Review Paper

Uptake of knowledge and technologies for adaptation to climate change in crop production systems in Uganda: A review

ABSTRACT

Aim and place: The aim of this study was to appraise the status of uptake of innovations (knowledge and technologies) of climate change adaptation in crop-based systems in Uganda, and propose viable interventions for enhancing the process of uptake to obviate the escalating effects of climate change and its associated variability. The study was conducted in Uganda during June to December 2017.

Methodology: This study was dominantly a desk review, primarily based on existing online information sources and other national institutional repositories. The other information source was from a two-day stakeholder workshop, involving key actors within the climate change research and development value chain in Uganda, who during the process validated the synthesised information and supplemented with more recent events and hitherto undocumented scenarios.

Results and conclusion: Uptake of climate change adaptation actions was measurably low in the country; hence, communities were far from ready to face the recurrently changing and increasingly aggressive climate change events. Contributors to slow uptake were lack of a coherent climate change activity coordination entity in the country, to organise actors into a functional service delivery system with minimum duplication; ensuring quality actions and following a unidirectional long term goal. The other hindrances included scattered knowledge and technologies, sub-optimal communication and extension services, technology products misconception, low adaptation capacity, unfavourable policies and policy environments, ineffectiveness of traditional public and civil society extension agencies. Interventions are proposed to obviate these bottlenecks using largely internal mechanisms.

Key words: Rain-fed agriculture, vulnerability, information communication, food insecurity

1. INTRODUCTION

Climate change and climate variability are among the major factors that currently define crop production, food insecurity and poverty in the largely rain-fed agricultural economies, especially in sub-Saharan Africa. This situation manifests partly because of the high climate change vulnerabilities and weak adaptation capacities of farming communities in African countries such as Uganda, where agriculture determines the livelihoods of more than 80% of the country's population [1]. Unless countries and communities take urgent steps to enhance their adaptive capacity and build resilience, climate change is likely to undermine agricultural development, increase food insecurity and malnutrition, and entrench poverty on the African continent, and Uganda in particular. Increasing climate resilience in agriculture requires, among others, increased climate change knowledge base and uptake of adaptation technologies by agrarian communities to reduce their exposure to climate change risks and disasters.

The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) reported that global average temperatures to have increased by about 1^{o}C over the period 1901-2012, specifically emphasizing that each of the last three decades have been successively warmer than any preceding decades since 1850 [2]. In addition, the IPCC AR5 projects that global temperatures are likely to increase by up to 4.8^{o}C by 2100 [3]. For the African continent, the report indicates temperatures have already increased by 0.5–2℃ over the past hundred years [4].

Uganda is highly vulnerable to the current and future climate change. The country's average temperatures are reported to have increased, in the range of 0.8 to 1.5^{o}C over a period 1900-2000 and are projected to increase by approximately 1.5^{o}C as early as 2030 and up to 5^{o}C by 2080 [5]). Although the rainfall projection patterns are more uncertain [6], a slight decrease in total annual rainfall is expected in most of the country, with slightly wetter conditions over the west and north-west; while rainfall totals might

drop significantly over Lake Victoria (-20% from present). Uganda has been characterised by several climate change extreme events in the form of severe droughts, floods, storms, landslides, and delayed/early rainy seasons [7]. The projected changes in climate will result in higher temperatures, more erratic and heavy rainfall, change in the timing and distribution of rainfall, and an increase in the frequency and duration of droughts. Uganda's climate change vulnerability is amplified by the high dependence on rain-fed agriculture, the high population growth (rate>3.4%)and its increased demand for food and the pressure it exerts on the natural resource base, the dependence on subsistence agriculture, as well as the frail information and knowledge base, and weak institutional frameworks to address climate change [8]. Without adequate adaptation capacity built, and appropriate agricultural adaptation technologies adopted, crop production will reduce significantly thus undermining Uganda's development efforts.

Whereas various climate smart technologies exist that could be leveraged from in Africa, such as conservation agriculture, sustainable crop/farming management systems, soil fertility management, sustainable water use and management, improved post harvest management and value addition, and ecosystem based adaptation, the adoption of climate smart practices by Ugandan communities and farmers has been generally low and most farmers still depend on the traditional subsistence farming systems [9]. For example, fertiliser use is still very low, averaging 1 kg of nutrients per hectare, which is one the world's lowest rates.

