing and monitoring of EbA measures. Therefore, there is a need to identify the knowledge gaps and needs regarding Ecosystem-based Adaptation through a participatory assessment process to improve cross-sectoral collaboration and coordination mechanisms between ministries and relevant stakeholders.

[1] IPCC, 2018.

This gap analysis assessment is structured into five sections:

Section 1 provides an introduction and includes information on the background and rationale of the paper, as well as the method carried out;

Section 2 presents Rwanda's context on vulnerability and risk to climate change and the governance structure;

Section 3 defined the conceptual framework for Ecosystem-based Adaptation.

Section 4 outlines and describes the identified knowledge gaps, needs and further research areas; and discusses the identified barriers that constrain the effective planning and implementation of viable adaptation options with EbA approach;

Section 5 provides recommendations in the way forward. This includes recommendations for action to fill the identified knowledge gaps and needs.

1.2 OBJECTIVE

The assessment was developed with the objective to gain a sound understanding of the country's knowledge gaps and needs on planning and implementing Ecosystem-based Adaptation (EbA) approach. The results from the assessment will inform the design, implementation and results of a tailored training of professionals strengthening through capacity building and awareness raising on the topic.

As a wider scope, this assessment will enable and inspire country stakeholders to apply a more effective capacity development approach for integrating Ecosystem-based Adaptation actions in development initiatives.

1.3 METHODOLOGY

This Gap Analysis Report was informed by a conceptual and interactive research design that included document analysis of key national and sub-national documents focusing on climate change in Rwanda. The following methods were used to compile the Gap Analysis Report, within an overall participatory and consultative methodology.

Phase 1. Document analysis: The analysis consisted in identification and review of existing strategies and policies relevant to climate change and nature conservation. The document analysis did not have an in-depth focus on sectoral policy and institutions but focused on overarching policy dealing with mainstreaming climate change and EbA in particular into planning and development. The lists with documents analyzed through desk review include:

- National Strategy for Transformation 2017 - 2024[2]
- Vision 2020 Development Programme[3]
- National Adaptation Programme of Action[4]
- National Environment and Climate Change Policy[5]
- National Strategy for Climate Change and Low-Carbon Development - Green Growth and Climate Resilience[6]
- Fiver-Year Strategic Plan for the Environment and Natural Resource Sector[7]
- Third National Communication to UNFCCC[8]
- National Land Policy[9]
- District Development Strategies (DDSs)

Phase 2. Stakeholder consultations

As part of the Gap Analysis Report, stakeholder consultations were held at a Workshop in Musanze District on 15 - 17 December 2018. The workshop had a multi-stakeholder group of 30 participants from the government, academia and NGO sectors (See Annex 1 for the list of participants). The workshop results form a substantive basis of the data used to inform the Gap Analysis Report, combined with document analysis and questionnaire data. The objective of the workshop was to explore various aspects regarding EbA and especially the different levels of integrating EbA into development and ecosystem management planning and policies.

Phase 3. Questionnaires and surveys

A survey and a questionnaire were prepared to obtain more in-depth data on climate change (See Annex 2). Altogether 25 surveys were collected, and 2 in-depth interviews were conducted. There was a significant diversity of thematic or sectoral areas in which the respondents perform their main activities. About 70% of respondents work on issues related to environmental protection and quality, while the remaining 30% work on various issues related to social development, economy and finance, education and research, agriculture, planning, and others. This diversity is relevant, because it indicates that the survey involved officials who work on adaptation issues not only as part of the traditional environmental agenda, but as part of a broader range of issues or public policy agendas. Table 1 presents a summary of the survey respondents per sector and Annex 4 presents a table with the names and affiliation of each respondent. The interviews were conducted with two decision-makers from REMA and the Ministry of Environment.

Table 1. List of Survey respondents per sector

Sector	Number

[2] GoR, 2017. National Strategy for Transformation. URL: http://www.minecofin.gov.rw/fileadmin/user_upload/NST1_7YGP_Final.pdf
[3] GoR, 2012. Vision 2020 Development Programme. URL: http://www.minecofin.gov.rw/fileadmin/templates/documents/NDPR/Vision_2020_.pdf
[4] GoR, 2016. National Adaptation Programme of Action. URL: https://unfccc.int/resource/docs/napa/rwa01e.pdf
[5] MoE, 2019. Environment and Climate Change Policy. URL: http://www.fonerwa.org/sites/default/files/Rwanda%20National%20Environment%20and%20Climate%20Change%20Policy%202019.pdf
[6] GoR, 2011. Green Growth and Climate Resilience. URL: https://cdkn.org/wp-content/uploads/2010/12/Rwanda-Green-Growth-Strategy-FINAL1.pdf
[7] MINIRENA, 2016. Fiver-Year Strategic Plan for the Environment and Natural Resource Sector. URL: http://www.minecofin.gov.rw/fileadmin/templates/documents/sector_strategic_plan/Environment_Natural_Resource_SSP_Oct_13.pdf
[8] MoE, 2018. Third National Communication to UNFCCC URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf
[9] MINIRENA, 2004. National Land Policy.

National Government	16
Provincial Government	4
International organisations	1
Education/Academia	3
NGOs	1

Phase 4. Data analysis framework

The data analysis was based on information collected from the previous phases, in order to complete a pre-designed excel sheet, which was used to facilitate the qualitative and quantitative assessment of the results. On the basis of this data conclusions on the key knowledge gaps were drawn. The analysis of data collected was performed focusing on three dimensions: (i) at individual level; (ii) at organizational level and (iii) at enabling environment level.

The data analysis used mixed methods – qualitative and quantitative data collection – in order to best reflect the results and provide necessary information to inform the capacity building planning. The analysis uses the information from the consultation and in-depth interviews in order to complete a pre-designed excel sheet, which will be used to facilitate quantitative assessment of the results. The knowledge needs and capacity gaps were assessed against five categories of knowledge and capacity:

- Climate information and risk assessment
- Technical planning and implementation
- Coordination and partnering/networking
- Monitoring and Evaluation of adaptation process
- Policy making and mainstreaming

This methodology was chosen because it has proven to help improve the design and impact of capacity development, giving a more systematic and consistent approach to assessments. It helps to meet the following needs:

- To assist the prioritisation of needs, since the scope of capacity development circumstances needs and types of interventions is huge, and so having a framework and tool to guide and focus a capacity development and knowledge needs assessment is helpful.
- To give a comprehensive approach to identifying the relevant aspects of capacity, whilst being flexible and adaptable to the user's needs.
- To produce numeric assessments of the current capacity to achieve a function or goal, and of the feasibility for improvement of this capacity. This numeric scorecard then assists the identification of priorities for capacity development and gaps, by giving an overall picture of how much of a capacity gap exists and the feasibility of addressing each element of capacity.
- Take a multi-dimensional approach to ensure that knowledge gaps and capacity needs are captured at all levels. The analysis considers three dimensions: at individual level; at organizational level and at enabling environment level:

- At the individual level – on awareness, knowledge, skills and competences. Findings at this level will inform the development of the capacity building activities.
- At the level of organizations – on performance, current roles and responsibilities for adaptation planning; mandate for ecosystem-based adaptation; coordination among ministries and other stakeholders, namely non-governmental organizations (NGOs), academia, and the private sector; national budget allocation to EbA and capacity to mobilize resources, sectoral monitoring and evaluation (M&E) for adaptation. Findings at this level will inform following activities on communication and capacity development.
- At the enabling environment level- on alignment among sectoral policies with regard to adaptation and EbA in particular; integration of adaptation into key sector strategies and plans; as well as existing national adaptation planning processes. Findings at this level will inform the following activities regarding identification of entry points for EbA mainstreaming.

The framework analysis informing this Gap Analysis Report is threefold. It firstly maps out a 'needs analysis' which identifies country-based knowledge, research and capacity gaps for key climate change and adaptation priorities as articulated in documents. it provides a perspective on the 'enabling environment' supporting the integration of EbA in Rwanda. Secondly, it provides an 'individual analysis' examining the existing capacity needs of experts and technicians. Thirdly, the 'institutional analysis' is providing insight into existing institutional capacity for climate change and EbA knowledge co- production.

1.4 LIMITATIONS OF THE STUDY

This Gap Analysis Report was constrained by limited baseline data on knowledge and research gaps for climate adaptation and ecosystem management, and by time and resource constraints that did not allow for higher number of individual interviewing or observation before, during and after the consultation process. Moreover, the information generated at the country workshop relates to the number of participants, their expertise and the number of different sectors and institutions present. Further, while every effort was made to obtain questionnaire responses from as wide a range of stakeholders as possible, and follow-ups were made post-workshop to enhance this, the range of questionnaire responses obtained does provide certain limitations to the data set. However, the best available information was carefully consolidated, reviewed and verified in the construction of this Report. Therefore, this Gap Analysis Report presents a useful 'insight' and it is hoped that Rwanda can take this analysis forward in ongoing mapping and planning activities related to EbA and climate change research, knowledge co-production and informing policy development.

2. CLIMATE CHANGE AND VULNERABILITY IN RWANDA

2.1 OBSERVED AND PROJECTED CLIMATE CHANGE

Rwanda is situated in the equatorial zone and is one of Africa's most biologically diverse countries with montane rain forest in the West, grass savannas in the central plateau, low altitude savannas on hill slopes in the valleys of East and South, medium and high swamps and alpine and sub-alpine volcanic vegetation in the North West. The country is the most densely populated in Africa with over 11 million inhabitants living in an area of 26,338 sq.km in 2011 and which is projected to rise to 16 million by 2020. Rwanda is a predominantly agrarian economy with approximately 74% of the population residing in rural areas and agriculture providing around 36% of GDP and 80% of employment in Rwanda. Rwanda's administrative structure comprises 4 provinces (Eastern, Western, Northern and Southern Provinces) and City of Kigali, all subdivided into 30 districts.

Rwanda is characterized with predominantly hilly topography with steep, over-cultivated hills and high rainfall give rise to high levels of run-off, erosion and flooding during intense rainfall events that have become more prevalent in the last decade. The altitude varies between 900 m and 4507 m from east to west where eastern plains are lying on 1,000 m to 1,500 m and the central plateau region is located between 1,500 m and 2,000 m.

The climate in Rwanda varies significantly across the country and between seasons. The country has four main climatic regions – the eastern plains, the central plateau, the highlands, and the regions around Lake Kivu. The eastern plains receive an annual rainfall of between 700 mm and 1,100 mm (in 57 to 100 days), with a mean annual temperature between 20 °C and 22 °C. The central plateau receives rainfall of between 1,100 mm and 1,300 mm (in 90 to 150 days), with an annual mean temperature between 18 °C and 20 °C. The highlands, including the Congo-Nile Ridge and the volcanic chains of Birunga, receive annual rainfall of between 1,300 mm and 1,600 mm (in 140 to 210 days), with an annual mean temperature between 10 °C and 18 °C. Regions around the Lake Kivu and Bugarama plains get annual rainfall of between 1,200 mm and 1,500 mm (in 150 to 210 days) and have an annual mean temperature between 18°C and 22°C.[10]

There are four seasons, in which the long rainy (March-April-May) and short rainy (September-October-November) seasons alternate with long dry (June-July-August) and short dry seasons (Mid-December-January-February) throughout the year. The four seasons are largely controlled by the position and intensity of anticyclones such as Mascarenes, Saint Helena, Açores and Siberian.[11]

According to Rwanda's Third National Communication on Climate Change, the following climate trends were observed for the period 1961-2016:[12]

- Temperature: an increasing trend in mean temperatures with the increase varying between 1.4°C and 2.56°C.

[10] Republic of Rwanda (2018). Third National Communication: Report to the United Nations Framework Convention on Climate Change. Republic of Rwanda, Kigali
[11] Idem
[12] Republic of Rwanda (2018). Third National Communication: Report to the United Nations Framework Convention on Climate Change. Republic of Rwanda, Kigali

- **Rainfall:** decline in the frequency of rainfall of between 35-45 days and a reduction of 250 mm in mean rainfall in the eastern region, while in the north-western highlands and south-west region precipitation increased by between 30 and 100 mm.
- **Change in seasonality:** Rainy seasons have become shorter and more intense, leading to a reduction in agricultural production and events such as droughts in dry areas and floods or landslides in areas experiencing heavy rains.

In recent years, higher temperatures, prolonged droughts, and elevated rates of evapotranspiration have resulted in disturbances in the hydrologic cycle and altered river flows.[13] While Rwanda has not yet experienced serious water availability problems, in the long-term, climate-related impacts such as changes in rainfall and temperature, and increases in floods and droughts, will impact water availability.[14]

Rwanda is already experiencing the impacts of climate change, including increased and longer droughts and more frequent and severe floods leading to landslides. In recent years, extreme weather events in Rwanda increased in frequency and magnitude, leading to significant losses including human lives. Extreme events have also intensified in terms of their impacts.[15] This includes droughts in the eastern and southern regions that have resulted in a series of severe famines, and heavy rainfall in northern and western regions has led to erosion, flooding, and landslides.

