WORKING PAPER

CLIMATE SMART AGRICULTURE IN UGANDA

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Climate Smart Agriculture In Uganda

1. Introduction

Population growth, rapid urbanization, and dietary changes are placing tremendous pressure on food systems, particularly in developing countries. Based on current income, population and consumption trends, the Food and Agriculture Organization of the United Nations (FAO) estimates that, by 2050, some 50 percent more food will be needed to satisfy the extra demand compared to 2013 (Alexandratos and Bruinsma, 2012). The challenges posed by rapid growth in food demand are intensified by the effects of climate change on agricultural systems, including crops, livestock, forestry and fisheries.

Climate change effects will vary by region, country and location and will affect people differently depending on their vulnerability and capacity to adapt. Some areas are expected to become drier and more drought-prone, while others will witness more intense rains or altered rainfall patterns as well as mean temperature changes.

In Uganda, climate projections based on the Global Climate Models (GCMs) used in the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) indicate the possibility of an increase in the country's near-surface temperature in the order of +2°C in the next 50 years, and +2.5°C in the next 80 years using Representative Concentration Pathway (RCP) 4.5 scenarios (Zinyengere *et al.,* 2016). They also predict a slight decrease in total annual rainfall in most of the country, with slightly wetter conditions over the west and north-west under both RCP 4.5 and RCP 8.5 scenarios. These events threaten food production and the livelihoods of food producers, particularly those with the weakest adaptation capacity who are too often located in areas exposed to the most severe changes. Moreover, for agricultural systems to sustainably contend with climate change, their contribution to greenhouse gas (GHG) emissions must also be addressed. Therefore, this added variability changes the conditions in which agriculture is practiced and requires context and site-specific strategies and responses.

Climate –Smart Agriculture (CSA) technologies and practices offer opportunities for addressing climate change challenges, as well as for economic growth and development of the agriculture sector. Climate-smart agriculture (CSA), a concept developed by the FAO, is an approach to creating the technical, policy and financial conditions for achieving sustainable agricultural development that promotes food security in the context of climate change (FAO, 2014). It integrates the three dimensions of sustainable development (economic, social and environmental) by targeting the challenges of food security, ecosystem management and climate change at the same time. It consists of three main pillars: Sustainable increase in agricultural productivity and income; - Adaptation and strengthening of resilience to climate change; - Reduction of greenhouse gas emissions and/or absorption where possible.

A range of CSA technologies/practices are being promoted and implemented across the different agricultural systems and agro-ecological zones in Uganda. However, implementation of the approach both in higher institutions and communities is still limited due to a mosaic of factors including the inputs, knowledge capacity among others. Therefore, this report analyzes explicitly the existing

practices/technologies, related policies, gaps (training needs) and its adoption in the Universities' academic programs of Uganda.

During the meeting involving 21 representatives from nine (9) African countries held in Cotonou, Benin at RUFORUM's Triennial conference on 12-13th Dec 2021, a review was initiated to provide a baseline information on preferred climate-smart agriculture (CSA) practices and existing programmes in institutions of higher learning in the represented countries that included Kenya, Zambia, Ethiopia, Democratic republic of Congo, Benin, Burundi, Uganda, Ghana and Zimbabwe. Table 1 depicts the prioritization of the eight (8) clustered areas as identified by the different countries during the Cotonou meeting. About 77.8% of the countries proposed Land Restoration and Agroforestry system (LRA) as the priority area number one, except Uganda and Ghana who ranked it priority 2 and 3; respectively. Crop diversification CD, Water Harvesting and Management-Small scale irrigation (WHM) and Livestock and Aquaculture Management-LAM, were ranked second for Ethiopia, Benin, Burundi and Ghana; Water Harvesting and Management-Small scale irrigation (WHM) was ranked second by Zambia and Kenya. The third priority include ISFM for the 33.3% of the countries followed by CD (22.2%), LAM, MVM and PHM were proposed by 11.1% of the countries. ISFM was not proposed as priority CSA for Zimbabwe only. It was ranked number 1 for Ghana, third for Ethiopia, DRC and Burundi. WHM was also ranked 4 in Burundi. LAM was only ranked third by Zambia. MVM was only proposed and ranked third priority in Benin. A relatively high number of countries (44.4%) ranked ISFM as priority number 4, and Sustainable Bio-Energy-SBE was prioritized by only DRC and Zimbabwe.

TABLE 1: Clustered priority areas for the targeted African countries

Clusters	Zambia	Ethiopia	Kenya	DRC	Benin	Burundi	Uganda	Ghana	Zimbabwe
1) LRA	1	1	1	1	1	1	2	3	1
2) CD		2	3		2	2	1	2	3
3) ISFM	4	3	4	3	4	3	4	1	
4) WHM	2		2			4			
5) LAM	3	4		2					2
6) PHM							3	4	
7) SBE				4					4
8) MVM					3				

Key: Ranking of **1** to **4,** where **1** indicates highest rank, while **4** indicates lowest rank in terms of priority.

Note: LRA- Land Restoration and Agroforestry system**; CD-** Crop Diversification; ISFM- Integrated Soil Fertility and Management; **WHM-**Water Harvesting and Management-Small scale irrigation; **PHM-**Post-Harvest Handling; **SBE-** Sustainable Bio-Energy; **MVM-** Market, Value chain and Micro-finance; **LAM-** Livestock and Aquaculture Management

To widen the consultations, the experts were tasked to i) review and compile information about CSA and CIS including policies, and conduct an inventory of existing academic programmes and course units related to CSA and potential resource persons; and ii) conduct country specific consultations and consensus building on the priority CSA and CIS/CSA training needs.