Only 6.3% of Uganda's farmers use improved seeds; while application of agro-chemicals is at a meager 3.4% [10] and value addition is negligible with less than 5% of Uganda's agricultural commodities and products processed [9]. As a result, increasing crop production in Uganda has been achieved more through increasing the land under cultivation rather than productivity improvements [11]. The increase in land under agriculture has contributed not only to widespread land and environmental degradation (deforestation, land degradation, destruction of wetlands, and encroachment on protected areas), but also to increase in green house gas emissions, thus exacerbates

the vulnerability of communities and ecosystems to the impacts of climate change. For example, currently agricultural land is increasing at 1% per *annum*, and if left unchecked, more than 90% of Uganda's land will be used for agriculture by 2040 [11]. This trend is unsustainable in the context of addressing climate change, and adoption of knowledge and practices that can simultaneously increase agricultural production, reduce land and ecosystem degradation; while increasing climate resilience are necessary.

Uganda has over the last two decades been a destination of a myriad of multinational climate change projects, which unfortunately have been characterised by insignificant impacts, owing to their sporadic nature and poor coordination [12; 13] Uganda, like other climate change vulnerable countries in SSA, is strategically positioned to respond to climate change, more from adaptive perspective, and less from the mitigation standpoint; the latter requiring multi-dollar investments and technical capacities at levels unaffordable by agrarian economies driven largely by small-scale farmer communities. Efforts must be made to scan the entire spectrum of the climate change response processes and systems, including knowledge and practices to re-define priority areas for reinvigorating the campaign for communities to deal with the speedy and adverse climate change impacts in the country.

A critical instrument that can quickly catalyse meaningful adaptation is proper diagnosis of adaptation innovation uptake pathways and mechanisms; and factors that define their smooth operationalisation among affected communities in the country. Uptake infrastructure forms the primary platform for adoption and eventual adaptation to prevailing climate risks and impacts. Areas with potential for generating intervention areas include understanding of the level of awareness of climate change adaptation, framework for uptake of innovations among communities, scope and role of indigenous knowledge, policy environment, gender perspective and funding mechanisms.

The objective of this study was to identify entry-points for bolstering uptake of climate change adaptation knowledge and technologies among communities in Uganda

2. METHODOLOGY

This study was conducted during 2016-2017 in Uganda, using two procedures, namely desk literature review, and interaction with selected key stakeholders in the climate change adaptation research and development value chain in Uganda. The desk review part involved scanning of literature from various database sources, predominantly from international and local online sources; and to some extent from hardcopies of published and unpublished materials. The climate change adaptation based keywords used in the search included among others: uptake, adaptation, adoption, diffusion, dissemination, gender, communication, policy, meteorological data and media; all within the climate change context.

During a two-day proactive interactive workshop with climate change adaptation stakeholders including policy makers, researchers, adaptation practitioners, knowledge brokers, among others, the synthesis from the desk literature search was presented to key stakeholders for consensus and update with especially undocumented and more recent significant events with a direct thrust on climate change knowledge and technology uptake and adaptation in Uganda. Thus, stakeholders played the role of validating and supplementing the outputs of the desk review.

3. FINDINGS AND SYNTHESIS

The following section highlights the findings and synthesis of this study.

3.1 Status of uptake

Limited literature exists on knowledge and technology uptake as subjects, with a direct thrust on climate change adaptation in Sub-Saharan Africa and Uganda in particular. This is, despite the vital role uptake plays in catalyzing efforts to coping with destructive climate change effects and extreme events, which presently define weather patterns in much of Sub-Saharan Africa. The term “uptake” seems to be less used, and is thus disguised behind other related terminologies such as adoption, diffusion and technology transfer.

3.2 Vulnerability to climate change and variability

Several studies have confirmed that Uganda, like many other African countries, is considerably vulnerable to climate change and variability [14, 12, 15, 16, 17, 18, 19]. Moreover, the level of uptake of climate change adaptation innovations in the country is generally insignificant, like in most other sub-Saharan African countries, despite the dramatic increase in climatic shocks and variability in the country [14]. This situation tends to prevail, notwithstanding the flux of local and regional efforts on combating climate risks, including international and regional agreements and policies in which Uganda is variously a party to including the United Nations Framework Convention on Climate Change (UNFCCC), The Paris Climate Change agreement, The East African Community Climate Change Policy, among others.

