

Local institutions and indigenous knowledge in adoption and scaling of climate-smart agricultural innovations among sub-Saharan smallholder farmers

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Abstract

Purpose – The purpose of this study is to discuss how enhancing the role of local institutions (LI) and incorporating indigenous knowledge (IK) in climate change adaptation planning can improve adoption and scaling success of climate-smart agriculture innovations.

Design/methodology/approach – A review of relevant literature from sub-Saharan Africa was used to answer the study research questions.

Findings – Embracing IK and LI in climate change adaptation projects can enhance adoption and scaling success of climate-smart agriculture innovations in smallholder farming. Such efforts will improve: information gathering and dissemination, mobilization of resources, establishment of useful networks with relevant stakeholders, capacity building farmers on various fronts and provision of leadership in climate adaptation programs.

Practical implications – Fully embracing IK and LI can improve the scaling of climate-smart innovations only if development partners recognize IK systems that are to be transformed and build on them instead of trying to replace them. Also, participatory approaches in scaling innovations will enhance input from rural people in climate change adaptation programs.

Originality/value – Development interventions aimed at taking proven effective climate-smart innovations to scale must, therefore, engage local communities and their indigenous institutions as active stakeholders in designing, planning and implementation of their climate adaptation programs.

Keywords Traditional knowledge, Local institutions, Climate-smart innovations, Smallholder agriculture, Upscaling

Paper type General review

1. Introduction

Climate change significantly threatens rural livelihoods in sub-Saharan Africa (SSA). This is partly because rural communities in Africa, particularly SSA, are relatively more vulnerable to the effects of climate change (Brooks *et al.*, 2005; Leichenko and O'Brien, 2002) than other regions (IPCC, 2014). The vulnerability of the rural communities in SSA to climate change



effects is a function of several social, economic, physical and environmental processes that increase their susceptibility to climate change effects. For instance, high dependence on rain-fed agriculture (Runge *et al.*, 2004), weak institutional capacities, limited knowledge, inadequate financial and technical resources necessary for climate change adaptation (Rockstrom, 2000), poor production techniques and incompetent policies towards use of productive inputs such as fertilizers and agrochemicals (Clay *et al.*, 2003) and poor governance (Brown *et al.*, 2007) are some of the factors making rural communities in SSA more vulnerable. The SSA region is exposed to climate risk through increased temperature, changes in rainfall patterns and variations in intensity and frequency of extreme weather events such as drought and floods (IPCC, 2014). The estimated impact of climate risk exposure in the region is huge. For instance, climate variability and change are predicted to continue decreasing agricultural production of major cereal crops in the region, including maize, sorghum and millet. Maize, sorghum and millet yields are estimated to fall by 22, 17 and 17 per cent, respectively, by 2050 (IPCC, 2007; IPCC, 2014; Schlenker and Lobell, 2010).

Problems related to weak institutional capacities, incompetent policies and limited knowledge of rural communities in climate change, and how they affect management, are of interest to this research. Evidence exists that the aforementioned can be improved in smallholder farming if climate change adaptation programs integrate local institutions (LI) and indigenous knowledge (IK) systems in climate change management programs (Agrawal, 2010; Ajibade and Eche, 2017).

IK is the institutionalized local knowledge built upon and passed on from one generation to another, usually by word of mouth. IK is often treated as secondary in climate change adaptation debates (Kronik *et al.*, 2010; Nyong *et al.*, 2007), even though it can form the basis for effective adaptation to climate change effects in smallholder farming communities. IK can be important in building climate resilience in smallholder farming communities through a better understanding of ways of promoting climate resilient innovations acceptable in those communities (Mafongoya and Ajayi, 2017), among various other reasons.

Furthermore, the problem of weak institutional capacities can be minimized by giving local community institutions and existing IK systems a central role in climate change management work in SSA. LI here are those localized humanly created formal and informal mechanisms that shape social and individual expectations, behaviour and interactions (Agrawal, 2010; Ostrom, 1990). Given the importance of local adaptation efforts to climate change effects in agriculture, it becomes critically important to better understand the roles that can be played by LI and hence find ways to enhance their contributions towards climate change adaptation. According to Agrawal (2010) LI are critical in effecting climate resilience in rural communities mainly because they:

- mediate between the individual and collective responses to climate change impacts and shape outcomes of climate adaptation;
- they structure the impacts and vulnerability to climate change; and
- they act as a mode of delivery of external support for climate change adaptation, and hence, they govern access to key resources for adaptation (Agrawal, 2010).