2. Climate Information System (CIS) tools in Uganda

Accordingly, the Uganda National Meteorological Authority (UNMA) produces a suite of products ranging from daily weather summaries to seasonal and decadal agrometeorological forecasts. The CIS used in the country include climate scenarios and climate analogues to improve local and national planning by identifying target technology and development domains. Generally, there is still limited evidence of co-production of climate information services between the UNMA and users. The feedback loop from local users back to information producers is largely absent or ineffective. UNMA focus is constrained in terms of financial and human resource capacity. This affects its ability to deliver on core aspects of its mandate, from maintaining observational infrastructure to recruiting and retaining staff and engaging with end users. This has had a significant bearing on the pace of change in the meteorology system and has prompted UNMA to look for alternative sources of funding, including public–private partnerships, charging for data and selling of services (particularly to the private sector). The consultations revealed that university staff working on aspects related to climate find difficulties in using NMS data because of the issues raised in the previous paragraph. University staff in Uganda need information on weather forecast, early warning, modelling and scenario setting, climate change monitoring, and daily climate information.

The majority of the respondent university staff prefer to get some of this information from international sources because it is free and easily accessible. These sources include National Aeronautics and Space Administration (NASA) power; National Oceanic and Atmospheric Administration (NOAA)'s National Climatic Data Center and Climatic Research Unit time series. In addition, there is a continued challenge with the perceived relevance and trustworthiness of forecasted information in the country related to technical and institutional capacities of UNMA, the level of education of the users and political sensitivity associated with issuing seasonal forecasts predicting unfavorable agricultural conditions. Sources of none UNMA climate Information used by University staff are presented in Table 2.

The climate information services required by the university staff and therefore the basis for future training and programming include building capacity to use and interpret the outputs CIS tools, generation of gap free high resolution gridded historical climate data, short term accurate climate forecast and early warning. Respondents believe that gap free and accurate historical meteorological records, is the foundation for the generation of an expanded series of localized historical climate data and accurate forecast that meet recognized needs of end-users and decision makers.

TABLE 2: Clustered priority areas for the targeted African countries

Source	Link
NASA power	https://power.larc.nasa.gov/data-access-viewer/
NOAA's National Climatic Data Center	https://nas-sites.org/climate-change/climatemodeling/
Climatic Research Unit Time series (CRU)	https://climatedataguide.ucar.edu/climate-data/cru-ts-gridded-precipitation-and-other-meteorological-variables-1901
World Meteorological Organization	https://public.wmo.int/en
University of Chicago, Climatological data for the world	https://guides.lib.uchicago.edu/c.php?g=297202&p=1983953

3.0 Status of Climate Smart Agriculture in Uganda

3.1 Existing CSA technologies in Uganda

There are various CSA practices and technologies currently being used in Uganda (Table 3). These include those related to land restoration and Agroforestry (**LRA**), Water Harvesting and Management-small scale irrigation - **WHM**, Integrated Soil Fertility Management **ISFM**, crop diversification- **CD**, Post-Harvest Handling-**PHM,** Sustainable Bio-Energy-**SBE,** Market, Value chain and Micro-finance-**MVM and** Livestock and Aquaculture Management-**LAM**

TABLE 3: Existing CSA Practices and Technologies

CSA cluster	CSA Type	Description	Potential for climate change adaptation and mitigation
Land Restoration and Agroforestry system-(**LRA)**	Agroforestry	The intentional planting or guarding against the removal of more than one tree within 12 months on agricultural land or from its borders and on land set aside for purposes of tree planting. It manifests through practices such as planting of fruit trees, windbreaks, live fences, planting on boarders, and execution of strip cropping.	Results into sustainable land use management through soil fertility maintenance, creation of favourable microclimates like shade, and reduces moisture-related stress. It also leads to carbon sequestration, soil erosion prevention, and tree products that offer environmental services.
	Ridge planting	Is the construction of continuous lines of mounded soil on which crops/ potato tubers are planted – ridges constructed along the contours of farmland help to prevent run-off of rainwater, thus controlling soil erosion.	Increases on water retention to compensate for the dry spell and low rainfall, increases nutrient absorption and leads to increased productivity on compacted and sloping marginal areas.
	Terracing	Refers to a soil conservation measure put in place to prevent rainfall- runoff mostly on sloping land from building up and causing severe soil erosion. Terraces consist of both ridges and channels constructed in a planned and systematic way across the slope.	Reduces runoff and soil loss that may occur because of water erosion. This results into reduced soil fertility loss and increased water infiltration into the soil.
Water Harvesting and Management-Small scale irrigation-(**WHM)**	Drainage management	This encompasses the removal of excess water caused by flooding from the garden through the use of water control structures like channels.	Reduces risks of crop failure due to flooding that may wash away the crops, which may lead to waterlogged conditions, therefore resulting in rotting of crops.

	Irrigation	Supplying water to crops by making use of labour-saving or increased-efficiency technology, either on a large scale such as a canal/pump system or as a smaller micro-irrigation scheme.	Enables dry season production that compensates for the reduced rainfall. By making offseason production possible, it leads to increased diversification and productivity.
	Minimum tillage	Tillage refers to all techniques used to prepare the soil for farming. It entails the loosening by breaking of topsoil using farm implements like hoes. Minimum tillage occurs when land preparation is done by slashing of existing vegetation that allows regrowth of the vegetation followed by the application of herbicides, followed by hand planting using a planting stick. Under minimum tillage practices, residues from vegetation removal are used as mulch to cover the soil surface.	Reduces resource wastage on land preparation, improves water percolation, and amount of organic matter in the soil. This results in improved soil structure and prevents soil erosion. In the long run, it leads to improved productivity through moisture retention and soil compaction and degradation prevention.
	Mulching	The covering of the soil surface with a layer of organic residues and allowing for eventual decomposition to smother weed growth and reduce evaporation of soil water.	Reduces soil temperatures compensating for higher air temperatures, compensates for drought and reduced rainfall by improving the moisture retention capacity, reduces emissions from the uncovered soil surface and reduces risks of crop loss.
	Rainwater harvesting and storage	The collection and storage of rainwater using a rooftop harvesting into concrete tanks and plastic tanks and use of ponds that collect the runoff.	It avails additional water sources during dry spells. This results in reduced crop/ animal loss when used for irrigation and watering animals leading to increased productivity.
Integrated Soil Fertility and Management (ISFM)	Synthetic fertilizers	These are substances of manufactured origin that, when applied to the soil, release one or more critical nutrients needed by plants for growth and increased yields.	Compensates for the declining soil fertility and mostly nitrogen