According to the International Climate Risk (CIGI) Report [20], the most dominant and widespread hazard due to climate change in Uganda is drought, whose intensity and frequency are on the increase. The report reveals that Uganda is one of the least prepared and thus most vulnerable countries to climate risks in the world. Moreover, according to the same report, Uganda has the least adaptive capacity, thus making adaptation the most priority area for targeting development efforts [21, 22].

3.3 Local community awareness and adaptive capacity

According to Environmental Alert [12] and [13], awareness among communities about climate change, its impacts and options for obviating vulnerability is generally low in Uganda. Even within the dismal knowledgeable community groups, there is heterogeneity at the different stakeholder levels; yet decisions are made and actions take which may aggravate, ameliorate, prevent or conserve the impacts of climate change. A living example is, due lack of access to credible weather information, farmers in West Nile still plan their farming activities for the traditional two rainy seasons per year; yet the sub-region presently receive only one long rainy season throughout the year [12].

171

172 According to Osbahr *et al.* [16], farmers in Uganda acknowledge the adverse to effects
173 of climate change, especially in terms of temperature increases and rainfall seasonal
174 vagaries and unreliability. However, several reports present no downward trend in
175 rainfall quantities; instead they reflect on a marked shift in intensity of rainfall events or
176 in the start and end of the rainy seasons[23].

177

178 Mangheni *et al*. [18] on the other hand, reported marked increase in awareness among
179 communities in Uganda about climate change and its disastrous effects on livelihood
180 resources. This is in direct contrast with previous literature, which consistently attested
181 to low levels of community knowledge of climate change and its vagaries [24]. The
182 drivers of the recent surge in awareness among communities in the latter case were not
183 alluded to by the report (18]. However, it could be due to the occurrence of the more
184 recent severe and lengthy droughts, which have caused failure and/or decimation of
185 hitherto promoted climate change coping strategies. The overall impact of the 2016-
186 2017 drought in particular, on agricultural resources in the country remains to be
187 assessed; however, it is visibly evident, for instance that previously promoted drought
188 tolerant crop varieties, totally succumbed to this disaster. Also, most rainwater
189 reservoirs previously designed to cater for household crop production needs till the next
190 cropping season, dried out completely and prematurely. Owing to this unprecedented
191 drought in recent years, stakeholders seem to be more than ready to pay attention and
192 receive climate change innovations that can avert the catastrophic effects of such
193 shocks. The likely danger is that research and development agencies are prone to
194 respond haphazardly in the usual uncoordinated manner [13], thus mixing up short and
195 long term interventions and, which may further the vulnerability of communities to
196 climate change disasters.

197

198 With respect to adaptive capacity to climate change, the communities and actors in
199 Uganda represent cases of the weakest groups at all levels along the climate change

value chain in sub-Saharan Africa [12]. Adaptive capacity is defined as the ability of a system to adjust and cope with climate change and climate variability, to minimise potential damages, seize opportunities, or cope with the repercussions [25, 26, 27]. According to UKCIP [27], adaptation can be inherently spontaneous or may be directed to respond to present or future changes in climatic conditions. Mendis *et al*. [26] shortlisted determinants of community adaptation capacity as wealth and its diversity, infrastructure, information, technology, culture, education, skills, health, institutions and their linkages, community cooperation and equity or social capital.

Uganda's weak adaptive capacity is mainly attributed to limited availability of livelihood options; inadequate or lack of support to climate change adaptation actions at all levels of policy and programme implementation; dismal awareness of climate change adaptation innovations and options [13, 28]; and routine planning without consideration of climate change variability and impacts. With the limited availability of alternative adaptive options, communities tend to resort to any perceived coping mechanisms, including those that are illegal and may be disastrous to their livelihoods such as theft and infidelity [12], but also extending production to forests, protected areas, wetlands and rangelands.