Between 1990 and 2014, six major agricultural droughts occurred in the country leading to crop failure, food shortage and famine. Almost all drought events occurred in either southern province or the eastern province. The 2006 drought affected over 1 million people.[16]

Rwanda is highly susceptible to landslide and 42% of the country's area is classified with moderate to very high susceptibility.[17] The lack of vegetation cover and increased rainfall intensity are the major factors for the high susceptibility to landslides in the country. Due to limited land availability in Rwanda, agriculture and infrastructure are often established at slopes with high potential risk of landslides. From 2011 to 2013, landslides caused 74 deaths, 22 injuries, 573 houses destroyed or damaged, and 656 ha of affected land.[18] The most impacted were the Western and the Northern Province.

2.2 CLIMATE PROJECTIONS

Climate change in Rwanda is expected to result in increased temperatures, intensified rainfall, and prolonged dry seasons[19] Each region in Rwanda will experience these challenges differently:

[13] USAID, 2012. Climate Change Adaptation in Rwanda.
[14] Netherlands Commission for Environmental Assessment, 2015. Climate Change Profile: Rwanda.
[15] Republic of Rwanda (2018). Third National Communication: Report to the United Nations Framework Convention on Climate Change. Republic of Rwanda, Kigali
[16] MIDIMAR, 2015. The National Risk Atlas of Rwanda.
[17] Idem.
[18] Idem.
[19] Republic of Rwanda (2018). Third National Communication: Report to the United Nations Framework Convention on Climate Change. Republic of Rwanda, Kigali

increased soil erosion will affect the mountainous west region, parts of the central north and south will suffer floods, and the east and southeast will experience droughts and desertification.

The Third National Communication on Climate Change used the new version of the stochastic weather generator-LARS-WG incorporating predictions from 15 GCMs used in the IPCC AR4 and was used to project precipitation and temperature data for 2050 (with baseline 1961-1990):

- **Temperature:** Projections show a rise of up to 2.5°C by mid-century, up from the 1970 average.[20] It is expected that the number of hot days will continue to rise.[21] In addition, increases in average maximum and minimum monthly temperatures ranging from 1.5-2.7°C and 1.7-2.8°C, respectively, are expected.[22]

- **Rainfall:** Average annual rainfall may increase by up to 5-10% by the 2030s from 1970.41 The mean rainfall is predicted to increase by between 0.1 and 1.24 mm and 0.1 and 0.82 mm per year in the north-east and the south-west regions of the country respectively except during the short rainy season (Mid-September-October-November- Mid-December), showing a marked decline of between 0.412 and 1.65 mm per year in the north-east region of the country.

Due to climate change, the negative impacts seen from today's climate variability are likely to become worse. This includes an increase in extreme events including severe droughts and floods. Seasonal droughts are expected to be prolonged, which will cause problems especially in the east and south- east.[23] An intensification of heavy rainfall is also projected, meaning that more rainfall will occur during only a few storms, thus increasing the risk of disasters such as floods and landslides. These can lead to greater human mortality, contamination of water sources, loss of crops, and damage and destruction to homes and critical infrastructure.

Models suggest that Rwanda could lose over 1% of its GDP each year due to climate change related losses by 2030, and an even greater proportion thereafter.[24] It is therefore a key priority for the country to engage in urgent adaptation solutions.

2.3 CLIMATE RISKS AND VULNERABILITY OF ECOSYSTEMS AND LIVELIHOODS

Rwanda's high population density combined with hilly landscape, means that rural population is increasingly farming smaller and smaller plots of available land. More than 80% of households own less than 1 ha of land. Moreover, as the population has grown and land has become increasingly

[20] Republic of Rwanda (2018). Third National Communication: Report to the United Nations Framework Convention on Climate Change. Republic of Rwanda, Kigali
[21] Future Climate for Africa, 2016. Rwanda Climate Fact Sheet. Africa's climate: Helping decision-makers make sense of climate information
[22] Republic of Rwanda, 2015. Intended Nationally Determined Contribution (INDC) for the Republic of Rwanda.
[23] Netherlands Commission for Environmental Assessment, 2015. Climate Change Profile: Rwanda
[24] Rwanda Environment Management Authority and SEI, Economics of Climate Change in Rwanda (2009). http://www.rema.gov.rw/~remagov/fileadmin/templates/Documents/rema_doc/CC%20depart/Economics%20of%20CC%20in%20Rwanda.pdf

scarce, farmers have started to cultivate marginal land on steep slopes (up to and above 55%). The large number of people farming on Rwanda's hilly and mountainous terrain has led to serious environmental degradation due to overexploitation of the soil and extensive erosion which results in increased soil erosion causing extensive sedimentation of the main rivers and other waterbodies.

Rwandan agriculture is heavily dependent on climate conditions as most of agriculture productive system depend on rainfall. Extreme weather events such as floods, heavy rainfall, wind and storms highly affect the agriculture and livestock. An analysis of agricultural production since 1999 revealed that yield fluctuations are remarkably related to annual precipitation although from 2006 the crop intensification program has greatly influenced the yield trend. (Fig.4.18).The analysis of the existing yields between 1999 and 2014 (Fig.4.18) showed significant positive Pearson correlations of total annual rainfall with yields of maize ($r=0.279$, $p<0.05$), rice ($r=0.257$, $p<0.05$) and wheat ($r=0.635$, $p<0.05$). However, no significant relationship with crop yield was found for the number of rainy days, min and max temperature at country level. A more localized study could be appropriate to compare agro- ecological zones, microclimates and regions where specific crops are grown to understand better the relationships with climatic parameters and develop more specific adaptation recommendations.

Climate change is affecting both physical habitats and species from various Rwandan ecosystems. Eastern ecosystems are the most exposed to the prolonged droughts which affect plant species and reduce the availability of food and water for herbivores which dominate the animal population of the Akagera National. The Nyungwe National Park ecosystems, and a number of ecosystems located in Congo-Nile region are vulnerable to landslides. Indirectly, climate change affects the remaining ecosystems due to increased human activities resulting in deforestation for firewood and agricultural activities.

It is difficult to distinguish the impacts of climate change on forest resources from other non-climate change factors such as agriculture, infrastructure development, urbanization, etc. However, it is recognized that the socio-economic and political drivers will likely be exacerbated by future climate change with projected increase in temperature, decreased rainfall in many parts of the country and occurrence of extreme events such as drought, flooding and landslides. The potential climate change impacts are summarized in Table 2. Drought is considered as the most critical factor which affects different parts of Rwanda mostly Eastern regions as a result of a prolonged dry season or a delay in the onset of the rainy season.

Table 2. Potential climate impacts on agriculture and livestock and forestry.

Climate change scenarios	Description of impacts
Potential impacts on agriculture and livestock	
Increasing trend in mean temperatures (projected annual	• Decrease in tea and coffee production • Leads to significant reduction of crop yields of cereals; • Shift in pest ecologies, and thus resulting in pest and disease outbreaks in new areas;

mean temperature increase between 0.10°C and 0.30°C)	• Heat stress affects physiological processes health and mortality of livestock.; • Higher disease pressure on livestock, through change of the thermal optimum for pathogens, hosts, vectors and epidemiology, together with a number of indirect effects;
Decreasing trend in mean rainfall and number of rainy days coupled with more days with extreme rainfall intensities particularly in the Eastern and parts of Southern regions	• Late harvests, delay of sowing in the next season, seasonal crop failures and low yield; • Famines and food insecurity; • Limited grazing and feed resources during long dry spells significantly reduce milk productivity and thus affect food security of cattle farmers; • Increased use of swamps for agricultural purposes will soon or later also have implications for overall water balance in the country and its availability for agriculture.
Increase in rainfall intensities in North-west highlands and South-western regions	• Increase soil loss and nutrient leaching from soil, thus challenging agricultural productivity growth. • Increased runoff during heavy storms destroy existing soil conservation facilities, increase sedimentation of lakes and ponds thus altering fish habitats.
More frequent violent storms (strong winds, hailstones, thunders, torrential rains)	• Crop damage or total crop destruction and thus yield reduction; • Increased flooding and landslides destroying crops cultivated on vulnerable/fragile areas such as valleys and steep slopes;
Potential impacts on forestry	
Increasing trend in mean temperatures (projected annual mean temperature increase between 0.10°C and 0.30°C)	Increasing temperature will create a favourable environment for more forest pests and diseases. This will reduce productivity of forests and may increase risks of deforestation and forest degradation.
Decreasing trend in mean rainfall and number of rainy days	• Decrease in rainfall will likely increase water stress of trees particularly in semi-arid areas in Eastern and Southern regions, reducing their productivity and leading to dieback; • More frequent droughts will upsurge anthropogenic stress and increase deforestation and forest degradation, frequent and severe forest fires and reduce capacity of water catchment;
Increase in rainfall intensities coupled with strong winds, hailstones, thunders, torrential rains in North-west highlands and South-western regions	Increased forest productivity due to increased rainfall availability; however, subsequently increased extreme weather events such as strong winds, violent storms, violent floods and landslides will affect negatively forest resources particularly in fragile areas such as on steep slopes and valleys.

3. ECOSYSTEM-BASED ADAPTATION: CONCEPTS, KNOWLEDGE AND CAPACITIES

3.1 UNDERSTANDING ECOSYSTEM-BASED ADAPTATION

Ecosystem-based Adaptation (EbA) is an approach that focuses on people, helping them to adapt through the goods and services provided by ecosystems and with the explicit objective of helping to reduce vulnerability of both population and ecosystems to climate variability and change.[25] EbA places people at the center and uses participatory and culturally appropriate methods to address the challenges, but with a greater emphasis on natural solutions. The general objective of EbA is to help reduce vulnerability and increase adaptive capacity of ecosystems and in turn communities through the effective use and management of natural resources such as forests, wetlands and coastal ecosystems within a given area.

The EbA approach is defined as "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change".[26] The EbA approach has been receiving increasing attention for it has a great potential to reduce the vulnerability of both people and ecosystems to climate change impacts. Also, the approach provides multiple social and economic benefits such as clean water, food security, risk reduction and other services essential for livelihoods and human well-being.[27] The EbA approach considers that equity, gender, and the importance of local and traditional knowledge are critical constituents in effective adaptation efforts.

Figure 1. Ecosystem-based Adaptation (EbA) Analytical framework.

[25] Martin, 2016.
[26] CBD, 2009.
[27] TEEB, 2010.

The concept of EbA draws on a range of existing practices employed by the conservation and development sectors, such as sustainable natural resource management, community-based natural resources management and community-based adaptation. These practices include existing ecosystem or landscape level approaches, and can involve, for example, integrated watershed management, sustainable land management, or coastal zone management to secure ecosystem functions and services.

EbA measures include coastal habitat restoration, agroforestry, integrated water resource management, livelihood diversification, and sustainable forest management interventions that use nature to reduce vulnerability to climate change. Examples of EbA measures include:[28]

- Conservation, sustainable management and/or restoration of mangrove forests to reduce the impact of coastal flooding and erosion from storm surges linked to changing frequency and intensity of storms;
- Sustainable management of upland wetlands, forests, and floodplains for the regulation of water flow and control of water quality;
- Conservation and restoration of forests to stabilise land slopes and regulate water flows;
- Establishment of diverse agroforestry systems to cope with increased risk from changes in climate conditions;
- Management of ecosystems to complement, protect and extend the longevity of investments in hard infrastructure;
- Conservation of agrobiodiversity to provide essential gene pools and facilitate crop and livestock adaptation to climate change;
- Establishment and efficient management of systems to ensure the continued delivery of ecosystem services to support resilience to climate change, for example through protected areas, land use and agricultural systems.

A critical aspect of the ecosystem-based approach is that it can be applied to diverse ecosystems and geographical scales – local, national, regional and global.[29] Thus, due to its multi-sectoral and multi-scale characteristics, it can integrate a variety of disciplines, stakeholders, and institutions, so that they can work at a range of governance levels and can influence decision-making.[30]

[28] UNFCCC, 2013.
[29] Devisscher, T. 2010. Ecosystem-based Adaptation in Africa: Rationale, Pathways and Cost Estimates. Stockholm Environment Institute.
[30] Vignola et al., 2009.