	Compositing	Refers to the collection and heaping of waste materials of either plant or animal origin such as food remains, crop residues, and or animal manure piled in a pit or any other structure to hasten decomposition and application to cropland soil afterward.	Compensates for the declining soil fertility, avoids emissions from the use of raw animal manure, improves soil carbon sequestration and increases productivity with low inputs.
	Intercropping	Refers to the planting of two different but complementary crops on the same piece of land at the same time in a mixed pattern, in rows, or done through strip intercropping.	Improves nitrogen fixation and improved soil quality and reduces risks of total crop failure.
	Crop rotation	Is the systematic and planned change of crop plots per season or per year to avoid the depletion of soil nutrients that may occur when the same type of crop is planted in the same area seasonally or year. It entails the farmer choosing to alternate crops that can replenish and or help to fix the nutrients used up by the other; this includes scenarios like planting groundnuts after maize.	Compensates for the reduction in soil fertility, increases resistance to pests and diseases, soil structure improvement, contributes to carbon sequestration, prevents erosion and sustains productivity through soil exhaustion avoidance.
Crop Diversification-(CD)	Improved crop varieties	Is the use of genetically and phenotypically improved crop planting materials that have been bred for their traits such as increased yield, tolerance to stress (cold and heat), and disease resistance?	Ensures stress (drought, flood, and heat and cold stresses) tolerance and disease resistance; early maturing that avoids crop loss from shorter growing seasons and unreliable rains. It also results in higher productivity and reduces risks of crop failure.
Post-Harvest Handling-(PHM)	Post harvesting handling and food storage	Postharvest handling is the stage of crop production immediately following harvest, including cooling, cleaning, sorting, packing and storage.	This feeds into reduced food losses in the entire value chain and sustainable management of food.
	Food processing	Food processing refers to a set of methods and techniques used at home or in processing facilities that transform raw agricultural produce into differentiated food products. Food processing may include both primary and secondary processing	

	Food distribution and marketing	This covers all of the activities needed to get a final product to the consumer, identifying product offerings, setting prices, determining the places to sell, and business promotion	
	Food consumption and food waste disposal	Building on the triple R concept "Reduce, Reuse, Recycle," for environmental protection and fully recognizes the impacts of the wasted food	
Sustainable Bio-Energy-SBE	Biogas	Anaerobic digestion of energy crops, residues, and wastes, for reduced greenhouse gas emissions and to facilitate a sustainable development of energy supply. The methane produced can replace fossil fuels in both heat and power generation and as a vehicle fuel.	Results into sustainable use of energy, promote use of clean energy.
	Improved cook stoves	Key to reduce fuel use and hence reduce deforestation, and improve the health conditions of users by reducing environmental emissions.	Results into improving the social life of people and reducing global climate change.
	Energy switching	Provides consumers with alternatives sources of energy, transparent and impartial way to compare energy tariffs.	Help to reduce energy bills, save money for other activities.
Livestock and Aquaculture Management-LAM	Aqua-silviculture	The integration of aquaculture with (mangrove) forestry, otherwise known as silviculture	Provides an additional income in tree-based production systems, and mitigating risks associated with crop failure or livestock diseases.
	Diet management	Feed management is managing the quantity of nutrients fed to livestock and poultry for their intended purpose. This involves development of diets that supply the quantity of available nutrients required by livestock and poultry.	Key for maintenance, production and reproduction of the livestock and aquaculture systems
	Pest and disease management	It is important in maintaining the desired food safety standards	Is an important part of Integrated livestock Production Management
	Genetic improvement	Genetic merit is improved through selection	Adequate genetic variation in livestock/fish populations is necessary both for adaptation to

			climate change, increased consumer demand, and for continual genetic improvement of economically important traits. Key for survival of local breeds.
	Improve pasture	Extension of the growing and quality of pasture	Reduces the need for supplementary feeding and can increase the production options in a livestock enterprise.
	Manure management	Capture, storage, treatment, and utilization of animal manures in an environmentally sustainable manner	Improve soil health and reduces emission of greenhouse gases.
	Rotational grazing	Subdivision of large pasture into smaller paddocks allowing livestock to be moved from one paddock to the other easily	Improve productivity, weight gain or milk production per unit area, and overall net return to the farm.

3.2 Climate Smart Agriculture-Relevant Policies and Strategies in Uganda

A range of CSA and CIS policies have been enacted in Uganda within the agriculture sector (Table 4). These include the Macro-economic policy framework such as the Uganda Vision 2040; National Development Plan as required by article 190 of Constitution of the Republic of Uganda 1995, which is further operationalized in the Local Government Act, cap 243 section 36 and 78. Table 4 shows the adaptation and mitigation options recognized within the climate change strategies associated with agriculture and climate change in Uganda.

TABLE 4: Clustered priority areas for the country

Policy framework	Brief notes about the policy
Uganda Vision 2040	Uganda Vision 2040 defines the development pathway and strategies that will transform Uganda from a predominantly peasant and low income country to a competitive upper middle income country. It builds on the progress that has been made in addressing the strategic barriers that have constrained Uganda's socio-economic development since independence, including: ideological disorientation, weak private sector, underdeveloped human resources, inadequate infrastructure, small market, lack of industrialization, underdeveloped services sector, underdevelopment of agriculture, and poor democracy, among others. The Uganda Vision 2040 calls for development of appropriate adaptation and mitigation strategies on Climate Change to ensure that Uganda is sufficiently cushioned from any adverse impact brought by climate change.