Climate change indirectly also results in weakened communities through frustrated families, leading to, for instance, increased alcoholism, domestic violence, and household abandonment by male heads, when the latter get overwhelmed with the impacts climate change [12]. These developments notwithstanding, there is hardly any proactive response in the country towards supporting viable community based climate change adaptation. Support often emerges after occurrence of major disaster floods, landslides and lengthy droughts. At national level, there is the Ministry of Disaster Preparedness, which is responsible for dealing directly with such disasters; but

evidence suggests that it is often ill-prepared and under capacitated in terms of personnel and funding to measure up to its expectations [29].

3.4 Role of local leadership and policy

The local leadership including policymakers are often positionally advantaged to highly influence uptake and diffusion of development extension messages in the country [29, 30]. Unfortunately, the level of knowledge related to climate change and its effect, on communities, is generally dismal among at various levels in Uganda (13). There is need for deliberately targeting of local government structures as outlets for climate change messages, by capacitating them with appropriate skills, information and training [13].

As far as policy is concerned, it is common practice that most natural resources policy formulation processes in the country inadequately involve policy implementers (communities), thus making the latter rarely committed to implementation process. As such, the expected outcomes of the relevant laws and guidelines are rarely actualised, as the implementers fail to agree with the aspirations of the policy originators (26). Besides, there are structural issues that hinder smooth coordination and harmonisation of the policies and associated laws, thus leading to confusion among implementers (12, 13). Most sector driven policies lack synergies with other sectors at implementation level. For instance, the Ministry of Water and Environment, is supposed to contribute to the performance of the agricultural sector; unfortunately, this is nearly entirely the domain of the Ministry of Agriculture, Animal Industry and Fisheries [26].

From the political standpoint, policy implementation is reportedly frequently interfered with by politicians, especially during elective political seasons [26]. This interference reportedly manifests in three modes, namely, manipulation of politically driven undertakings (e.g. projects); conflict of interest, whereby politicians attempt to save votes from the electorates by encouraging otherwise illegal natural resources destructive activities; and outright corruption [31, 12, 26, 32]. Definitive policies or policy interventions are needed to enhance adaptive capacity in the agricultural sector and uptake of adaptation technologies by farmers but also to protect the integrity of natural

resources whose persistent degradation continues to increase the vulnerability of agrarian communities to the impacts of climate change. Natural resource management and climate change adaptation efforts need to remain on course, irrespective of prevailing political events in the country. Otherwise, political leaders and policy makers should play instrumental roles in facilitating uptake and diffusion of climate adaptation innovations and protection of the integrity of ecosystems, by integrating them in routine local government funded activities and programmes.

Whereas the Uganda's National Climate Change Policy [33] provides for mainstreaming of climate change in all sectors and programmes, and the National Agricultural Policy [33] foresees the need for building climate resilience in agriculture, climate change adaptations issues have not yet adequately featured among the priorities of local programmes and projects that are implemented at community level. Ideally, policy makers should be concerned with raising awareness, building adequate capacities and helping to put capacities into action [34]; in addition, to resolving conflicts, reducing external effects that are triggered or reinforced by climate change, and ensuring that public infrastructure withstands future climate impacts [35]. Thus, the policy environment should not only be conducive for adaptation, but should also serve to facilitate appropriate innovations for creative adaptation to climate change impacts.

3.5 Mode of communication

In Uganda, most communication messages related to climate change adaptation are disseminated through environmental conservation systems, which is are mostly confounded with instructions such as "do not do" command messages, such as "do not cut trees", "do not dump litter in the streets" or ""do not build on wetlands". In addition, although some communities may be willing to comply with the regulations, they often genuinely posses no alternative options (13). Relevant development agencies need to flag out viable alternative options such as in the case of "do not cut tree", promote wide distribution of affordable energy-efficient cooking stoves and solar panels at affordable.

The media in Uganda play a major role in disseminating development messages to communities to both rural and urban communities across the country. In particular, there are hundreds of FM radios covering the entire country and broadcasting largely in local languages [36, 13]. This is partly because many rural Ugandans are unable to read well or even afford other media materials such as daily news papers. In 2009, the African Media Barometer report (36), reported 89% of households in Uganda owned a radio set, while 80% received radio signals. It should be noted that only the state-owned Uganda Broadcasting Corporation (UBC) covers the entire country with six channels, and mostly in different local languages [13]. Just over two decades ago, another national survey involving nearly 6,000 adults, revealed that 95% of rural respondents regularly listened to radio compared to 97% of urban folks. In yet another survey conducted in the same year revealed that up to 83% households accessed a radio in the country [13]. Hence, local FM radios are potential channels for enhancing uptake of climate change adaptation messages in the country [37].