Although it is clear what is the difference between EbA and other approaches to adaptation and nature conservation, it is important to have a guide to be able to answer the question "Is the adaptation measure designed with the EbA approach or not?". The EbA measures should: 1) Help people adapt to the adverse effects of climate change; 2) Use sustainably biodiversity and ecosystem services; and 3) Forms part of a larger climate adaptation strategy.[31] See Box 1 for more details.

Box 1. Principles and criteria for EbA (FEBA, 2017).

I. Help people adapt to the adverse effects of climate change

Criteria 1. Reduce social and environmental vulnerabilities: The EbA explicitly addresses current and future climate change and climate variability. That is, it is based on assessments of climate vulnerability, hazards and risks for people, as well as the adaptation benefits derived from ecosystem services.

Criteria 2. Generates social benefits in the context of adaptation to climate change: The EbA reduces the vulnerabilities of people through the use of biodiversity and ecosystem services and the generation of social benefits in a fair and equitable manner.

II. Through the sustainable use of biodiversity and ecosystem services

Criteria 3. Restores, maintains or improves ecosystem health: The EbA preserves and restores the ecosystems and landscapes that are necessary for adaptation to climate change, in accordance with the ecosystem approach. Helps to ensure the stability and resilience of ecosystems as a whole, as well as connectivity and its multiple functions in the landscape.

Criteria 4. Receive multi-level policy support: As part of a broader adaptation strategy, the EbA can operate at one or more levels (eg local, national, regional, landscape and sectoral) and geographic scales. In addition, EbA should be integrated into existing policy frameworks, so that interventions can be sustainable and scalable, rather than short-term and isolated.

III. As part of a larger strategy

Criteria 5. Supports equitable governance and enhances capacities: The EbA measures improve the governance of natural resources with respect to the use of biodiversity and ecosystem services, following a community-centered, participatory approach that incorporates gender and intercultural perspectives.

[31] FEBA, 2017. Making Ecosystem-based Adaptation Effective: A Framework for Defining Qualification Criteria and Quality Standards.

3.2 KNOWLEDGE AND CAPACITIES FOR EBA PLANNING AND POLICY MAKING

Knowledge and capacities on EbA require integrating approaches, methods and knowledge across disciplines that are often based on different perceptions. EbA considers both ecosystems and socio-economic aspects, but in its core, the concept refers to the mutual dependence on each other. Both natural and social science capacity is needed to understand the EbA concept. Knowledge on natural sciences is necessary to understand the boundaries of the ecosystem to be managed and to describe linkages between and within ecosystem functions, understand vulnerability to climate change and potential impacts. Meanwhile, knowledge on social science allows the understanding of the traditions, attitudes and societal structures, that frame the social values regarding ecosystems and their services and understanding of their importance for adaptation. A combination of natural and social sciences can help better understand ecosystem vulnerabilities and the link to peoples' livelihoods vulnerability, the climate risks they face, and the extent to which ecosystem management addresses those climate risks effectively.[32]

Knowledge and capacity are critical to every phase of policy making for EbA, from planning to implementation and evaluation. The knowledge and capacity assessment for EbA covers the four technical and functional capacities for adaptation planning defined in Table 3 below.

Table 3. List of key knowledge needs at Enabling Environment level, institutional and individual levels for effective planning and implementation of EbA.

Knowledge categories	Example of knowledge needs required for planning and implementation of EbA	Levels of knowledge		
		Enabling environment	Institutional level	Individual level
Climate information and risk assessment	Quality downscaled climate information			
	Integrated and consistent climate and ecosystem information is available and accessible			
	Knowledge and experience in the use of methodologies for conducting climate risk and vulnerability assessment at local level.			
	In-depth understanding of the role of ecosystems to build resilience to climate change.			
	Multidisciplinary research to grasp the multiple dimensions of EbA approach			
	Designing adaptation strategies with EbA approach			

[32] Haberl, H.; Fischer-Kowalski, M.; Krausmann, F.; Winiwarter, V. (Eds.) 2015. Social Ecology. Society-Nature Relations across Time and Space. Springer International: Basel, Switzerland

Technical Planning and implementation				
	Assessing the costs and benefits of EbA measures to generate evidence for the effectiveness of the approach.			
M&E of adaptation process and enhanced climate resilience	Adequate M&E framework capturing EbA processes and their implications			
Policy making and mainstreaming	Policies are informed by state-of the-art climate adaptation knowledge and sound science			
	EbA approach is mainstreamed as a cross-sectoral solution to enhance climate resilience			

4. ECOSYSTEM-BASED ADAPTATION IN RWANDA: KNOWLEDGE NEEDS AND GAP ANALYSIS

The assessment based on literature review, reveals clear knowledge and capacity gaps across the three levels of analysis (individual, organization and enabling environment) with respect to planning and implementation of adaptation actions with ecosystem-based adaptation approach. The results of the survey of public officials and other actors confirm this assessment of a greater relative deficit of available knowledge on impacts or social, economic and governance aspects of climate change adaptation in Rwanda. The survey was focused on stakeholders' knowledge, partnering and implementation capacity to support the short-, medium- and long-term ecosystem-based adaptation actions.

4.1 ENABLING ENVIRONMENT

The analysis of the Enabling Environment begins with a summary of the Rwanda's policy framework for climate change, development and environment. It then discusses some of the

current EbA initiatives and programs in Rwanda. Following that, it examines the political commitment on climate change and the extend of integration of EbA approach to climate adaptation in national strategies and sectoral policies.

4.1.1 POLICY FRAMEWORK: MAINSTREAMING EBA IN PLANNING PROCESSES

The Green Growth and Climate Resilience Strategy (GGCRS) provides the country's roadmap for becoming a climate resilient, low carbon economy by 2050. The GGCRS developed in 2011 is central in directing the achievement of Rwanda's development targets through low carbon and climate resilient pathways and has high- level commitment from GoR. GGCRS' strategic objectives include the achievement of sustainable land use and water resource management and reduced vulnerability to climate change. The strategy contains 14 Programmes of Action towards its achievement, including Sustainable Land Use Management and Planning and Sustainable forestry, agroforestry and biomass energy.

Rwanda's Intended Nationally Determined Contribution (INDC) mainstreams many topics relevant for EbA such as: agro ecology techniques (agro forestry, kitchen gardens, nutrient recycling, and water conservation); organic waste composting; mainstreaming sustainable pest management techniques; improving soil conservation and land husbandry (terraces and agroforestry); increasing irrigation and water management including rainwater harvesting; afforestation through enhanced germplasm and technical practices in planting and post-planting processes; Improved Forest Management for degraded forest resources; and sustainable use of biomass fuels through the increased uptake of improved cookstoves and biogas. Table 3 lists the major national strategies for development, climate change and environment.

National Strategy for Transformation 2017 – 2024. In the medium-term, the National Strategy for Transformation, NST-1/Seven Years Government Program (2017-2024) sets the priority for a Green Economy approach in its Economic Transformation Pillar that promote "Sustainable Management of Natural Resources and Environment to Transition Rwanda towards a Green Economy". Moreover, Environment and Climate Change were highlighted in NST1 as cross-cutting areas of policy concern which can be positively impacted by a range of development activities with priority given to agriculture, urbanization, industries and energy.

Vision 2020 Development Programme (2000). The VISION 2020 seeks to fundamentally transform Rwanda into a middle-income country by the year 2020. This will require achieving annual per capita income of US$ 900 (US$ 290 today), a poverty rate of 30% (64% today) and an average life expectance of 55 years. The six pillars of Vision 2020 are interwoven with three cross-cutting issues including protection of environment and sustainable natural resource management.

National Adaptation Programme of Action (NAPA) (2004). The NAPA articulates Rwanda's strategy to reduce vulnerability to climate change particularly from the main climatic hazards including intense rainfall, flash flooding, landslides, drought and low flows, extreme temperatures and heat waves. The six NAPA priorities are: 1) Integrated Water Resource Management; 2) Setting up information systems to early warning of hydro-agro meteorological system and rapid intervention mechanisms; 3) Promotion of non-agricultural income generating activities; 4) Promotion of

intensive agro-pastoral activities; 5) Introduction of species resisting to environmental conditions; and 6) Development of firewood alternative sources of energy.

National Strategy for Climate Change and Low-Carbon Development "Green Growth and Climate Resilience" (2011). This Strategy was developed in 2011 and aims to guide the process of mainstreaming climate resilience and low carbon development into key sectors of the economy. It provides a strategic framework which includes a vision for 2050, guiding principles, strategic objectives, 14 programmes of action (1. Sustainable intensification of small-scale farming; 2. Agricultural diversity of markets; 3. Sustainable land use management; 4.Integrated water resource management; 5. Low carbon energy grid; 6. Small scale energy access in rural areas; 7. Disaster management; 8. Green Industry and private sector development; 9. Climate compatible mining; 10. Resilient transport systems; 11. Low carbon urban system; 12. Ecotourism, conservation and payment of ecosystem services; 13. Sustainable forestry, agroforestry and biomass; and 14. Climate predictions), enabling pillars and a roadmap for implementation

Rwanda's collective vision for development is embodied in Vision 2020, which seeks to transform the country from a subsistence agriculture economy to a knowledge-based, middle-income economy by 2020. It calls for increased protection and enhancement of biodiversity and ecosystem services and reduction in fuelwood demand pressure on the forest resource. Increasing climate resilience in agriculture and human settlements and targeting public works schemes to areas most at risk from climate change are key areas of focus in the strategy. Sustainably exploiting natural resources and protecting the environment and reducing the dependence on fuel wood are also priorities.

On contrary, there are still sectoral policies and laws that do not contain adequate environment and climate change concerns, and that are not harmonized with each other. These include policies and laws concerning agriculture, land, water, forests, trade and industry which have significant implications on the environment and mitigation of climate change. In addition, insufficient enforcement of laws and weak implementation of environment and climate change related policies, and strategies remain a major issue of concern in Rwanda's environment and climate change sector.

Analysis of the current efforts for EbA mainstreaming at national and sectoral levels in Rwanda, provide an overview of the enabling environment for further promoting and upscaling EbA measures. The contents of key national policies and strategies on climate change and development were reviewed and analyzed following the criteria:

- Evidence of acknowledgement of ecosystem services (ESS) approach for climate change adaptation (CCA);
- Measures considering ecosystem services (ESS) approach to climate change adaptation (CCA);
- Recommendations for adoption of ecosystem services-based approaches to climate change adaptation.

Table 4 shows that all reviewed national policies provide some degree of focus on EbA approaches. Most of the policies do not provide any direct connection between ESS and CCA, nonetheless provided objectives, strategies and targets for ecosystem management, which is vital for grounding EbA. An excellent example of EbA mainstreaming is demonstrated in the Environment and climate change policy (Box 2).

Table 4. Content analysis of major national strategic documents and sectoral policies to identify the level of EbA mainstreaming.

Name of policy	Major contribution and focus in relation to EbA
National policies	
National Strategy for Transformation	No specific mention of ecosystem services and their role for climate adaptation.
Vision 2020 Development Programme	The vision does not consider ecosystem services nor climate adaptation as key priorities.
Environment and Climate Change Policy	There is a direct statement that the policy seeks to promote EbA approaches in local development and climate change actions (see Box 2).
National Adaptation Programme of Action (NAPA)	Considers ecosystem services are fragile and important for livelihoods, however there is no direct connection with their role for climate adaptation.
National Strategy for Climate Change and Low-Carbon Development "Green Growth and Climate Resilience"	Promotes agroforestry and ecosystem conservation approaches however there is a weak link with climate change adaptation.
Sectorial policies	
National Disaster Management Policy	There is no mention of ecosystem services and the management of ecosystems as potential solution to reduce disaster risk such as droughts, landslides or floods.
Fiver-Year Strategic Plan for the Environment and Natural Resource Sector 2014-2018	Ecosystem services and defining their value is a key priority for the strategy however it does not directly relate to climate change adaptation solutions.
Strategic Plan for Agriculture Transformation	Sustainable management of natural resources, water and soil conservation is mentioned as a priority but with no relation to climate change adaptation.

National Policy for Water Resources Management	Rehabilitating critical watersheds and protecting water bodies is yielding tangible results in water quality and aquatic ecosystems.
National Land Policy	There is limited consideration of ecosystem services and consideration of adaptation measures to climate change.
Forest Policy and District Forest Management Plans	To contribute to sustainable land use through soil, water and biodiversity conservation, and tree planting through the sustainable management of forests and trees.

Box 2 – Environment and Climate Change Policy: Example of EbA integration

Climate-resilient, low-carbon development is a national priority for Rwanda because it will support the country to absorb disturbances and build capacity to adapt to additional stress and change. Measures to address existing climate variability and achieve national development goals should not be at the expense of preparing for future climate change. Adaptive capacity is key to improving socio-economic characteristics of communities, households and industry. Adaptive capacity is also a necessary condition for the design and implementation of effective adaptation strategies to reduce the likelihood and magnitude of harmful outcomes resulting from climate change.