National Development Plan II (2015/16 – 2019/20):	National Development Plan 2015/16 –2019/20 (NDPII) is the second in a series of six five-year Plans aimed at achieving the Uganda Vision 2040. The NDP II serves as the most powerful guide for investment planning, budget allocation and social interventions in the country— all government programs are linked to the NDP within the existing policy, legal, planning, monitoring and reporting systems. The Water and Environment sector subscribes to the strategic objectives and interventions under NDPII (e.g., in formulation of its development plan).
Uganda Green Growth Strategy:	The strategy is to operationalize green growth tenets outlined in Agenda 2030, the Uganda Vision 2040 and the NDP II (2015/16-2019/20) to accelerate the country's transition to a middle income status.
National Agricultural Policy 2013	This policy was developed to harmonize the different thoughts and approaches to national agricultural development. The vision of the policy is "a competitive, profitable and sustainable agricultural sector", while the mission of the policy is to: "transform subsistence farming to sustainable commercial agriculture." The overall objective of the policy is to achieve food and nutrition security and improve household incomes through coordinated interventions that focus on enhancing sustainable agricultural productivity and value addition; providing employment opportunities, and promoting domestic and international trade.
Agriculture Sector Strategic Plan (ASSP) 2015	This policy is a flagship plan for investment and development of the agricultural sector, in line with the National Development Plan to be implemented through a multi-sector wide approach involving the Government of Uganda, Ministries, Departments and Agencies of Government, District Local Governments, Development Partners, Civil Society Organisations and the private sector. The ASSP describes the priorities, strategies and interventions required to achieve wealth creation, and employment through implementation of actions for the value chain development of twelve priority and four strategic commodities to ensure that agriculture enables Uganda to achieve its NDP II goal.
National Irrigation policy 2017	**National Irrigation policy** 2017 aims to ensure sustainable availability of water for irrigation and its efficient use for enhanced crop production, productivity and profitability that will contribute to food security and wealth creation.

National Coffee Policy 2013	**This policy** was developed to guide and regulate activities of various stakeholders in the coffee industry; so as to improve production, roasting, processing and marketing of coffee. The policy seeks to, among others, increase coffee production and productivity at farm level in a sustainable way that addresses the social, ecological and economic dimensions and to support and strengthen coffee farmer organizations to participate effectively in all the stages of the coffee value chain.
Food and Nutrition Policy 2003	**It** is intended to ensure that the entire food chain, from production to consumption, is efficiently managed within the overall development strategy, through building capacities at all levels for adequate action to improve household food security. However, the policy contains limited discussion on the relationship between food and nutrition security and climate change and hence needs to be reviewed.
Draft Rangeland Policy	**It** recognises overgrazing and overstocking as the major causes of rangeland degradation. Bush encroachment and spread of invasive plant species is affecting rangeland and forest ecosystem in Uganda. Bush encroachment leads to suppression of green grass biomass production and, thus, the rangeland's grazing capacity for livestock.
Uganda CSA Programme 2019-2030	Intends to build resilience and associated adaptation and mitigation co-benefits. CSA are key for reducing vulnerability of Uganda's agriculture sector by increasing productivity, enhancing adaptation and resilience of the farming systems and reducing GHGs emissions
National Agricultural Extension Strategy 2016:	The NAES is derived from the National Agricultural Extension Policy (2016) and aligns with the 5-year NDP II. The strategy has main objectives: (i) To establish a well-coordinated, harmonized pluralistic agricultural extension delivery system for increased efficiency and effectiveness. (ii) To empower farmers and other value chain actors (youth, women and other vulnerable groups) to effectively participate and benefit equitably from agricultural extension processes and demand for services (iii) To develop a sustainable mechanism for packaging and disseminating appropriate technologies to all categories of farmers and other beneficiaries in the agricultural sector (iv) To build institutional capacity for effective delivery of agricultural extension services.
National Adaptation Plan for the Agriculture Sector (NAP Ag):	The National Adaptation Plan for the Agriculture Sector (NAP-Ag) contributes to the second National Development Plan (NDP II) priority of strengthening ecologically sound agricultural research

	and climate change resilient technologies and practices. The plan also contributes to different government policies and planning frameworks, such as the National Climate Change Policy (2013) and the Agriculture Sector Strategic Plan (ASSP). The overall goal of the NAP-Ag is to increase resilience of the Agricultural Sector to the impacts of climate change, through coordinated interventions that enhance sustainable agriculture, food and nutritional security, livelihood improvement and sustainable development by boosting production and productivity for all agriculture sub-sectors - crop, livestock, fisheries, forestry, land and natural resources. Ultimately, the plan is to ensure a resilient agriculture sector across all the sub-sectors through gender responsive actions guided by knowledge, evidence and information on climate change.
Uganda Strategic Investment Framework for Sustainable Land Management 2010-2020	The policy aims at upscaling Sustainable Land Management (SLM) Practices across sectors and its development objective is to 'to strengthen sector cooperation in order to halt, reverse and prevent land degradation/ desertification and to mitigate the effects of climate change and variability. The SIF targets to: i) raise crop and range productivity; ii) reduce deforestation; iii) secure ecosystem services such as water filtering, biodiversity, and carbon storage; and (iv) improve rural livelihoods. It is important these targets are integrated in sectoral policies in agriculture, water, forestry, wetlands, energy and trade policies.
National Climate Change Policy (NCCP) 2015	It has a goal to "ensure a harmonised and coordinated approach toward a climate- resilient and low-carbon development path for sustainable development in Uganda." The policy is prepared and designed within the context of the country's vision and national development priorities. The policy aims at a harmonized approach towards a climate-resilient and low-carbon development path for sustainable development in Uganda.
National Adaptation Programmes of Action (NAPAs) and National Adaptation Plans (NAPs):	Uganda was among the first least developed countries (LDCs) to develop and submit its National Adaptation Programmes of Actions (NAPAs) in 2007. The NAPAs includes a list of the following nine priority projects, many of which are yet to be rolled out and implemented (MWE, 2015) including, but not limited to Community tree growing, Land degradation management, Strengthening meteorological services, Community water and sanitation, Water for production, Drought adaptation, Vectors, pests and disease control. Indigenous knowledge and natural resource management, and Climate change and development planning. A climate resilient and sustainable agricultural sector contributing towards achievement of the Uganda Vision 2040"