One operational limitation for the radio medium for successful delivery of desired messages is the lack of journalist capacity to develop climate change messages that appeal to local audiences, with features that draw listenership attention [13]. Hence, there is need for appropriate journalists' capacity building to be able to engage with communities, opinion leaders and policymakers in the country, on matters related to climate change adaptation.

In terms of print media, newspapers are generally considered an urban medium, owing to the comparatively greater level of literacy required to understand them digest their contents [13]. In a survey conducted in 2008 involving 6,000 respondents, it emerged that 27% of rural respondents read newspapers regularly, contrasting with 56% of urban respondents. It also emerged that in most cases, a single newspaper copy was read by 5-10 people, wherever it was accessed [13]. Despite the low level of readership of newspapers, they were found to be important sources of information for the urban, the educated, the affluent, policy makers, politicians, business people and academics. In

fact, it is believed that the print media have a strong influence on key decision makers and are often determinants of stories picked up by radio and television media channels [13].

3.6 Role of indigenous knowledge

Farming communities in Uganda draw capital from environmental resilience to be able to defend themselves against climate change effects. As such, they use traditional ways of anticipating weather and supporting decision making based on environmental indicators [38, 39, 13, 40, 41, 42, 43], as part of their adaptation mechanisms. It is imperative that climate change experts leverage from this knowledge base [44] to strike a balance between utilising the power of indigenous beliefs and integrating scientific knowledge and innovations. Establishment of platforms for local communities and individuals with scientific or other climate related science expertise would allow dialogue between these two groups to articulate and learn from community experiences derived from climate change events [13]. Adger *et al*. [45] concluded that local community adaptation to climate change is constrained by issues of values and ethics, risk, knowledge and culture constructs which are mutable. According to Berkes [46] and Nakashima *et al*. [40], combinations of knowledge can lead to new innovations; proper conextualisation of local knowledge and practices can lead to further innovations and opportunities for adaptation through mutual learning (co-learning) and knowledge co-generation. William *et al*. [47] assert that traditional knowledge is useful in defining earlier environmental baselines, availing observational evidence for modelling, identifying impacts for mitigation, providing indigenous technologies for adapting, and for identifying traditionally relevant values for protection from direct impacts or from the impacts of adaptation measures themselves.

In Uganda, the number of local languages and dialects is estimated at more than 50 [13, 48]. This has made translation of technical climate change terminologies largely impractical. Moreover, use of local languages rich in vocabulary and with examples of household situational problems, to illustrate climate change (e.g. tree cutting, droughts),

makes the process pertinent and realistic to the affected communities, thus causing swift uptake and adaptation [13].

3.7 Funding mechanisms

Like in many other sub-Saharan countries, Uganda's national budgets are so constrained that programmes related natural resources management including climate change hardly receive direct priority attention [26, 49]. As such, there is recurrent over dependence on donor, also referred to as development partner support. This practice limits the scope of adaptation activities and balance of the implementation process to the interests and objectives of the development partners. Besides, this reduces implementation to the "project mode", whereby only adaptation strategies that fit within the specific objectives of the project are considered. A typical example of this is the National Adaptation Programme of Action (NAPA), which was formulated and implemented in the project mode [50]. When funding expired, further implementation of actions was virtually halted. National governments need to bring on board climate change adaptation activities, to ensure sustainability of implementation of climate impacts response actions.

3.8 Gender issues

Research has generally demonstrated that, to achieve sustainable community climate change knowledge and technology adoption, gender compliant climate change policy framework is a pre-requisite [51, 52]. Acosta *et al*. [48], in a desk review which also involved field work in Rakai and Nwoya districts in Uganda, concluded that gender and climate change were treated as cross-cutting issues that lacked priority consideration within the national budget. Besides, mainstreaming of gender was only relegated to an addendum rather than integral components in relevant natural resources and climate change policies, despite the anticipated adaptation benefits that accrue from entrenchment of gender [48]. According to Acosta *et al*. [48], there is need for strong coordination of gender related activities and accountability, in addition to addressing

structural constructs that impair women from accessing productive resources for climate change adaptation.