Therefore, strengthening the role of IK and LI in climate change effects management is likely to improve adaptation to climate change in smallholder farming communities in SSA. Improved adoption and scaling of climate-smart agriculture innovations are likely to benefit significantly. Research on climate-smart agriculture has shown numerous agricultural technologies and practices that can affect climate change adaptation in agriculture in rural agro-based communities (FAO, 2018). However, adoption of the same proven climate-smart

agricultural innovations is still low in developing countries and particularly in the SSA region (FAO, 2018; Nkonya *et al.*, 2018; Teklewold *et al.*, 2013). This article aims to highlight how adoption and scaling of proven climate-smart agricultural innovations in SSA can benefit from enhancing the role played by LI and strengthening efforts toward complementing formal knowledge systems with IK systems in climate change adaptation work in smallholder farming.

Innovations are defined in this article as the workable ideas, practices, products, or changes to rules or processes which involve the extraction of economic, ecological and social values from knowledge (Asenso-Okyere *et al.*, 2008; Meinzen-Dick *et al.*, 2013). Scaling is defined as a series of processes to introduce climate-smart innovations with demonstrated effectiveness, with the aim of improving geographic spread, ensure equitable access to the innovations and enhancing their livelihood impacts, following the definition by Mangham and Hanson (2010). Climate-smart innovations considered in this study include any workable ideas and practices relevant in climate change and variability adaptation in smallholder agriculture from weather-related, water related, seed/breed related, carbon/nutrient related and market/institutional related practices (see Table I).

The rest of the article is organized as follows. Section 2 outlines the study conceptual framework, while Section 3 presents a summary of the approach used in selecting relevant literature. Section 4 discusses how LI can be critical in spreading climate-smart agriculture innovations in smallholder agriculture while Section 5 gives a discussion on how incorporating IK systems can be of help in improving adoption and scaling of climate-smart agriculture innovations. Section 6 discusses necessary actions that need to be taken to enhance the role played by LI and IK systems, in adoption and scaling of climate-smart agriculture innovations in smallholder farming. Section 7 concludes the article.

2. Conceptual framework

The study relied on the adaptations, institutions and livelihoods (AIL) framework to critically analyze the potential influence of LI and IK systems in improving the adoption of climate-smart innovations in smallholder agriculture. Figure 1 summarizes the AIL framework. The AIL framework here shows how LI and IK shape the problem's (climate change) impact in society and also how adaptation and mitigation of the problem can be affected by the same institutions and IK systems. This study applies the same conceptual framework to see how LI and IK can affect the adoption and scaling of climate smart innovations of demonstrative effectiveness in smallholder agriculture. Several innovations are considered climate-smart in this study. Some of the innovations considered climate-smart are summarized in Table I.

Table I.

Example of climate smart innovations that LI can help in upscaling for improved climate resilience in smallholder agriculture

Innovation category	Weather smart	Water smart	Carbon/nutrient smart	Seed/breed smart	Institutional/market smart
examples	Weather forecast services Agro advisory services Weather insurance (e.g. index-based insurance)	Solar pumps Rain water harvesting Watershed management Small-scale irrigation	Conservation agriculture Integrated soil fertility management Agroforestry Crop diversification	Adapted crop and livestock species (e.g. drought tolerant maize and, indigenous livestock breeds) Community seed banks	Market information Credit Government subsidies Cross-sector linkages Membership to community institutions