	through reducing vulnerability and enhancing adaptive capacity of Uganda's agricultural sector to the impacts of climate change in order to achieve sustainable agricultural development.
National Adaptation Plan (NAP)	The NAP for Agriculture was developed by MAAIF in conjunction with the Climate Change Department of the MWE, and FAO and UNDP. It was launched in 2018 and supported by the Integrating Agriculture in National Adaptation Plans Programme (NAP-Ag). The NAP has 21 action areas with adaptation options for crop production, livestock, fisheries, climate information, forestry, land and resources management, knowledge sharing, and early warning and disaster preparedness.
Nationally Determined Contributions (NDCs) and NDC Partnership Plan	Uganda submitted its first s in 2015. The NDC emphasizes adaptation actions and the commitment to reduce emissions by 22% relative to business as usual scenario with actions focused on energy, forestry and wetlands. Through the Partnership Plan, Uganda is raising its ambition by setting the timeline to achieve several NDC actions sooner. Uganda seeks to mainstream climate resilience across sectors and develop early warning systems and robust monitoring systems by 2020, much earlier than originally planned. The Plan also aims to create an enabling environment for the country's NDC by elaborating and clarifying actions for transformative change as the country grows and develops into the future. The five priority areas for Uganda identified in its NDC Partnership Plan are: (1) strengthened operational and gender-responsive policy and institutional frameworks for the effective governance of climate change; (2) increased climate financing for planning and budgeting on the national and local levels; (3) effective and institutionalized measurement, reporting and verification (MRV) systems to monitor greenhouse gas emissions and gender-responsive adaptation measures; (4) strengthened capacity of government officials, civil society, the private sector and academia to effectively integrate NDC and Sustainable Development Goal (SDG) commitments with a gender lens into existing and future programs; and (5) accelerated project financing for NDC implementation.
Disaster Preparedness and management Policy 2010:	The policy goal is "to establish institutions and mechanisms that will reduce the vulnerability of people, livestock, plants and wildlife to disasters in Uganda". The policy focuses on risks, including those related to climate hazards (especially droughts, floods and landslides). The DPM policy identifies policy actions to make agriculture less vulnerable to extreme weather events and offers a number of specific interventions to achieve this goal.

National Land Policy 2010	The objectives include, inter alia: stimulate the contribution of the land sector to overall socio- economic development, wealth creation and poverty reduction in Uganda and harmonize and (ii) streamline the complex tenure regimes in Uganda for equitable access to land and security of tenure.
Meteorology Policy 2012	The policy seeks to promote, monitor weather and climate, maintain a climate database, provide regular advice on the state of weather and climate and provide accurate and timely climate and weather information to various stakeholders.
National Environment Management Policy 1995	The policy seeks to promote a development that enhances environmental quality and resource productivity on a long-term basis to meet the needs of the present generations, without compromising the ability of future generations to meet their own needs. This is especially important because land degradation is a major threat to agricultural productivity in Uganda. Agricultural practices are already having an impact on Uganda's natural ecosystems and this is undermining the delivery of ecosystem services. Moreover, ecosystem services are crucial for agricultural production and the encroachment of cultivation into natural ecosystems is itself severely undermining the sustainability of agricultural growth.
Forest Policy, 2001	The policy emphasizes watershed management and soil and water conservation, all of which contribute to climate change resilience. It promotes community forestry, addresses the concern of forests on private land and government land. The policy also promotes commercial forestry, collaborative forest management, farm forestry, forest biodiversity conservation, urban forestry, and supply of tree seed and planting material.
National Science Technology and Innovation Policy	The goal of this policy is to strengthen national capability to generate, transfer, and apply scientific knowledge, skills and technologies that ensure sustainable utilisation of natural resources for the realisation of Uganda's development objectives.
National Policy for the Conservation and management of Wetland Resources:	The Wetlands Policy (1995) and the Wetlands Sector Strategic Plan (WSSP) 2011-2020, recognize the importance of wetlands as sources of essential goods and services (food, incomes, water, and aesthetic beauty) to local populations. Wetlands provide a large array of ecosystem services to the population and the system of interconnected wetlands plays a crucial role at a regional level by filtering pollutants and regulating water flows (influencing groundwater recharge, flood impacts, and water availability during the dry season).

National Water Policy, 1995:	The policy provides a framework to support management of Uganda's water resources in an integrated and sustainable manner, so as to secure and provide water of adequate quantity and quality for all social and economic needs of the present and future generations; with participation of all stakeholders. The Ministry of Water and Environment has developed a Water for Production Strategy and Investment Plan 2010 – 2035 and the Draft National Irrigation Master Plan; which are aimed at promoting the use of water in agricultural production through supporting farming system diversification, private investment in bulk water infrastructure; service delivery and more Public-Private Partnerships.

4.0 Required interventions to increase adoption of CSA technologies/practices and CIS tools in Uganda

Table 5 indicates the key interventions needed to increase adoption of climate smart agriculture practices and climate information system tools in Uganda

TABLE 3: Needed intervention to increase adoption of CSA practices and CIS tools

Proposed Intervention	Community level	Community leaders	Civil society actors	Academia/Research	Extension service	Decision makers	Media	Private sector	Politicians	Proposed Intervention
Improved access to information for adaptation and mitigation, compilation of information from different areas	Awareness, Training, demonstration, monitor, exchange visit, experiential learning, mapping existing knowledge (SK and IK) and CSA practices, packaging of CC and weather data,	Awareness, involvement	Awareness, Map engagement to CSA (intervention, funding), Institution strategy/priorities	Awareness and empower acad. staff, Inventory of existing knowledge, Map existing programme, courses and researchers, mainstream CSA in curriculum, Co-generation of knowledge with media, Communication channel being used, recognition of IK, Develop reliable weather data and improve access to climate info, encourage multi-disciplinary teams,	Awareness, training, Map existing knowledge on CSA, distribution of extension staff, approach for extension	Awareness of CSA,, them to develop CSA strategy	Awareness of CSA, map the communication channel and packaging, support training on CSA, engaging them in dissemination, support agriculture graduates in journalism	Awarenes s, Training,	Awareness, Advocacy and lobbying	Improved access to information for adaptation and mitigation, compilation of information from different areas