In a study conducted by the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS), involving Kenya, Uganda and Senegal, Twyman *et al*. [53] reported that both men and women changed their behavior in response to climate change, albeit relatively minor shifts in existing agricultural practices. The most prevalent changes reported included switching crop varieties, switching types of crops and changing planting dates. Women were less aware of many Climate Smart Agriculture (CSA) practices than men; though in many cases, especially in East Africa, women when aware, were more likely than or just as likely as men to adopt CSA practices [53]. Furthermore, access to information from different sources varied greatly between men and women and among the sites; though, those with access to information used it to improve their agricultural practices. From this study, it is apparent that targeting women and youths with climate and agricultural information is likely to result in greater uptake and widespread use of new adaptation knowledge and technologies.

3.9 Climate Smart Agriculture

Uganda, in recognition of the existing and anticipated impacts of climate change, designed and launched the Uganda National Climate Smart Agriculture programme for the duration of 2015-2025, under the auspices of two ministries, namely the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), and the Ministry of Water and Environment. This is a comprehensive document clearly outlining stakeholder consensus derived objectives, activities, respective actors in the implementation process, coordination and required budget support. Unfortunately, since its launching, hardly any information exists on empirical achievement of planned milestones thus far, against its clearly stated objectives. Otherwise, when properly implemented, this programme should be able to elevate the communities' adaptive capacity to climate

change impacts, and in particular promote uptake of verified knowledge and technologies.

3.10 Variability in onset and cessation of rainy seasons

Uganda's cropping systems are almost entirely rain-fed, and agronomic research has over the years vested efforts on fitting activities and crop life-spans within these agro-ecological cycles. As such, precise knowledge of the onset, length and cessation of rainy seasons is critical for ensuring optimisation of cropping activity cycles [54]. Determination of when to prepare land for planting specific crops is often occasioned by predictable patterns of the onset of rainfall [55]. This, until more recently, was rightly taken for granted by farming communities; but the present day vagaries in weather, characterised by shocks and stresses, have not only been greatly influential on the final crop yields, but have also led to losses of seed; the most critical input among farming communities. This shift in weather patterns has invoked rigorous research on determining the behavior of rainy seasons in some parts of sub-Saharan Africa [55, 56]. For instance, Omotosho *et al*. [56] developed empirical methods for predicting the onset and cessation, and seasonal amounts of rainfall at Kano in station in Nigeria. Mugalavai *et al*. [57] also analysed the two rainy seasons in western Kenya using soil water balance data in order to determine the patterns of rainfall onset, cessation and length of growing season. They found out existence of organised rainfall onset progression within the western Kenya region, whereby the long rains showed a southerly progression; while the short counterparts showed a south-westerly progression. Rainfall cessation for both seasons showed strong, but localised influences, particularly around Lake Victoria and forested areas, including orographic features.

Hardly any such investigations have been done for Uganda, a country typically characterised by a variety of agro-ecological regions, with a diversity of onset, cessation and duration of rainy seasons. Rainy season cessation, like onset, occurs variously for

different seasons and years. This directly affects the rainy season and certainly the crops that were developed to fit within specific seasons. While crops cut short by early cessations are devastated, especially during their reproductive stages, those that should mature early are wasted in the field as the drying conditions are interfered with, by excessive rainfall. In the latter scenario, seeds may germinate in the field before harvesting and diseases and pests may become problematic under these humid conditions.

Hence, the disorder within the rainfall patterns in the country might have not only disorganised farmer cropping patterns, but has also disrupted the disease and pest cycles to levels mismatched with farmer and scientists' predictions, and hence, management capacities. This is not helped by the persistently low farmer adaptive capacity to all these challenges.