Mainstream green and ecological and climate resilient practices and interventions in all development sectors and districts, including their plans, budgets, functions and actions.

- Promote Ecosystems-based Adaptation (EbA) approaches in local development and climate change actions
- Promote resource recovery and reuse in all sectors, including agriculture, water and sanitation and industrial sectors.
- Integrate climate change into the infrastructure planning and development.
- Promote and encourage water storage at different levels (institutional, households, etc.) and improve storm water management
- Promote afforestation and reforestation of critically- degraded and residential areas

Although, Rwanda has a considerable advance in planning for climate change adaptation, the levels of complexity and uncertainty surrounding this issue raise difficult challenges to public policymaking processes and governmental structures. In particular, EbA highlights the complex relationships between science and public policy, and more broadly, between knowledge and decision-making processes.

4.1.2 IDENTIFIED NEEDS AND BARRIERS FOR EBA MAINSTREAMING

There is a wide consensus, which has also been highlighted by the emblematic Adaptation Gap Report[33] that 'knowledge gaps' are some of the main obstacles or barriers that affect the planning and implementation of climate change adaptation measures. This is particularly relevant for EbA as it is a relatively new concept and limited evidence of its effectiveness is available to support policymaking. Such gaps refer not only to the lack of specific type of information but also to problems in the integration of different knowledge systems, and in the uptake of knowledge for policy purposes.

The gap analysis at the level of enabling environment was performed on the basis of the identified knowledge needs for planning in implementing EbA (Table 3). The summary of results on knowledge needs, baseline and gaps is presented in Table 5.

Table 5. Summary analysis of EbA knowledge needs, baseline and gaps at institutional level.

Knowledge category	Target level	Baseline	Knowledge Gap
Policy making and mainstreaming	**National and sectoral policies are informed by state-of the-art climate and ecosystem knowledge and sound science**	At present, Rwanda has relevant climate and ecosystem information, however it is fragmented and not easily accessible by policymakers. In particular, there is lack of integration of ecosystem services and climate change information for designing adaptation in sectoral policies	Inadequate uptake and use of knowledge for climate adaptation policy with EbA approach
	EbA approach is mainstreamed as a cross-sectoral solution to enhance climate resilience: Effective adaptation planning with EbA approach is present across all sectors in a way that	National policies in Rwanda integrate directly or indirectly aspects from EbA. However, sectoral policies demonstrate limited or no consideration of EbA approach.	Lack of mainstreaming of EbA approach in sectoral policies

[33] UNEP, 2014. The Adaptation Gap Report.

	recognises sectoral interdependencies and policy entry points.		

Gap analysis: Policy making and mainstreaming

(1) Inadequate uptake and use of knowledge for climate adaptation policy with EbA approach

A widespread view from this analysis is that one of the critical problems facing climate adaptation policies is not so much the lack of knowledge as such, but its limited appropriation and use by decision makers. In other words, there is knowledge available, but it is not used. Even the limited knowledge available in Rwanda on climate change (climate data, impacts studies, ecosystem-services assessment, vulnerability assessment, etc.), it is perceived as fragmented and dispersed. This is an important obstacle affecting the uptake and use of available knowledge for adaptation policy making. Therefore, the level of certainty of information is insufficient to justify adaptation policies. The factors affecting the uptake and use of available information for policy making include:

- Scientific information is difficult to understand for policy makers
- Scientific information is not easily accessible
- Information is fragmented
- Information is not disaggregated at local, municipal, provincial level to properly inform policies
- Costs and benefits of adaptation policies with EbA approach
- Effectiveness of adaptation policies

(2) Lack of mainstreaming of EbA approach in sectoral policies.

Climate change adaptation and in particular EbA are not explicitly addressed in sector policies such as agriculture and water sectors (see Table 4). Although agricultural and forestry policies recognize climate change potential impacts, they lack details on adaptation approaches. It can be noted that the strategies remain incremental, rather than supporting transformational adaptation with focusing on the potential of ecosystems to reduce expose to climate risks and increase resilience of populations. This can partly be explained by the limited awareness of long-term climate scenarios to inform planning across all government departments in the study countries.

Longer term adaptation strategies were more diverse, but less regularly mentioned, than short-term event-based issues that have a more immediate risk and disaster management need in both agriculture and water policies. Examples of long-term adaptations relating to water include integrated water resources management, improving coverage and access to urban and domestic water supply, increasing reservoir water storage and enhancing hydropower generation capacity. The most frequently mentioned strategies for agriculture include food and nutrition security, livestock management, risk management (including early warning systems for crops), food and seed storage systems and the appropriate use of fertilisers and pesticides. Common examples of long-term adaptations in the agricultural sector include soil and crop research, use of appropriate technology and irrigation development. These strategies, however, do not consider EbA approach

and therefore EbA is not effectively integrated through the sector policies in Rwanda. There is a need for identification of entry points to mainstream EbA and achieve comprehensive cross-sectoral adaptation strategies.

4.2 AT INSTITUTIONAL LEVEL

The institutional analysis begins with a summary of wider institutional arrangements for climate change in Rwanda including relevant research frameworks. It then discusses some of the current EbA initiatives and programs in Rwanda. Following that, it examines understandings of EbA and capacity needs at institutional level.

4.2.1 INSTITUTIONAL ARRANGEMENTS GOVERNING CLIMATE CHANGE IN RWANDA

Rwanda has a comprehensive and progressive institutional framework and has established agencies to work cross-sectoral to support natural resource management, notably REMA and the Rwanda Water and Forests Authority (RWFA) within the Ministry of Environment (MOE). In addition, a National Fund for Environment and Climate Change (FONERWA) has been established to address cross- sector financing needs. Rwanda also recognises the importance of engaging multiple stakeholders and has established mechanisms including regular cross-sectoral planning meetings and the Joint Action Development Forums (JADF), consultative platforms used for promoting cooperation between the private sector, civil society and the public sector. Table 6 shows the key institutions relevant to the climate change governance in Rwanda.

The National Climate Change Committee (NCCC) at national level was established to develop Third National Communication (TNC) and various relevant institutions have nominated their representatives to be members of the Committee and those already having representatives in the TNC Working Groups were automatically Members of NCCC.

Ministry of Natural Resources (MINIRENA) - Ministry responsible for establishing norms and practices for rational exploitation and efficient land management, environment protection, water resources and evaluating their implementation. Several agencies function under MINIRENA (Table 6).

Table 6. List with agencies functioning under MINIRENA.

Agency	Description
Rwanda Natural Resources Authority (RNRA)	Rwanda Natural Resources Authority (RNRA) manage natural resources (water, forestry, mines, land and any other natural resources) until 3 February 2017, that is. As of 3rd February 2017, when it was repealed and replaced with Rwanda Land Management and Use Authority (RLMUA), Rwanda Water and Forestry Authority (RWFA) and Rwanda Mines, Petroleum and Gas Board.

Rwanda Water and Forestry Authority (RWFA)	RWFA is responsible for implementing policies, laws and strategies and Government decisions related to the management of forests and natural water resources. The National Tree Seed Centre (NTSC) is responsible for the management and provision of tree seed within the country.
Rwanda Land Management and Use Authority (RLMUA)	RLMUA is the authority tasked to implement national policies, laws, strategies, regulations and Government resolutions related to the management and use of land.
Rwanda Environment Management Authority (REMA)	REMA is the authorized Government institution to determine modalities of protection, conservation and promotion of the environment in Rwanda.

National Fund for Environment and Climate Change (FONERWA) - FONERWA is responsible for the streamlining, coordination, channeling, programming, disbursement and monitoring of environment and climate finance within Rwanda.

Ministry of Agriculture and Animal Resources (MINAGRI) - MINAGRI is responsible for policies, norms and practices for the development and management of programmes for the transformation and modernization of agriculture. Areas of responsibility include standards and guidelines concerning land husbandry, soil protection and agroforestry. Seed importation and phytosanitary control is administered and managed by the seed inspection unit within MINAGRI.

Ministry of Infrastructure (MININFRA) - Among MININFRA's responsibilities is the supervision, monitoring and assessment of national policies and programs on matters relating to habitat and urbanism, transport, energy, water and sanitation. MININFRA shares responsibility for the implementation of the Energy Sector Strategic Plan and the SE4ALL action plan.

4.2.2 IDENTIFIED NEEDS AND KNOWLEDGE GAPS

The government and other institutions[34] at national, subnational and local levels have a central role for the promotion and mainstreaming of EbA in different sectors and territorial scales to respond to growing climate stresses and risks. Despite the considerable progress made towards building governance systems for climate change adaptation in Rwanda, EbA is a relatively new approach and limited evidence exist in the country. The assessment concluded that there are some knowledge needs and gaps that constrain the effective formulation and implementation of climate change and in particular, EbA-related policies and strategies. The gap analysis at

[34] For the purposes of this paper, it is considered that institutions are the formal entities designed to perform a set of functions related to decision making and implementation. They can be classified according to their status or function (e.g., private, public, nongovernmental, bilateral, multilateral, humanitarian, financial, etc.).

institutional level was performed on the basis of the identified knowledge needs for planning in implementing EbA (Table 3). The summary of results on knowledge needs, baseline and gaps is presented in Table 7.

Table 7. Summary analysis of EbA knowledge needs, baseline and gaps at institutional level.

Knowledge category	Knowledge needs for EbA planning and implementation	Baseline	Knowledge Gap
Climate information and management	**Quality downscaled climate information:** climate information on historical trends and projections, impacts and their implication for the ecosystems and other sectors.	Climate information is general, at national and partly provincial levels. There is Early Warning System for onset disasters. The main focus is on vulnerability (hazards) rather than climate information such as changes in aridity, precipitation, temperature.	Lack of quality and detail downscaled climate information to inform adaptation and planning processes.
	Integrated and consistent climate and ecosystem information is available and accessible: The climate and ecosystem information are consistent, integrated, and available at a common platform to effectively inform policy making.	There are multiple online platforms related to climate change and ecosystem management in the country, however they are not adequately coordinated and there is lack of data consistency (e.g. format, methods of data collection, etc.) comprehensive repository with information on climate impacts on ecosystems and livelihoods.	Lack of an integrated knowledge platform on climate change and ecosystem assessment data
	Multidisciplinary research to grasp the multiple dimensions of EbA.	Currently there is a lack of research on climate change adaptation and in particular EbA in Rwanda.	Insufficient research and information about the climate change impact on ecosystems, concerning ecosystems goods and services
M&E of adaptation process and enhanced climate resilience	**Adequate M&E framework capturing EbA effectiveness and impact:** Comprehensive indicators that measure how effectively climate risks are managed and adaptation outcomes are achieved.	The current M&E frameworks are relying exclusively on a logical framework with indicators that are not specifically designed to track the adaptation processes.	Need for comprehensive metrics and monitoring systems to capture EbA effectiveness and impact.

Gap analysis: Climate information and management

(1) Lack of quality and downscaled climate information to inform adaptation planning processes

The Rwanda Meteorological Agency (Meteo-Rwanda) is responsible for the provision of weather and climate services for various sectors in Rwanda. Projections of climate change in the country are hindered by the high heterogeneity (terrain, climate) and the lack of long-term meteorological data. The information base on the impacts/risks of future climate change is low, especially for climate impacts on ecosystems and their services. Changes in rainfall variability and increases in flood/landslide/soil erosion risk are perceived as the greatest risk, though increases in drought are also frequently mentioned.

There is a gap in generating timely, reliable and accurate environment and climate change data to inform decision making process and citizens (MoE 2017). Climate information was reported as being very general in nature, so further studies for sector-specific information were highlighted as being in great demand. The majority of respondents identified that their organisations have high or very high capacity for collection and analysis of ecosystem data. However, the quality and detail of information on vulnerability and adaptation were identified by the majority of informants (60%) as insufficient, especially at local level regarding ecosystem sensitivity and household vulnerability (Figure 3). Specific detailed and scientific information needs mentioned by informants included the impacts of increasing temperature on surface water quality and hydrological levels; the impacts of climate changes on crops, especially rice production; and the impacts of climate change on human health.