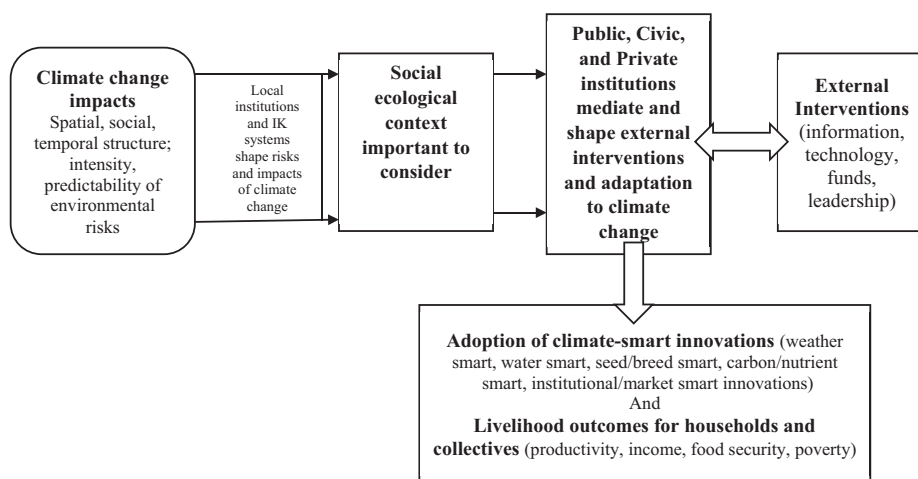


Figure 1.
Conceptual framework

Source: Adapted from Agrawal (2010)

The climate-smart innovations given are considered essential in effecting the upgrading of smallholder value chains in the face of climate change and variability.

According to the AIL framework, LI and IK structure the impacts of climate risks on smallholder farming households in a given social-ecological context. That is, LI or IK systems can determine the extent of harm by climate change to locals (e.g. local farmers).

In cases where strong LI or IK systems exist, farmers or local people can be supported to be resilient to the climate change shock, which may not be the case where weak institutions exist. Also, LI shapes the nature and degree to which households respond either as individuals or collectively. Where LI or IK systems are functional, necessary support can be given to farmers, which can aid their adaptation to climate shocks. It, therefore, implies that institutions and IK systems can influence (promote or discourage) collective action in the adoption of climate-smart innovations.

As highlighted in the AIL framework, LI and IK systems can also mediate the influence of the outside world in terms of adaptation to climate change. This implies that LI and IK systems in smallholder farming systems can determine external support in terms of finance, knowledge and other climate-smart interventions a particular community can receive. For instance, hostile LI who cannot form meaningful pacts with the external world limit support coming to their communities. Conversely, LI that develops a good rapport with external stakeholders may be better off in bringing resources (knowledge, finance, technologies) to the parent communities. This makes LI very important in climate change management in smallholder farming.

However, the effects of LI and IK systems will not be uniform across communities of varying socio-ecological contexts. Various factors will determine the exact manner and the extent to which LI and IK systems influence the adoption of climate smart innovations. As given in [Agrawal \(2010\)](#), nature and severity of climate change-related stress, household and community attributes and social and political contexts within particular local communities, among others, are some of the critical factors that can influence the exact manner in which LI can influence uptake of climate smart innovations. Also, community people's perceptions and trust in the available LI and IK systems are critical factors. Community people

(including farmers) are more likely to embrace LI and IK systems if they believe and trust in them [Nyong et al. \(2007\)](#). In addition, it is important to note that climate change adaptation is context-specific. Hence, the influence of LI or IK cannot be assumed to be the same on the adoption of different climate smart innovations.

In summary, the AIL conceptual framework shows how LI and IK systems influence: extent of climate change impacts felt by community people, how LI and IK systems can give first line defence in effecting adaptation to climate shocks (using local community resources) and how LI and IK systems can influence external support coming to the community to effect adaptation.

3. Review approach

The article is a synthesis of relevant published evidence on the role of IK and LI in upscaling adoption and impacts of climate-smart agricultural innovations in smallholder agriculture. Contender publications were identified mainly through Google Scholar search and forward searches of publications that cited relevant studies for the research topic. The Google literature search used several key words and phrases to gather relevant studies. Published literature was included in the analysis as long as it addressed any of the following:

- what IK or LI are and their roles/importance in adoption and scaling of technologies in agriculture; and
- how to enhance contribution from IK and LI in adoption and scaling of climate-smart innovations in smallholder agriculture.

Important to note, however, is that other supporting literature was cited outside the criteria given. For instance, some literature cited in building the introduction was not strictly selected based on the inclusion criteria. A flow chart summarizing the approach adopted in selecting literature is shown in [Figure 2](#).

From about 105 candidate publications that were reviewed (mainly by reading the title and or abstract), only 81 met the inclusion criteria. All literature referred to in this review were accessed and read.