3.11 Unreliable meteorological information

Meteorological information is important in helping communities plan their cropping activities and scientists breed for varietal improvements, especially within the rain-fed agriculture in SSA. Therefore, reliable information is critical in supporting farmer decisions for implementing farm activities; and adding credence to extension messages packaged to ensure uptake. The Uganda National Meteorological Authority (UNMA) is responsible for providing weather information to the farming communities in Uganda. Unfortunately, the pattern of information dissemination is inconsistent and unreliable [56, 58]; exemplified frequently by the opposite of what has been predicted tending to occur, thus sending mixed signals to the farming communities. Such messages lead to failed seed germination, thus causing repeated plantings, and mismatching cropping with rainy season cycles due to early/late onset/cessations of rainy seasons. This has great potential for discouraging uptake of climate change adaptation knowledge and technologies. UNMA owes the public a clear justification for providing inconsistent weather information leading to such crop failures and losses.

461 **Factors against uptake and proposed interventions**

462 Table 1 summarises the main factors constraining speedy and effective uptake of
463 climate change adaptation options, and proposes interventions in light of the above
464 status quo considerations.

465 Table 1. Major hindrances to swift and effective uptake of climate change adaptation
466 and proposed actions in Uganda
467

Factor limiting uptake	Proposed intervention
1. **Scattered knowledge and technologies:** There exists a range of climate change indigenous and scientifically derived knowledge and technologies with potential for uptake, but scattered among institutions locally and within the east African region.	(a) Efforts should be made to gather relevant information and technologies that can be tested under farmer conditions and packaged for subsequent dissemination for uptake. (b) Relevant institutions with such knowledge and technologies need to be mobilised to participate in the testing and dissemination processes. (c) Indigenous knowledge and experiences should be used as the foundation for introducing new climate change adaptation knowledge and technologies within communities.
2. **Suboptimal communication and extension** (a) There is a multitude of local languages and dialects in Uganda. This complicates	In the short run, the available information needs to be translated into at least the five major local languages (*Luganda*, *Luo*, *Runyakitara, Lugbara* and *Ateso*). (a) Employ entertaining/persuasive modes of dissemination, such as music (catchy

communication of climate change messages; which must be preceded by proper translation of terminologies, concepts and contexts. Unfortunately, several key climate changes related terminologies and concepts cannot be directly translated in local languages to impart the intended adaptation emotions and actions. (b) FM radios are the most effective media option for delivering messages among communities in the country. Apart from effective climate change communication being impaired by the range of languages, journalists lack the capacity to contextualise and package climate change issues for targeted dissemination. (c) Climate change messages are usually channeled through environment management systems characterised by community instructions such as "do not do" instructions such as	songs), drama and games that appeal to better understanding, learning and also help listeners to easily relate with the communicated information and thus improve uptake. This could be much more valuable than an information campaign in the newspapers or on the television. (b) Develop more innovative communication methodologies such as the radio 'skit' developed by the National Environment Management Authority (NEMA); this approach is known to reach audiences who are otherwise difficult to engage. (c) Climate change campaigners and civil society must be more pro-active in turning climate change related information into 'news' that the media can report. Campaigners need to seize the initiative and create news stories about climate change that do not require major disasters to happen to attract attention, and thus serve as postmortem rather than preventive measures. (d) Regularly review/revise climate change related messages in order to upgrade them to accordingly adjust to the

"do not build in wetlands", "do not cut trees" and "do not litter". This makes climate change development and extension agencies less friendly to communities; and thus creates an unfavourable environment for uptake of climate change adaptation knowledge and technologies.	dynamics of temporal and spatial weather changes.
3. **Technology misconception** Through research, hundreds of improved crop varieties have been developed in response to some of the climate change effects. These could greatly contribute towards increased food security in the country. However, many of the improved technologies carry negative or derogatory connotations such as "Kawanda" to imply a banana variety which is unnatural and, therefore, is either harmful to human health or less tasty than the "traditional" one.	(a) Climate change research and extension agencies ought to devise means of allaying community perceived fears related to otherwise harmless, yet stress alleviating technologies generated by scientists. This could be through ensuring, for instance, running farmer based participatory crop improvement/breeding research programmes. The research effort should also be linked with or directly derived from communities' needs and should be articulated to fit into the indigenous knowledge systems. (b) Research efforts need to me matched with policy adjustments so as to keep the target audience abreast with cutting edge innovations.