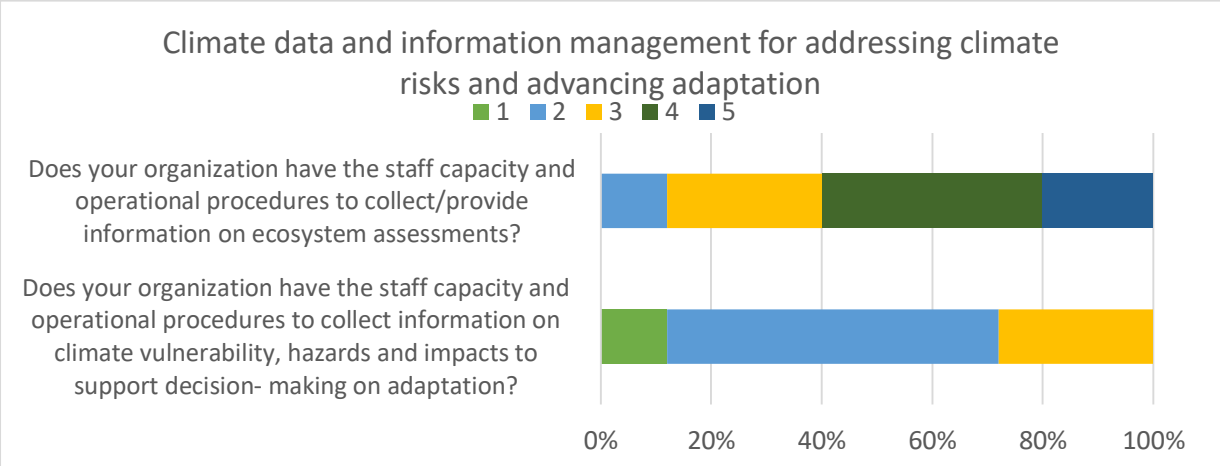

Figure 2. Results from the survey assessment at organizational level on knowledge gaps for planning and implementation of EbA. (Total 25 respondents - # respondents - 1=None; 2=Low; 3= Moderate; 4=High; and 5 = Full Capacity)

(2) Lack of an integrated knowledge platform on climate change and ecosystem assessment data

In Rwanda, Government agencies already have systems for collecting and managing data to meet specific needs. For example, REMA has the Climate Change Portal[35] and other initiatives on strengthening the climate services[36] with Meteo Rwanda are under way. However, a platform for

[35] REMA Climate Change Portal. See: https://www.rema.gov.rw/climateportal/?article176

[36] The Rwanda Climate Services for Agriculture project is a four-year initiative (2016-2019) that seeks to improve agricultural planning and food security management in the face of a variable and changing climate at both local and government levels. See: https://ccafs.cgiar.org/building-climate-services-capacity-rwanda#.XSvuBC2B3xQ

data sharing and analysis of climate change information and its implication for ecosystems does not currently exist. See Annex C for detailed analysis of the information gaps relevant for EbA in the Climate Change Portal and recommendations for addressing them.

(3) Insufficient research and information about the climate change impact on ecosystems, concerning ecosystems goods and services

Scientific research capacity in Rwanda is strong, however adaptation, in particular EbA, as a specific domain of research effort, is a new concept. Most research attention continues to be assessing the effects of climate change on specific sectors but not the ecosystems and biodiversity. Key research gaps include:

- Identification of the link between climate impact – ecosystems services – societal impacts
- Need of multidisciplinary research and action research to grasp the various dimensions of EbA
- How implementation of adaptation strategies really works (e.g. actors, mechanisms)
- Development of climate change scenarios with environmental, land-use, geographical and socio-economic aspects
- Synergies / contradictions between adaptation and mitigation actions

These are important areas for continuing research effort, particularly when results can be better linked to decision-making through user-oriented information products.

Gap analysis: M&E of adaptation process

Need for comprehensive metrics and monitoring systems to capture EbA effectiveness and impacts

Although Rwanda has a strong monitoring and reporting culture, monitoring on adaptation initiatives remains a challenge. Monitoring and Evaluation (M&E) for EbA adds additional complexity as ecological processes are difficult to be predicted under uncertain climate change scenarios. There are conceptual and methodological challenges. There is a high degree of uncertainty around climate change impacts, and climate adaptation itself is an new concept, with no universally accepted definition or agreed metrics. Currently, M&E frameworks have no specific focus on EbA and rely on a logical framework with indicators that are not specifically designed to track the effects of the intervention on climate risk management and/ or climate vulnerability.

There is a need to ensure that monitoring captures how effectively climate risks were being managed through climate-sensitive decision making and the use of climate information. They also featured indicators aimed at measuring adaptation outcomes, and indicators related to climate effects. It is also important to monitor environmental variables such as land use change. Key knowledge barriers affecting the monitoring and evaluation of EbA measures include:

- No baseline from which to evaluate the impacts of EbA measures
- The information needed to monitor and evaluate adaptation measures is scattered or difficult to assess

- Government agencies lack technical and human resources to monitor and evaluate adaptation strategies
- No clear indicators on which to assess the effectiveness or impact of EbA measures.

Key identified issue is that monitoring the primary data is not useful to government agencies but rather an interpretation of data, which is represented in a relevant indicator. Some respondents (50%) to the survey indicated that there are adequate management arrangements and adaptation processes are being measured. However, other respondents (40%) consider that there is not an adequate specialized area for monitoring and evaluation in their organisations (Figure 4).

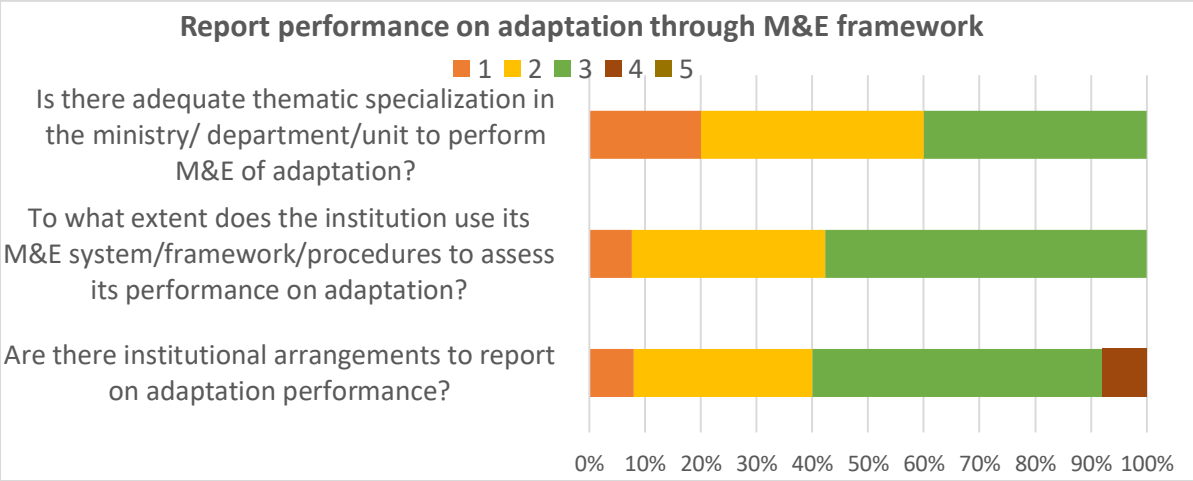

Figure 3. Results from the survey assessment at organizational level on knowledge gaps for planning and implementation of EbA. (Total 25 respondents - # respondents - 1=None; 2=Low; 3= Moderate; 4=High; and 5 = Full Capacity).

4.3 AT INDIVIDUAL LEVEL

Understanding adaptation in socio-ecological systems requires understanding of the degree and nature of observed and projected climate impacts, level of vulnerability and the adaptive capacity.[37] At individual level the assessment identified a number of knowledge gaps and limited planning and implementation experience on EbA measures. The gap analysis at individual level was performed on the basis of the identified knowledge needs for planning in implementing EbA (Table 3). The summary of results on knowledge needs, baseline and gaps is presented in Table 8.

Table 8. Summary analysis of EbA knowledge needs, baseline and gaps at individual level.

Knowledge category	Knowledge needs for EbA planning and implementation	Baseline	Knowledge Gap
Climate information and risk assessment	**Knowledge and experience in the use of methodologies for conducting climate risk and vulnerability assessment at local level:** Good understanding and using climate risk and vulnerability assessment serves as a basis for the identification and planning of adaptation measures at local level with ecosystem approach.	There is a vulnerability assessment conducted at a national level focusing on social, economic and physical aspects, with limited reference to ecosystems. However, at local scale, there is no institutionalized methodology to conduct climate vulnerability and risk assessment and inform project interventions.	Limited awareness and lack of analytical tools for climate vulnerability assessment at local scale relevant to EbA.
	In-depth understanding of the role of ecosystems to build resilience to climate change: A comprehensive grasp of the relationship between climate change – ecosystems – resilience of livelihoods.	There is a good understanding and information available on ecosystem state, however there is lack of knowledge regarding the key role of ecosystems and their services to reduce exposure and vulnerability of people.	Limited awareness on importance of ecosystem conservation in the context of climate change.
Technical Planning and implementation	**Good knowledge of designing EbA measures and best practices:** Knowledge of the state of	As EbA is a new concept adopted by Rwanda, at present, there is no systemized data on best practices for EbA	Lack of knowledge on best practices and principles for designing EbA measures.

[37] Field, et al. 2014. Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL, editors. 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY: Cambridge University Press.

	the art and principles for designing EbA measures.	planning and few relevant resources which such information are used.	
	Knowledge and use of tools for decision-making planning and implementation of EbA measures: Good understanding of variety of tools in adaptation planning and implementation support the identification of most appropriate adaptation options.	At present there is no evidence of the use of analytical tools to support decision-making for adaptation to climate change.	Limited awareness and use of tools for decision-making planning and implementation of EbA measures.
	Assessing the costs and benefits of EbA measures to generate evidence for the effectiveness of the approach.	At present there is no available information on the cost-effectiveness of current EbA projects in Rwanda.	Need for knowledge about the potential trade-offs and benefits between EbA and other engineered investments.

Gap analysis: Climate information and risk assessment

(1) Limited awareness and lack of analytical tools for climate vulnerability assessment at local scale relevant to EbA.

Climate vulnerability and risk assessments are widely used as a structured way to better understand potential risks, impacts and vulnerabilities both for natural and human systems. This is particularly relevant for EbA, in order to understand the boundaries and thresholds of ecosystems that could be exceeded in the future. Rwanda has developed a vulnerability index at national level, which provides information on provincial level regrading social and economic aspects. [38] However, the assessment provides limited reference to the vulnerability of ecosystems and specific local scale aspects. Therefore, the results of the study can only partially inform an EbA measure at especially at local level. There are isolated experiences of vulnerability assessments at local scale[39] but they are scattered and not institutionalized.

However, considerable knowledge gaps were observed at individual level, regarding the awareness and use of existing methodologies for climate vulnerability assessment at local scale. Specific knowledge needs include:

[38] REMA, 2015. Baseline Climate Change Vulnerability Index for Rwanda. URL: http://www.climdev-africa.org/sites/default/files/DocumentAttachments/Baseline%20climate%20change%20vulnerability%20index%20for%20Rwanda.pdf
[39] IFRC, 2003. Using the vulnerability and capacity assessment tool in Rwanda. URL: https://www.ifrc.org/Global/Case%20studies/Disasters/cs-vca-rwanda.pdf

- Vulnerabilities of regional/local natural systems and communities to current or projected climate related impacts, including hot spots;
- A comprehensive and institutionalised risk and vulnerability assessment methodology relevant for different levels (e.g. community level, sector level, landscape level)
- The influence of other drivers of global change, such as deforestation, unsustainable land-use; invasive species, and human population growth, on the ability of ecosystems underpinning EbA to sustainably deliver ecosystem services important for adaptation;
- Integrate effectively the local knowledge in risk and vulnerability assessment to inform adaptation strategies.

Figure 5 presents the results from the survey assessment regarding the knowledge gaps for experience with methodologies for conducting climate risk and vulnerability assessment. The majority of respondents (85%) convey that there is none to limited knowledge of methodologies for conducting such assessment. Only 15% of the respondents considered that their knowledge is moderate.

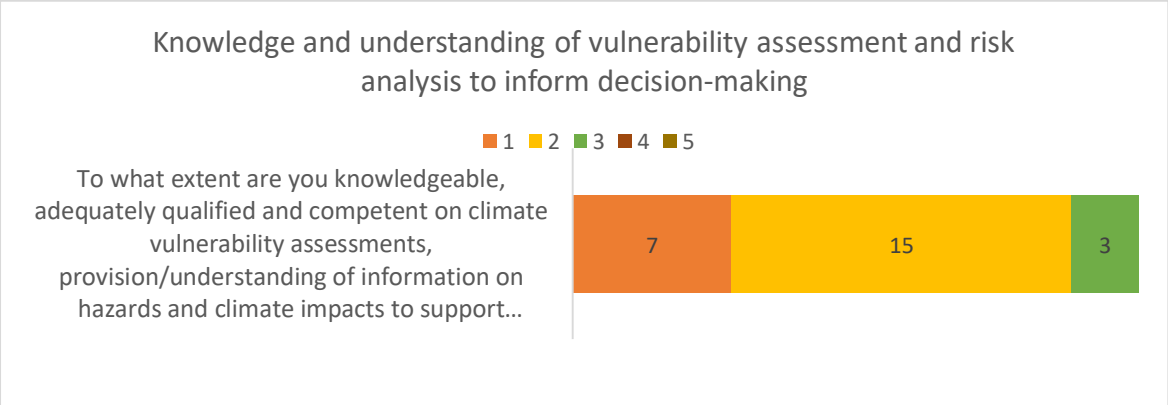

Figure 4. Results from the survey assessment at individual level on knowledge gaps for planning and implementation of EbA. (Total 25 respondents - # respondents - 1=None; 2=Low; 3= Moderate; 4=High; and 5 = Full Capacity).