				prioritize research on CSA						
Review and compilation of existing information on CSA practices and CIS tools	Provide site (crop/lives tock) specific IK and CSA; demonstra tion for validation	support the collection of information	support the collection of informatio n	Review and compile info on CSA for all identified stakeholders, develop policy, white papers	Participate in collection and compiling of informatio n	Support the collection and compilatio n of CSA informatio n	Support the collection and compilatio n of CSA info, strengthen info flow	Support (through participati on and funding) collection and compilati on of info	Approved and endorse the policy recommen dations on CSA practices	Review and compilation of existing information on CSA practices and CIS tools
Improved understandi ng of the CSA and CIS	Awareness , Training,	Awareness, involvement	Awareness , Training,	Awareness, Capacity building (tailored made training), mainstreaming SA and CIS into curriculum	Awareness , Training,	Awareness , Training,	Awareness , Training,	Awarenes s, Training,	Awareness , Advocacy and lobbying	Improved understanding of the CSA and CIS
Need for Reliable funding/ Gvt support	Promote innovation (IP, market based), in-kind contributio n for CSA demonstra tion	facilitate (mobilizing, champions) the implementat ion of CSA	Awareness Prioritizati on of CSA (integrated into the IP), contribute funds towards CSA adaptation	Involved in CSA proposal writing (Training and awareness on available call), demand driven research, allocate funds for CSA research, mobilize resources for CSA labs	Facilitate (financial) the Linking of various actors on CSA, promote the creation of network	Contribute financially towards facilitation of CSA adaptation of strategies. creation of an enabling environme nt for actors to focus on CSA, Engage them to	Mobilize resources for awareness and adoption of CSA	Play an active role in IP, contribut e to adoption of CSA, mobilize resources for CSA , build on PPP to avail resources for CSA adaptatio n	Contribute financially towards facilitation of CSA adaptation of strategies. creation of an enabling environme nt for actors to focus on CSA, Engage them to	Need for Reliable funding/ Gvt support

						get support for agriculture in terms of budget and CSA, support subsidies in CSA, tax exemption, provide incentive to actors to participate and contribute to CSA			get support for agriculture in terms of budget and CSA, support subsidies in CSA, tax exemption, provide incentive to actors to participate and contribute to CSA	

5.0 Priority training needs in CSA/CIS for the academic institutions of Uganda

5.1 Academic programs and Course Units Related to CSA in Uganda

Table 6 shows the existing academic programs and courses related to climate smart agriculture and Climate Information Systems in the different institutions of higher learning in Uganda (Table 6).

TABLE 6: Academic programs with elements of CSA in the various institutions of higher learning in Uganda

Makerere University									
LRA	**Academic level**	**WHM**	**Academic level**	**CD**	**Academic level**	**ISFM**	**Academic level**	**SBE**	**Academic level**
Agroforestry Systems, Practices and Technologies (CFE 7102)	Graduate level	Water Resources Engineering (CIV4202)	Graduate level	Plant Breeding Methods (CRS 7106)	Graduate level	Soil Conservation and Land Reclamation (SOS 3201)	Undergraduate level	Hydropower energy (RET 7102)	Undergraduate level
Drylands Agroforestry (CFE 7103)	Graduate level	Soil And Water Engineering (AEN 4102)-	Undergraduate Level	Seed Science and Seed Systems (CRS 8203)	Graduate level	Applied Soil Fertility and Plant Analysis (SOS 410)	Graduate level	Bioenergy (RET 7102)	Undergraduate level
Advanced Community Forestry (CFE 7104)-	Graduate level					Applied Soil Fertility and Plant Analysis (SOS 3107)	Undergraduate level	Solar Energy (RET 7102)	Undergraduate level
Agroforestry (CFE 3109)	Undergraduate level							Biomass Energy Production and Conservation (FPE 4201)	Undergraduate level

Forestry and Climate change (FOM 2105)-	Undergraduate level							Optimization of Energy Systems (RET7205)-	Undergraduate level
Agroforestry (CFE 4203)	Undergraduate level							Energy Policy, Planning and sustainable Development (RET7204)	Undergraduate level
								Low Energy Architecture (RET8111)	Graduate level
								Energy comfort in Buildings (RET8112)	Graduate level
Disaster Risk Management	Graduate level and PHD								
Meteorology	Undergraduate and Graduate level								
Climate Change and Sustainability	Graduate level								
Land use and Regional Development planning	Graduate level								
	Gulu University								
Biosystems Engineering	Graduate level	Treatment and utilization of solid waste and wastewater, specifically design of	Undergraduate level	Agricultural mechanization, irrigation, farm buildings, food storage facilities and value addition technologies	Both under graduate and graduate level	Design of soil conservation structures like terraces and contour bands.	Undergraduate and graduate level	Solar energy systems	Undergraduate and graduate level

		incinerators, landfills							
		Composting plants for organic wastes lagoons and constructed wetlands for treatment of sewerage and other liquid organic wastes	Undergraduate and graduate level					Design and management of micro- and pico-power plants	graduate level
		Floods and drought forecasting and management	Graduate level						
	Uganda Martyrs University								
Environmental Science and Disaster Management	Undergraduate	Water Engineering	Undergraduate	Crop Production and Farm Management	Undergraduate	Agro – Ecology	Undergraduate		
		Water and Sanitation-Undergraduate							
	Mbarara University								
		Petroleum Engineering and Environmental Management	Graduate level	Agricultural livelihoods and Farm production	Graduate level				

5.2 Existing human resources in CSA and CIS related programs in the universities of Uganda

Figure 1 shows the existing Human resources to deliver CSA and CIS training, and community outreach in the Ugandan institutions. There is almost the similar number of highly qualified staff (Professor, Associate Professor, senior lecturer) and lecturer at the University institutions of Uganda to train in CSA. Further, there are several actors/stakeholders qualified to conduct community outreach for CSA/CIS interventions in the country.