	(c) Politicians and policy makers who interphase directly with communities need to be equipped with proper information in order not to distort technology gains (e.g. policy briefs). (d) Greater focus into food and nutrition related innovations should be best anchored in women and youth groups which are invariably the most disadvantaged by climate change caused distress.
4. **Low adaptation capacity** Uganda is known to be one of the countries characterised by limited capacity to cope with climate change and its variability due to, among other factors, prevailing levels of poverty and illiteracy; factors that directly impair knowledge and technology uptake.	(a) Climate change development programmes ought to include more rigorous and coordinated community awareness campaigns, including training of both communities and extension service providers. (b) Access to credit should be enhanced particularly among the most vulnerable groups, which cannot afford the minimum costs associated with acquisition and implementation of climate change adaptation technologies and options. (c) Review curricular of agricultural resource management training institutions to strengthen their

	components of climate change adaptation and dissemination.
5. **Policies and policy environment** The level of knowledge about climate change effects and existing interventions with potential to move communities out of vulnerability is very low among policy makers and community leaders; who otherwise are best placed to directly interact with and enforce policies and programmes.	(a) Increase institutional capacity at local and national levels to develop climate change adaptation policies, strategies and programmes, shifting from a reactive response to a pro-active and anticipative preparedness approach. (b) Adequately involve communities in the formulation and implementation of climate change adaptation strategies and policies to facilitate community buy-in of new knowledge and technologies for adaptation. (c) In build the enforcement process of policies within climate change adaptation knowledge and technology uptake strategies. (d) Mainstream climate change considerations into agricultural sector policies, programmes and projects to advocate for planning based on “lessons learned”. (e) Climate change adaptation policy briefs need to be actively generated.
6. **Inadequate professional and institutional capacity**	(a) Improve the capacity of climate change professionals, including communicators such as FM radio staff and print media

(a) Implementation of climate change programmes and projects is impaired by inadequate expertise. (b) The number of in-country regional climate change research and adaptation/demonstration centres is inadequate to cater for community climate change adaptive capacity enhancement needs across the country's diverse agro-ecologies and social systems. (c) The Climate Change Department (CCD), located in the Ministry of Agriculture, is the overarching institution at the national level mandated to coordinate climate change adaptation actions in all the sectors and for all actors. It is particularly dreaded with skeletal staff and dismal funding to be able to martial the comprehensive and growing climate adaptation demands accruing from different sectors.	personnel to develop, package and disseminate suitable messages to the rightful stakeholders and at the right time. (b) Redesign the roles and diversify sources funding and other resources of the coordinating unit to be able to cope with the scope of the demands at local, national and regional levels.
7. **Ineffectiveness of traditional public and civil society extension agencies**	(a) Extension agencies should make efforts to innovate and embrace regional methodological paradigm shifts such as

The existing line extension agencies are unable to deliver agricultural development messages; thus are not in position for additional dissemination of climate change adaptation messages to effectively contribute to socio-economic development of the country.	the use of platforms involving innovation systems. This is defined by Klerkx [59] as a network of organisations, enterprises and individuals focused on bringing new products, processes, and forms of organisations into economic use, together with the institutions and policies that affect their behaviour and performance. It heavily contrasts with hitherto renowned linear extension models, which have clearly failed to deliver on the anticipated impacts on socio-economic development, especially in sub-Saharan Africa.

4. CONCLUSIONS

The level of uptake of knowledge and technology for climate change adaptation is too low to translate into meaningful resilience and socio-economic development among communities in Uganda. This is primarily due to several factors, the major ones being poor adaptive capacity caused by high illiteracy levels and poverty, scattered innovations among agencies and sectors, inadequate extension and communication systems, general lack of awareness about climate change in general and emerging scientifically derived innovations, suboptimal and development partner controlled research and development funding, gender technology insensitivity, and negative community attitudes towards otherwise potentially ameliorative innovations.

Proposed interventions include expansion of adaptive capacity through increased community literacy programmes and access to farmer friendly credit, and redesigning of the national climate change adaptation coordination systems and structures, especially the government department to match with the recurrently expanding demands as well as inter-sectoral nature of adaptation activities. Others include increased campaigns to

generate widespread awareness about climate change and its adaptation options, including a shift from the traditional linear knowledge dissemination methodologies to the regionally embraced innovation systems, involving partnership networks and enterprises.

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