(2) Limited awareness on importance of ecosystem conservation in the context of climate change.

Rwanda's economy is heavily dependent on sectors that are closely linked to the country's natural capital. Current and potential impacts of climate change on ecosystems are experienced very differently by the various sectors, communities and households across the country. Although Rwanda has a strong record and well-established methods for assessing the state of ecosystems, there is no adequate analysis on the link between climate change – ecosystems – resilience of livelihoods. The majority of the respondents (80%) consider that their knowledge and competence on analyzing impacts of climate change on the ecosystems and their role for people's livelihoods is note to low competence (Figure 6).

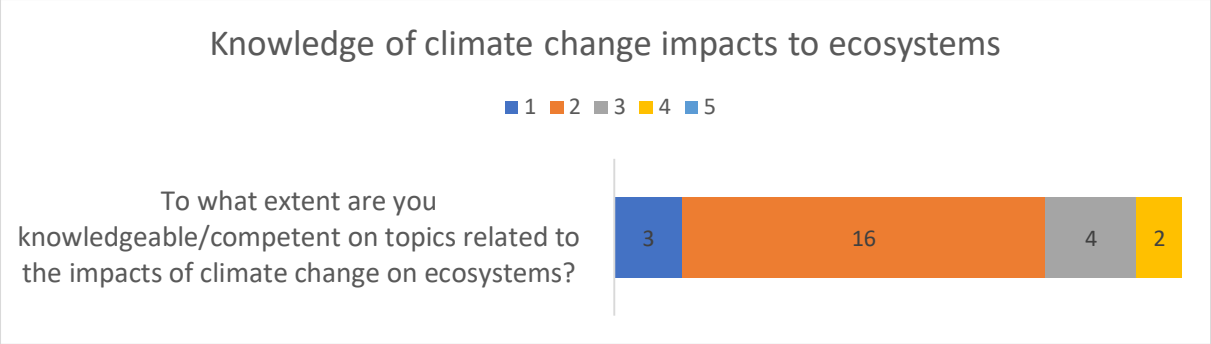

Figure 5. Results from the survey assessment at individual level on knowledge gaps for planning and implementation of EbA. (Total 25 respondents - # respondents - 1=None; 2=Low; 3= Moderate; 4=High; and 5 = Full Capacity).

Gap analysis: Technical planning and implementation

(1) Lack of knowledge on best practices and principles for designing EbA measures.

The concept of EbA is relatively new for Rwanda and therefore there are limited experiences to generate lessons learned and best practices for planning and implementation of such measures. There is also lack of knowledge on EbA successful experiences and best practices in the African region or worldwide. Figure 7 presents the results from the survey assessment on analyzing the level of knowledge and capacities on developing adaptation solutions with EbA approach. Although the majority of participants indicated that they have good understanding of the benefits of ecosystem services to humans (80% of the respondents) and that they have moderate level of capacity on adaptation (80% of the respondents), they indicated none or limited knowledge of Ecosystem-based Adaptation and relevant measures. Knowledge of the state-of-the-art and principles for designing EbA measures is a prerequisite for the design of effective EbA measures.

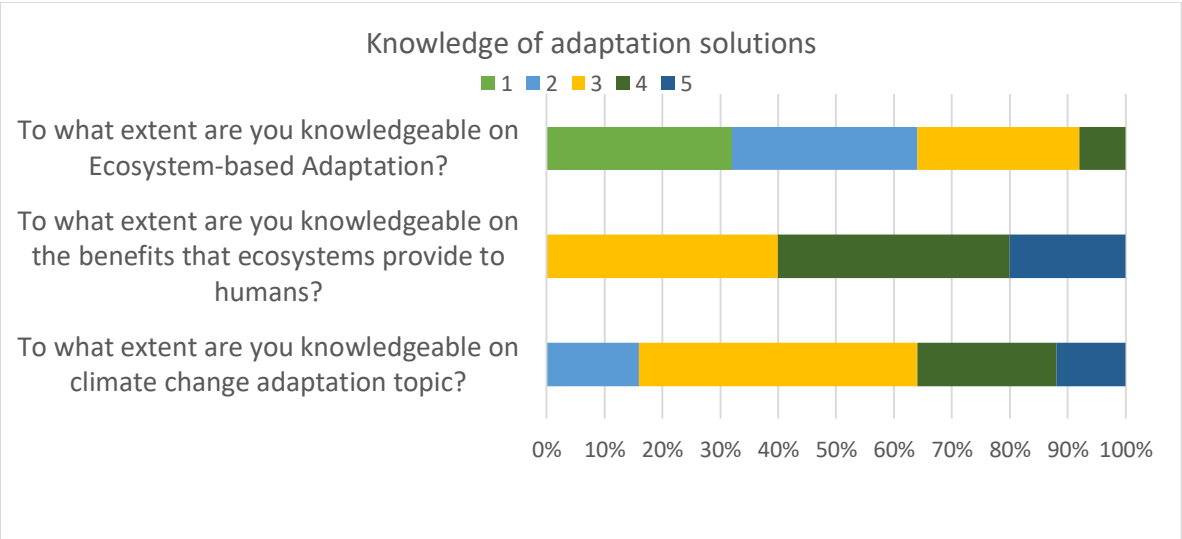

Figure 6. Results from the survey assessment at individual level on knowledge gaps for planning and implementation of EbA. (Total 25 respondents - # respondents - 1=None; 2=Low; 3= Moderate; 4=High; and 5 = Full Capacity).

(2) Limited awareness and use of tools for decision-making, planning and implementation of EbA measures.

At the stage for adaptation planning, it needs to be determined how best to address the identified climate risks, identify a range of adaptation options and select the preferred options with focus on EbA measures using a specific criterion. Often these processes need to be supported by tools for decision-making and planning in order to consider all available information on climate change, economic, social and environmental aspects. At present in Rwanda, there is a lack of knowledge and use of such tools, which often undermines the process for planning and design of the adaptation measures. In particular for EbA measures, key criteria for the prioritization is its cost-effectiveness and co-benefits. There criteria are often overlooked and EbA measures receive little attention in planning processes.

(3) Need for knowledge about the potential trade-offs and benefits between EbA and other engineered investments.

The valuation of EbA measures is the process of describing, measuring and analysing how the benefits, costs and impacts arising from the implementation of ecosystem-based approaches to adaptation are generated, received and perceived. Such evidence is essential, but currently insufficient to advocate for the cost-effectiveness of EbA in Rwanda and in the African region in general. Therefore, EbA solutions continue to be underestimated when compared to engineered options. There is a knowledge gap of the potential trade-offs and benefits between EbA and other engineered investments and the effects when these approaches are combines. Additional evidence of the effectiveness of EbA measures compared to other adaptation options is required to inform decision-makers and spur wider consideration and implementation. In spite of the wide range of methodologies for cost-benefit analysis, knowledge of their purpose and experience in using them is insufficient in the country. Specific knowledge and information needs include:

- Studies providing an analysis of two comparable sites, such as a ‘before and after’ situation or between sites with and without the implementation of adaptation measures.
- Environmental and social costs and benefits in monetary (quantifiable data) and non-monetary terms (i.e. cultural values, human health and ecosystem services).

5. CONCLUSIONS AND RECOMMENDATIONS TO CLOSE THE KNOWLEDGE GAPS

5.1 RECOMMENDATIONS TO ADDRESS THE KNOWLEDGE GAPS

To close the identified knowledge gaps on EbA it is needed the generation of specific **knowledge needs** to support processes for planning and implementation of such adaptation measures. Key information needs include:

AT ENABLING ENVIRONMENT LEVEL

Given that background and in the search of an integrated approach to development and adaptation in Rwanda, EbA has the capacity to play an important role for achieving this by mixing rather than isolating ecosystem management, climate change adaptation, and disaster risk reduction.[40] Therefore, EbA needs better attention at political agenda setting level, and needs mainstreaming at the climate, development and natural resource management policy and practice levels. Mainstreaming EbA at policy level enhances systematic integration of adaptation into ecosystem management and development activities and to ensure necessary financial, human, technological and knowledge supports.[41&42] In order to unlock the potentials of EbA, it is key to make interventions at the policy making and planning stages across scales (Table 9).

Table 9. Recommendations to close the identified knowledge gaps for enabling environment.

Knowledge category	Knowledge gap	Recommendations to close the gap
Policy making and mainstreaming	Inadequate uptake and use of knowledge for climate adaptation policy with EbA approach	Conduct multi-stakeholder awareness raising and capacity building between academia and policy-makers to identify specific knowledge needs for policy planning and opportunities for effective uptake of climate change knowledge.
	Lack of mainstreaming of EbA approach in sectoral policies	**Promotion of landscape approach which integrates land use-related EbA measures as a coss-sectoral articulation:** Given that it was identified the landscape management policy as a potential entry point for EbA mainstreaming, knowledge on land-use planning and the role of ecosystems and their services for increasing the resilience of livelihoods is essential. Nevertheless, this is a complex topic and integrated

[40] Doswald, N, R Munroe, D Roe, A Giuliani, I Castelli, J Stephens, I Möller, T Spencer, B Vira, and H Reid, (2014). Effectiveness of Ecosystem-Based Approaches for Adaptation: Review of the Evidence-Base. Climate and Development 6 (2). Taylor & Francis: 185–201. doi:10.1080/17565529.2013.867247

[41] Huq, N. (2016). Institutional Adaptive Capacities to Promote Ecosystem-based Adaptation (EbA) to Flooding in England. Int. J. Clim. Chang. Strateg. Manag., 8, 212–235.

[42] The World Bank (2009). Convenient Solutions to an Inconvenient Truth: Ecosystem based Approaches to Climate Change; World Bank: Washington, DC, USA.

		methods should be considered in the planning for such EbA measures.

AT INSTITUTIONAL LEVEL

The identified knowledge gaps at institutional level provide evidence that inadequate technical capacity coupled with low integration of research evidence leads to, what is perceived as, poor strategic planning and ineffective polices. It is therefore of greatest importance to promote capacity building and strengthen the vertical and horizontal communication between institutions to co-create relevant climate information and inform EbA solutions. Table 10 outlines a summary of recommendations to address the identified knowledge gap and unlock the potential of EbA.

Table 10. Recommendations to close the identified knowledge gaps at institutional level.

Knowledge category	Knowledge Gap	Recommendations to close the gap
Climate information and management	Lack of quality and detail downscaled climate information to inform adaptation and planning processes.	Methods to handle results from multiple scenarios for future development and to harmonise climate projections for adaptation on the local level without prescribing data. It requires the integration of territorial information needs, especially related to the impacts and risks of climate change, both in the research guidelines within universities and in the thematic priorities of the main sources of public research funds.
	Lack of an integrated knowledge platform on climate change and ecosystem assessment data	There is a need to integrate EbA information in the Rwanda Climate Change Portal administered by REMA with the participation of multiple relevant actors to inform and disseminate the existing information on EbA among all sectors.
	Insufficient research and information about the climate change impact on ecosystems, concerning ecosystems goods and services	Need to activate coordination mechanisms and methodologies, integrated in the guidelines and research funds of universities and the State, for the coproduction of knowledge between different actors (public sector in different levels and portfolios, academia, civil society and private sector). The transfer and integration in the decision-making processes must be encouraged.
M&E of adaptation process and enhanced climate resilience	Need for comprehensive metrics and monitoring systems to capture EbA processes and impacts.	The capacity to monitor, assess, manage and report the effects of climate change and their interaction with other pressures: Adequate investments for implementation have to be warranted, especially for long-term monitoring. Training for site managers and administration is essential to be prepared for changes resulting from climate change. Capacity building should

		also include technical and advisory services for financing and realising projects related to climate adaptation and biodiversity conservation. Need for technical training at all levels and sectors of the Government regarding the application, measurement, analysis and interpretation of adaptation indicator systems. **Information for the construction of monitoring and evaluation indicators**, and for the development of baselines. These allow to measure and monitor the impact of the implementation of public policies and climate actions on the vulnerability (social, economic, institutional, ecological) of the country and local territories.