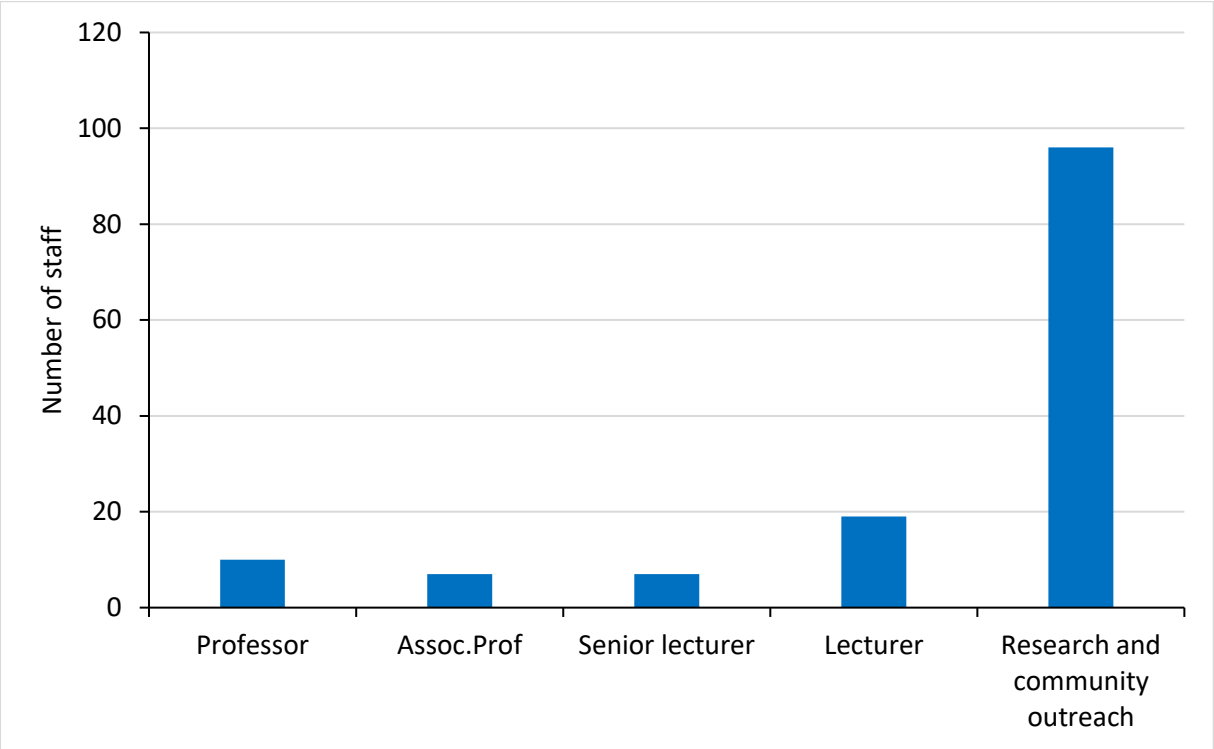

Figure 1. Staff involved in CSA/CIS teaching, research and community outreach in the Ugandan academic and other research institutions

5.3 Training needs for CSA/CIS in Uganda

The priority training needs related to CSA and CIS for the staff and students in the Ugandan Institutions of higher learning are shown in Table 7. Appendix 1 presents the various staffs for the training of trainers in the prioritized clustered CSA and CIS programs.

TABLE 4: Training needs in Uganda

Training theme	Description	Beneficiaries	Priority level
Practical understanding of the CSA approach	The CSA and CIS approach is obviously attractive and compelling in principle, but its application in the context of diverse agro-ecologies and highly heterogeneous farming systems, conditions and socio-economic policies still requires concrete success stories. Gathering clear empirical messages to inform farmers and policymakers and support scaling-up initiatives will depend on how well the CSA concept is understood in practice, allowing for continuous two-way adaptations and feedback mechanisms between researchers and practitioners, farmers and policymakers. There are also gaps on design thinking for CSA and CIS.	Staff and students	High
Climate information service and real-time agricultural data	Due to the increasing number of disasters and weather extremes on the continent, there is need to increase access to climate information services for the different stakeholders and use in agriculture. Climate information risk and management	Staff and students	High
Agriculture-livestock aquaculture integration	Previous initiatives have not included aquaculture in the crop-livestock integration projects. With an increasing expansion of aquaculture on the continent, training is necessary to support effective integration of aquaculture to already adopted integrated farming systems, Capacity building on aquaculture value chain initiatives	Students	High
Capacity building on the elaboration of effective CSA and CIS-specific policies	Several academicians have not been involved in policy formulation process. This is key in the promotion and adoption of CSA practices/technologies and/or CIS tools	Staff and students	Medium
Principles of agro-ecology farming system	Conducting agricultural activities on the basis of ecological principles is crucial for maintenance of healthy ecosystems at the same time addressing the challenges for food shortage and ecosystem degradation. There is a need to strength this aspect in training of future lecturers and students.	Staff and students	Medium
Assessment of carbon sequestration and greenhouse gas emission potential by different agro-ecologies and farming systems	The knowledge on how the carbon footprint can be estimated needs to be added to the university curricula and more practical work included.	Students	Medium