AT INDIVIDUAL LEVEL

Technical capacity and knowledge at individual level is essential to support processes and decision-making at local, sub-national and national scale. Awareness raising, capacity-building and training of trainers on methods and tools for EbA planning and implementation is essential, however it has to be specifically designed to address the identified knowledge gaps. Therefore, it is proposed that the capacity-building activities focus on some of the following topics: (1) Methodology for evaluation of climate risk and vulnerability to climate change tailored to inform EbA planning; (2) Tools to support planning processes and decision making for the implementation of appropriate EbA measures; (3) Monitoring and evaluation of EbA measures; and (4) Guidance for land use-related EbA measures with landscape approach.

Table 11 outlines a summary of recommendations to address the identified knowledge gap and unlock the potential of EbA.

Table 11. Recommendations to close the identified knowledge gaps at individual level

Knowledge category	Knowledge Gap	Recommendations to close the gap
Climate information and management	Limited awareness and lack of analytical tools for climate vulnerability assessment at local scale relevant to EbA.	Training on methodologies for the evaluation of vulnerability with focus on understanding the link between climate change, healthy ecosystems and their potential to enhance resilient livelihoods. Such methodology needs to be tailored to the local context in order to provide rigorous results and inform effective EbA solutions. Key tested methodologies at local level with relevance to EbA include: (1) CRISTAL and (2) Climate Risk Assessment for EbA (see Box 5).

	Limited awareness on importance of ecosystem conservation in the context of climate change.	Dedicated action should be taken to raise awareness of the local effects of climate change and the need for adaptation. The benefits of ecosystem-based adaptation through climate-adapted management in protected areas should be explored and illustrated in this regard.
	Lack of knowledge on best practices and principles for designing EbA measures.	It will be beneficial to document experiences from current EbA practices implemented in Rwanda and include technical details in the Rwanda Climate Change Portal. Additional resource is the platform PANORAMA, which provides a catalogue with EbA solutions from around the world (see Box 6).
	Limited awareness and use of tools for decision-making, planning and implementation of EbA measures.	Use a stepwise approach for planning and implementation of EbA approach. A suitable tool to support the decision-making and planning process is the Adaptation, Livelihoods and Ecosystems (ALivE) EbA Planning Tool developed by UN-Environment (see Box 7).
	Need for knowledge about the potential trade-offs and benefits between EbA and other engineered investments.	It is essential to know how to build a business case to convince planners and decision makers that EbA is a cost-effective approach. Therefore, a training on economic valuation methods is required (e.g. cost-benefit methods) to enable the better understanding of the value of benefits from EbA measures and preparing a compelling business case. A key resource to consult includes: Emerton, L. (2017) *Valuing the benefits, costs and impacts of ecosystem-based adaptation measures: a sourcebook of methods for decision-making*.

Box. 5 – Tools for EbA vulnerability and risk analysis for EbA at local level

Tool 1: The Community-based Risk Screening Tool - Adaptation and Livelihoods (CRiSTAL)
Website: http://www.iisd.org/cristaltool/
Organisation: UN-Environment
Description: CRiSTAL is a project-planning tool to help users identify and prioritize climate risks and identify livelihood resources most important to climate adaptation and uses these as a basis for designing adaptation strategies.

Tool 2: Climate Risk Assessment for EbA
Website: https://www.adaptationcommunity.net/wp-content/uploads/2018/06/giz-eurac-unu-2018-en-guidebook-climate-risk-asessment-eba.pdf
Organisation: GIZ / EURAC
Description: The Guide provides a standardised approach to climate risk assessments in the context of EbA- planning by following the well-established, modular methodology and using an illustrative application example.

Box. 6 – Platform for EbA solutions

PANORAMA: Ecosystem-based Adaptation Solutions
Website: https://panorama.solutions/en/portal/ecosystem-based-adaptation

Box. 7 – Tools for EbA planning and Implementation

Tool: Adaptation, Livelihoods and Ecosystems (ALivE) EbA Planning Tool
Website: http://www.iisd.org/project/ALivE
Organisation: UN-Environment

Description: ALivE is a computer-based planning tool designed to support practitioners in organizing and analyzing information to plan effective EbA options within a broader EbA planning process. It is a rapid qualitative assessment technique that can be applied in any ecosystem types and with relatively limited technical knowledge.

For more information on the tool see Annex 3.

5.2 CONCLUSIONS

This study shows the importance in assessing the knowledge gaps on EbA in order to identify suitable solutions. Various factors and conditions help explain the identified gaps and limitations in the knowledge available for EbA in Rwanda. By way of example, and without intending to be exhaustive, it can be pointed out the budgetary limitations in the matter of subsidies for research on climate change, with the consequent difficulty of access to adequate financing to carry out this type of studies; the difficulties to interact between government, productive and scientific sector actors.

In order to enhance the enabling environment for the mainstreaming of EbA in policy making in Rwanda we need to start:

Investing in human capacity development. Critical capacity enhancement needs include (i) how to quantify climate impacts on ecosystems and people and use of participatory and more inclusive approaches in multi scale adaptation planning such as EbA approach.

Strengthening research-policy linkages. National and international research institutions need to strengthen partnership with government ministries so that government information needs are reflected in their research agendas and scientific evidence on climate change impacts and the effectiveness of EbA is used to inform policy planning and decision-making. In order to ensure research uptake, it is recommended that policy makers should be part of the research process, rather than waiting for evidence at the receiving end, so that they can own the evidence generated and integrate it in the policy process.

Strengthening vertical and horizontal communication through multistakeholder knowledge action platforms. This research shows that multistakeholder knowledge platforms across scales have the following benefits (i) improved communication between national and local

stakeholders; (ii) increased awareness on the need to adapt and harmonize adaptation messages among actors; (iii) mechanism for skills improvement among extension staff, (iv) co-creation of knowledge on EbA though national processes such as the development of the National Communication for Climate Change.

ANNEX 1 – SURVEY TEMPLATE FOR THE ASSESSMENT OF KNOWLEDGE GAPS AND NEEDS ON EBA.

Dear Participant, this survey has the objective to collect information regarding knowledge and capacities for planning and managing projects and activities which integrate Ecosystem-based Adaptation. The results of this survey will be used for the preparation of a Gap Analysis report to highlight what are the current needs for capacity building and knowledge sharing at individual and organizational level. You may opt to keep the survey anonymous.

Thank you very much for your participation.

1. General information

1.1 Name:

1.2 Sex: _

1.3 Profession:

1.4 Institution:

1.5 What is your responsibility?

1.6 On which of the following topics do you work:

___Ecology___Biology___Agriculture___Water resources___Forestry___Infrastructure

___Economy___Social aspects___Health___Nature conservation___Environmental

engineering___Climate change___Others: please state what other topics you work on:

2. Ecosystem based Adaptation

2.1 Have you heard before about Ecosystem-based Adaptation (EbA) measures?

2.2 In what context have you learned about the EbA measures?

2.3 Have you been engaged in activities relevant to planning/implementing EbA measures?

Scoring system to assess the capacity (scale of 1-5) *1 - Very low (capacity) or none | 2 - Low (capacity) | 3 - Moderate (capacity), with less than 50% compliances | 4 - High (capacity), 75% compliance | 5 - Full (capacity), 100% compliance*						Comments / Recommendations for improvement
	1	2	3	4	5	
KNOWLEDGE AND SKILLS						
Dimension 1: Individual						
To what extent are you knowledgeable on climate change adaptation topic?						
To what extent are you knowledgeable on the benefits that ecosystems provide to humans?						
To what extent are you knowledgeable on Ecosystem-based Adaptation?						
To what extent are you knowledgeable/competent on topics related to the impacts of climate change on ecosystems?						
To what extent are you knowledgeable, adequately qualified and competent on climate vulnerability assessments, provision/understanding of information on hazards and climate impacts to support decision- making on adaptation?						
To what extent are you knowledgeable, adequately qualified and competent in prioritizing adaptation measures for the sector you work on (for example: using cost-benefit analysis)?						
To what extent is the staff in your organization/agency knowledgeable, adequately qualified and competent on **climate vulnerability assessments**, **provision/understanding of information on hazards and climate impacts** to support decision- making on adaptation?						
To what extent is the staff in your organization/agency knowledgeable, adequately qualified and competent on **ecosystem assessment** to support decision- making on adaptation?						
To what extent is the staff in your organization/agency knowledgeable, adequately qualified and competent on methods for ecosystem conservation to support decision- making on adaptation?						

What additional skills will be needed to perform effectively? What are the capacity strengths and gaps?						
Dimension 2: Institution						
To what extent can your organization manage climate change adaptation projects?						
Does your organization have the staff capacity and operational procedures to collect information on climate vulnerability, hazards and impacts to support decision- making on adaptation?						
Does your organization have the staff capacity and operational procedures to collect/provide information on ecosystem assessments?						
Is there clarity of mandate, vision and mission within your organization/agency with regard to adaptation planning?						
Is there clarity of mandate, vision and mission within your organization/agency with regard to ecosystem conservation?						
Is there clarity of mandate, vision and mission within your organization/agency with regard to Ecosystem-based Adaptation?						
Does your organization/agency have the staff capacity and operational procedures to ensure appropriate priorities for adaption are integrated in the sector in which you work?						
Dimension 3: Enabling environment						
Does the organization/agency have a mandate to manage and provide information on climate vulnerability, hazards and impacts or ecosystem assessments to support decision-making on adaptation?						
What additional skills will be needed to perform effectively? What are the capacity strengths and gaps?						
PLANNING AND IMPLEMENTATION						
Dimension 1: Individual						
To what extent is the staff knowledgeable, adequately qualified and competent in planning and implementing adaptation and disaster risk reduction responses, leveraging climate finance, addressing climate risks and opportunities, and appraising and identifying adaptation options? Please specify in the comments section						
Dimension 2: Institution						

Is there sufficient and appropriate expertise on community-based adaptation/nature conservation and management approaches and gender mainstreaming in the organization? Please specify in the comments section						
Dimension 3: Enabling environment						
To what extent is the staff in your organization/agency knowledgeable, adequately qualified and competent on **ecosystem assessment** to support decision- making on adaptation? Please specify in the comments section						
What additional skills will be needed to perform effectively? What are the capacity strengths and gaps?						
COORDINATION AND PARTNERING						
Dimension 1: Individual						
To what extent are you knowledgeable, adequately qualified and competent in coordinating and partnering with stakeholders at national and subnational levels on ecosystem-based adaptation?						
To what extent is the staff in your organization knowledgeable, adequately qualified and competent in coordinating and partnering with stakeholders at national and subnational levels on ecosystem-based adaptation?						
Dimension 2: Institution						
To what extent does your organization/agency coordinate and collaborate with actors and stakeholders at national and subnational levels for adaptation planning and implementation?						
To what extent does your organization/agency coordinate and collaborate with actors and stakeholders at national and subnational levels for nature conservation planning and implementation?						
To what extent is stakeholder engagement and partnership building a priority for the organization/agency in supporting implementation of adaptation/nature conservation priorities?						
Does the organization/agency have the staff capacity and operational procedures for mobilizing and engaging stakeholders and partners?						
Dimension 3: Enabling environment						
To what extent do the policy frameworks (climate change strategies, policies) and existing institutional arrangements support the organization's						

role in engagement with stakeholders on climate change adaptation/nature conservation? Please specify in the comments section.						
Is there political commitment to ensure that partners and stakeholders have adequate access to the organization's information and knowledge necessary to support the implementation of the national adaptation priorities? Please specify in the comments section.						
Is there political commitment to ensure that partners and stakeholders have adequate access to the organization's information and knowledge necessary to support the implementation of the nature conservation priorities? Please specify in the comments section.						
Is the organization/agency part of a national coordination body, network or partnership to support climate change adaptation?						
What additional skills will be needed to perform effectively? What are the capacity strengths and gaps?						
MONITORING AND EVALUATION						
Dimension 1: Individual						
To what extent is the staff knowledgeable, adequately qualified and competent in M&E of programs and projects, monitoring of financial resources allocated to adaptation and investigation of impact of adaptation policies?						
To what extent is the staff knowledgeable, adequately qualified and competent in M&E of programs and projects, monitoring of financial resources allocated to nature conservation and investigation of impact of such policies?						
Dimension 2: Institution						
Are there institutional arrangements to report on adaptation performance?						
To what extent does the institution use its M&E system/framework/procedures to assess its performance on adaptation?						