Effective seed delivery systems of resilient crop varieties	Crop productivity in a climate-stress scenario is dependent on the resilience of varieties used. In eastern DRC, seed production system is not operational. The training shall focus on how to produce seeds, and development a functional seed delivery system for such resilient varieties is crucial.	Staff and students	High
CSA and CIS-oriented extension strategies	Staff and students need to be equipped on the most appropriate extension strategies to increase chance of CSA and CIS practices' uptake by farmers	Staff and students	High
Digital-based platforms for plant and animal disease monitoring and control	With the increasing volume of data being generated across the country and the opportunities provided by the communication technologies, it is important to equip staff and students on how digital platforms could help for timely monitoring and information sharing on emerging animal and plant diseases.	Staff and students	Medium
Gender issues and CSA	Staff and students need more awareness on how women can be sustainably supported through a community-centered approach to adopting and adapting livelihood strategies in innovative ways, based on current and future climate change scenarios.	Staff and students	Medium
Information and Communications Technology (ICT) and CSA practices dissemination	These technologies have been instrumental in disseminating CSA practices and climate information in other African countries. Yet, these are still unknown on the continent and lack in the university curricula.	Staff and students	Medium
Biofertilizer and biopesticide development	Sub Saharan African is among regions with lowest external farm inputs worldwide because of poverty among farmers and cultural (belief system) resistance. Equipping staff and students on alternative approaches could help boost adoption and farm productivity on the continent.	Staff and students	High
Agricultural waste recycling options	Adequate options for waste recycling could help reduce pollution and increase farmers' food and income security on the continent. Adding economic and eco-friendly recycling options (such as mushroom production, animal feed processing, etc.) in the curricula is important.	Students	Medium

Cost-effective renewable energy and biogas production	The use of renewable energy such biogas is an effective mean of reducing pressure on forests and other natural resources in rural areas of the continent.	Students	High
Microdosing and micro-irrigation systems	The application of fertilizer and water is often inefficient due to misuse of products and the dosage is not well practiced by farmers. Training students on microdosing and micro-irrigation systems would help fix the situation in the near future.	Students	Medium
Crop diversification and climate-resilience potential of neglected and underutilized crop species	Neglected and underutilized crops, as the most adapted to local agricultural systems and climates, are now perceived as a mean to minimize adverse effects of climate changes. Yet, their knowledge is poor among staff and students.	Staff and students	Medium
Improve policy coordination and strengthen local, national and regional institutions to support implementation of CSA and CIS	Without appropriate institutional structures in place, CIS and CSA-related innovations can overwhelm smallholder farmers. Training on how to improve information dissemination; to leverage resources and organizing markets; provide insurance to address risks associated with climate shocks are important.	Staff	High
GIS and remote sensing in CSA amd CIS	Use of GIS and RS will support CSA through increased access to CIS and facilitate precision and digital agriculture.	Staff	Medium
Indigenous knowledge systems (IKS) on land use and CSA	Tapping on IKS for CSA and CIS	Students and staff	High
Climate smart post-harvest processing and storage techniques	A variety of these techniques are now available but known by end-users.	Students and staff	High
CSA and CIS and the Development agenda	Mainstreaming the development agenda in CSA and CIS and vice versa is crucial for achieving local, national and international sustainable development agenda.	students and staff	Medium
Climate Finance for CSA	Inadequate knowledge on financial opportunities for CSA projects	Students and staff	High
Statistical downscaling and modelling of climate data	Techniques/approaches converting satellite data into location specific data for climate change analysis are known by few professionals.	University staff and students, experts in line ministries & other institutions	Medium

Design thinking and Digital Technologies for CSA and CIS	Build capacity in App development and application for CSA and CIS is key for CSA and CIS promotion and adoption	Students and staff	High
The role of the media in CIS and CSA promotion	Enhancing the role of the media as a tool in promoting and raising awareness on climate actions among stakeholders	Students, staff and climate experts/practitioners	High
Climate Finance for CSA and CIS	Funding opportunities for CSA and CIS initiatives need to be disseminated.	Students and staff	High
CSA policy for strengthening academia-policy nexus and partnerships	Continued dialogue and collaborations are crucial for effective and dynamic climate-smart solutions. There is also need to address gaps through science-policy interactions.	University staff and policy makers	High
CSA and the Urban agenda	Promoting the practice and adopt of climate smart urban farming that ensures environmental protection and food and nutrition security	Students and staff	Medium

6.0 Conclusion and Recommendations

The government of Uganda has a high level of commitment to mainstreaming adaptation and mitigation goals into agricultural planning processes based on the existing policy and legislative frameworks related to climate change adaptation and mitigation. From the consultations, the country has identified and prioritize clustered CSA for intervention. These clustered CSA include Land Restoration and Agroforestry system (LRA), Crop diversification CD, Integrated Soil Fertility Management (ISFM), and Post-Harvest Management (PHM).

Various courses and course units with aspects of CSA and CIS are taught in the surveyed universities. These courses cover a wide range of the proposed clustered priority areas for the country. The CIS tools used include climate scenarios and climate analogues to improve local and national planning by identifying target technology and development domains. The CIS need for the university staff include gap free high resolution gridded historical climate data, short term accurate climate forecast, early warning and building capacity to use and interpret the outcome of CIS tools.

From the consultations, there is need to:

- Develop either short courses, and (or) infuse the elements of CSA and CIS in existing degree programs in selected pilot Universities since there is limited emphasis on CSA and CIS in degree programmes.
- Provide empirical evidence and demonstrations to support the training and practice. This will necessitate leveraging research funds to strengthen existing research evidence to guide training;
- Build adequate expertise/capacity in various aspects of CSA and CIS among the academia to further research and training on CSA & CIS. This calls for development of new degree programmes that will lead to training of critical mass of experts in CSA;
- Strengthen linkages between the higher learning institutions and the TVETs for efficient transfer of knowledge and skills to end-users;
- Establish adequate resources and infrastructure to support CSA & CIS at the learning institutions.
- Establish learning platforms with focus on CSA and CIS to enable wide and interactive engagement with knowledge, therefore need for multi-stakeholder knowledge & information sharing platform to enable learning among various stakeholders.

Appendix 1

TABLE 5: Training needs in Uganda

Training theme	Description	Beneficiaries Priority level
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Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) is a project that helps deliver a climate-smart African future driven by science and innovation in agriculture.

It is led by the Alliance of Bioversity International and CIAT and supported by a grant from the International Development Association (IDA) of the World Bank.

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