Is there adequate thematic specialization in the ministry/ department/unit to perform M&E of adaptation?						
Dimension 3: Enabling conditions						
Is there an existing M&E system/framework/procedures for adaptation?						
Is there an existing M&E system/framework/procedures for nature conservation? Please specify in the comments section						
Does the organization have a mandate for M&E of adaptation?						
What additional skills will be needed to perform effectively? What are the capacity strengths and gaps?						

ANNEX 2: PARTICIPANTS IN THE MUSANZE RETREAT

ATTENDENCE LIST: TRAINING AND CONSULTATION WORKSHOP ON ECOSYSTEM-BASED ADAPTATION IMPLEMENTATION PROCESS IN RWANDA

VENUE: FATIMA HOTEL, MUSANZE DISTRICT

DATE: 13/12/2018

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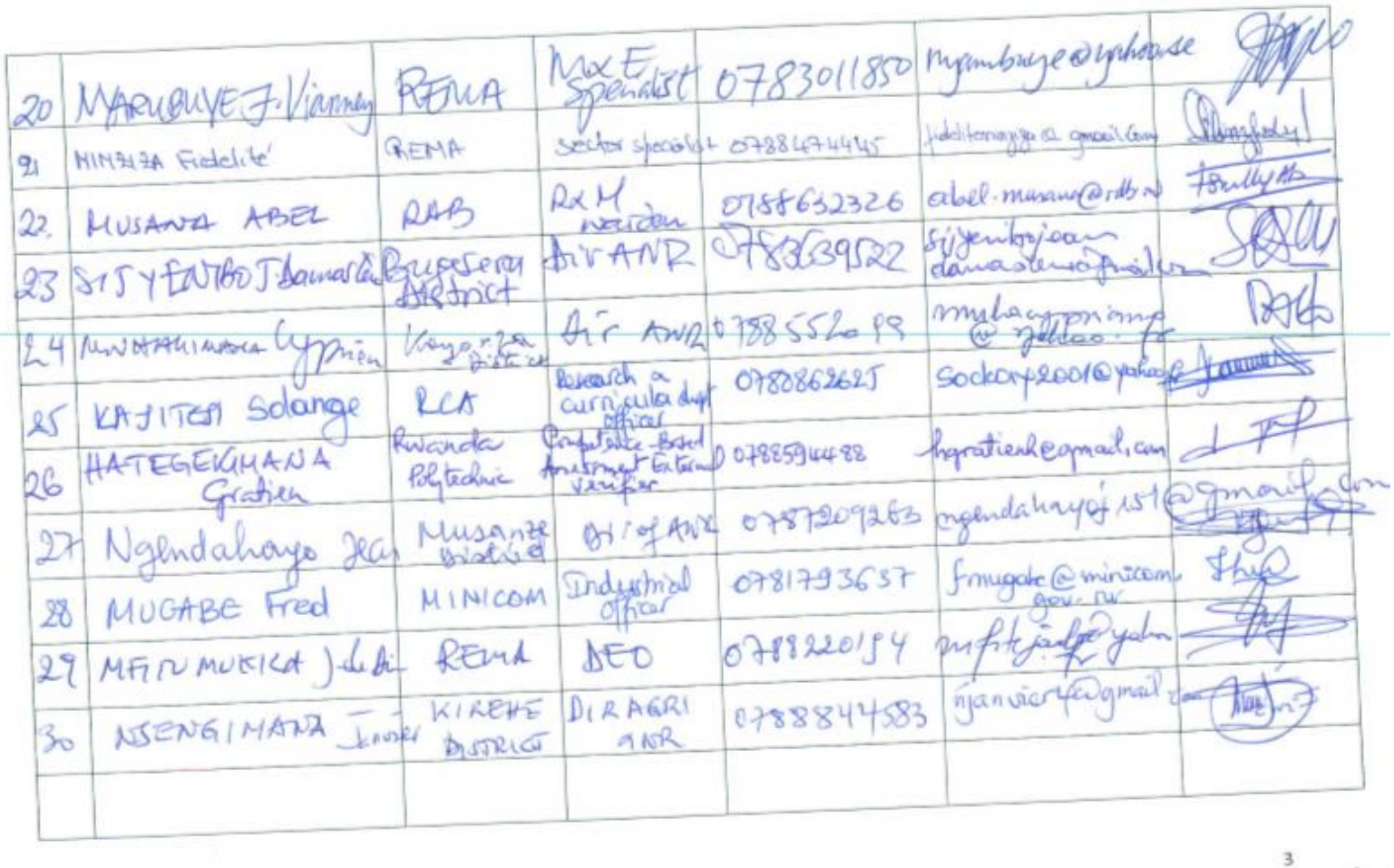

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ANNEX 3 – IDENTIFICATION OF INFORMATION GAPS IN THE RWANDA CLIMATE CHANGE PORTAL WITH REGARDS TO ECOSYSTEM-BASED ADAPTATION

Information gaps	Recommendation
Section on Climate Science	
This section presents definitions relevant to climate change and general information on GHG emissions and climate vulnerability with only limited reference to context specific climate projections and potential impacts in Guyana. There is as well lack of information regarding prioritized sectors in the country and identified mitigation and adaptation measures. There is lack of information regarding Ecosystem-based Adaptation neither at a conceptual not at practical levels.	The section will benefit from overall revision and restructuring. It is important that this section has the objective to provide summarized information for Rwanda's climate change profile (for example see the Climate Risk Profile - https://www.climatelinks.org/resources/climate-risk-profile-rwanda or Climate Knowledge Portal - https://climateknowledgeportal.worldbank.org/country/rwanda) It is suggested that this section considers including the additional sub-sections and information relevant for them: - Observed climate trends and impacts (per sector and/or ecosystem, when possible) - Climate projections and potential impacts (per sector and/or ecosystem, when possible) - Adaptation actions – in this subsection it can be included Ecosystem-based Adaptation. - Mitigation actions Information for these sub-sections can be accessed from the Third National Communication on Climate Change, Rwanda Risk Atlas. For each of these sub-sections it can be included additional sources of information for the reader to access more detailed information. Especially relevant to improve the knowledge dissemination on Ecosystem-based Adaptation: - Have a separate section under the section on Adaptation actions, where can be included the definition and principles of EbA. - Include additional resources on the topics - Include the list with the titles of the selected Mater Thesis - Include information regarding the state of ecosystems in Rwanda - Include examples of EbA measures that have been implemented in Rwanda through the GEF project
Section on Policies and Strategies	
This section at the moment of evaluation is empty and there are no policies included.	The section will benefit from including the relevant policies and strategies on climate change and ecosystem management in Rwanda. It is very important to include a paragraph describing the priority sectors for adaptation and mitigation, as well as to describe very briefly which are the most important documents that are guiding the climate change agenda in Rwanda.
Section on Resources	
This section provides limited list of resources and is not categorized per topics	This section will benefit from including sub-sections and a search tool to facilitate the reader. It is highly recommended to include a section specifically on resources regarding EbA and available tools to support planning and implementation. Proposed sub-sections may include:

therefore it is difficult for the readers to find information.	- Climate science – Include national documents but also latest IPCC report, among others - Mitigation – Include documents relevant to planning mitigation actions, if possible relevant to Rwanda context but also international guidelines - Adaptation – Same as for mitigation section but also include the suggested resources on Ecosystem-based Adaptation – good sources for finding resources on EbA include: o IIED: https://www.iied.org/ecosystem-based-approaches-climate-change-adaptation o International EbA Community of Practice: https://www.adaptationcommunity.net/publications/?topic=ecosystem-based-adaptation

ANNEX 4 - TOOLS FOR EBA-RELATED PLANNING AND MANAGEMENT

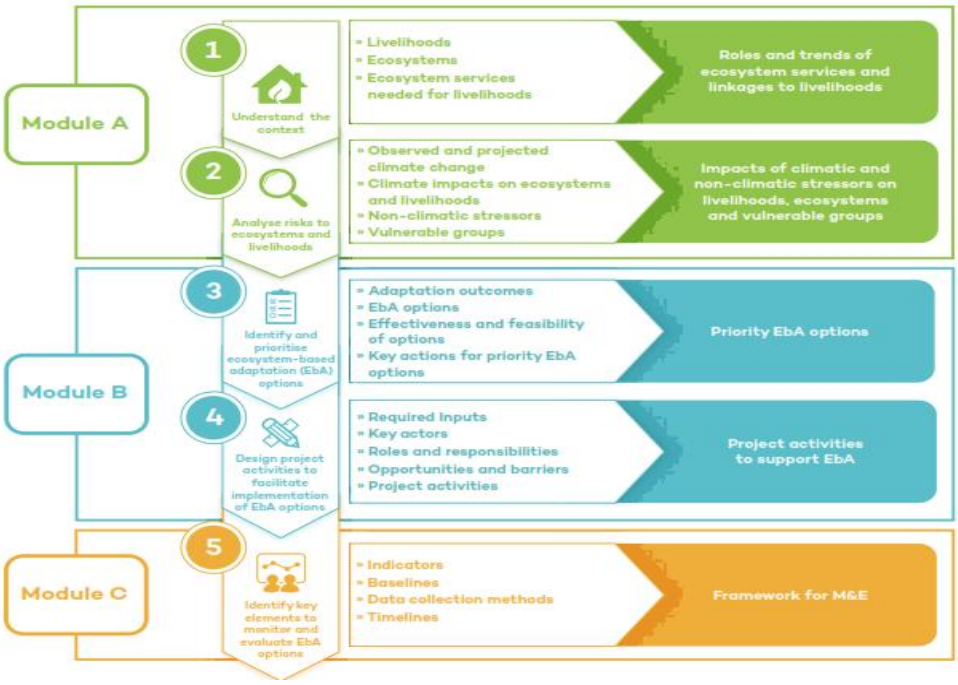
Many tools and methods now exist for EbA research, ranging from those that focus on ecosystem valuation and assessment, vulnerability and risk analysis to adaptation planning and decision-support. Multiple tools may be combined to design and carry out an assessment related to EbA and the particular techniques employed can vary from case to case. Many of the existing tools are rather general, therefore they can be applied to different ecosystem types and contexts. Different tools perform different functions and are useful at different steps in the research process.

The EbA Planning Tool 'ALivE: Adaptation, Livelihoods and Ecosystems'

'ALivE' aims to provide practitioners with a systematic process to identify and prioritise EbA options based on a context-specific analysis of ecosystems, livelihoods and climate change, in a broader effort to encourage greater uptake of effective EbA approaches. The tool and associated user manual seek to assist with the design, implementation and monitoring of EbA measures to address risks from climate variability to vulnerable people and their livelihoods, by using ecosystems and ecosystem services. Through a structured analysis, users identify and understand the climate vulnerability of livelihoods and people and how critical ecosystems and ecosystem services can reduce these vulnerabilities and improve adaptive capacities. Moreover, the user will understand how climate change and non-climatic stressors will affect the supply of ecosystem services that provide critical support for adaptation. This will facilitate the selection of options for restoring, conserving and managing ecosystems to reduce peoples' vulnerability to climate change and build ecosystem resilience.
ALivE specifically aims to enable users to:

1. Understand and analyze linkages among ecosystems, livelihoods and climate change.
2. Identify and prioritize EbA options for community and ecosystem resilience.
3. Design project activities that facilitate implementation of priority EbA options.
4. Identify key elements and indicators for a monitoring and evaluation framework.

The primary users of the tool are expected to be project managers and practitioners working at the local level designing or implementing an EbA intervention. The users will work closely with a range of stakeholders, including community members, local authorities, non-government organisations and policy-makers. Their engagement through participatory processes provides the necessary information that will be entered into the tool and validation of the results of the analysis.



ALivE is developed under the GEF-funded 'Enhancing Capacity, Knowledge and Technology Support to Build Climate Resilience of Vulnerable Developing Countries (EbA South) Project' in partnership with IISD and IUCN. EbA South is implemented by UN Environment and executed by the National Development and Reform Commission of China (NDRC), through the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences. For more information: http://www.iisd.org/project/ALivE

ANNEX 5 – LIST WITH SURVEY RESPONDENTS

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6	Marie-Laetitia Busokeye	REMA
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9	Jean Rukwaya	REMA
10	Venant Nzibaza	University Rwanda
11	Felicien Nsabukunze	METEO
12	Rongin Ntazinba	Ngororero District
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14	Samuel	University Rwanda
15	Abel Musana	RAB
16	Fred Mugabe	MINICOM
17	Jean Nsengimana	Kirehe District
18	Aimei Musabwamana	ACNR
19	Jean Sijyenibo	Bugasera District
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21	Thomas Gakwavu	RAB
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24	Charles Mugabo	Consultant
25	Marshall Banamwana	Ministry of Environment