4. What role local institutions can play in the adoption and scaling success of climate-smart innovations?

4.1 *What are local institutions?*

As highlighted earlier, LI are those localized humanly created formal and informal mechanisms that shape social and individual expectations, behaviour and interactions. Informal institutions are the set of informal rules that exist outside and alongside the structure of government while formal institutions are the laws and public policies written and documented ([Raymond and Weldon, 2013](#)). Both formal and informal institutions influence human behaviour and are, therefore, important in climate change management, especially in smallholder farming communities. LI important in climate change management can be categorized into civic, public and private institutions. Public institutions include the local governments (village and district administration), government agencies (e.g. research and extension agencies operating at local levels), while civic society institutions include local farmer organizations, cooperatives, savings and loan groups, local churches and other civic society groups based in local communities. Private institutions may include non-governmental organizations (NGOs), Charity organizations and private businesses (e.g. local agro-dealers in seed, fertilizer, agrochemicals, insurance, loan dealers).

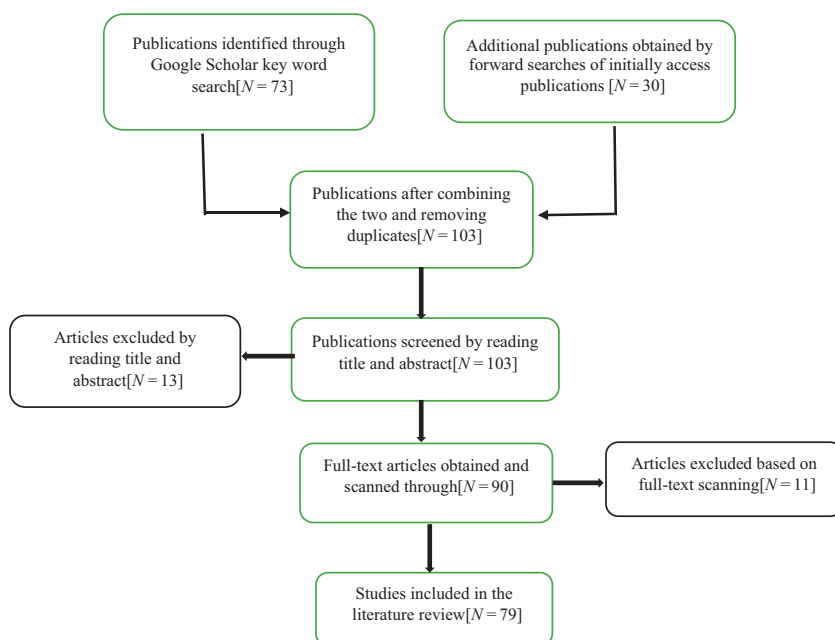


Figure 2.
Flow diagram
summarizing the
approach used in the
selection of literature

Examples of informal institutions can include women savings groups, traditional leadership, labour sharing groups and indigenous information exchange groups.

4.2 In what ways can local institutions be important in the adoption and scaling of climate-smart innovations?

As explained earlier under the study conceptual framework, LI are important in three aspects when it comes to climate change management debates:

- (1) They shape climate change impacts in a particular society.
- (2) They determine the type of adaptations actions taken by the people.
- (3) They determine external support coming to the local communities in climate change effects management.

Relevant to this article is the possible influence of LI on adaptation actions taken by farmers and the level of external support received by local communities.

It is evident from reviewed literature that LI in rural communities can be key in improving adoption and scaling success of innovations mainly through their influence on information gathering and dissemination on available innovations, skills development and capacity building, resource mobilization, creating networks, providing leadership among other functions (Agrawal, 2010; Raymond and Weldon, 2013) which are key elements for awareness and subsequent adoption of proven climate-smart innovations. Literature agrees to the fact that LI is key in facilitating the adoption and scaling of agricultural technologies (Ajayi *et al.*, 2018; Meinzen-Dick *et al.*, 2013). However, the effective participation of LI in the adoption and spread of climate-smart innovations is basically driven by their interests. For instance, private sector institutions will be more interested in making profit out of their

involvement in adoption and dissemination of climate-smart innovations, while the public institutions may be more interested in promoting adoption and scaling of innovations with benefits of more public than private good nature (Meinzen-Dick *et al.*, 2013). Practical examples include that of seed companies promoting adoption of stress adapted crop varieties and local government agencies pushing for resuscitation or development of irrigation infrastructure. Seed companies may have the prime aim of making a profit and growing their business, but it may not be the case for the local government due to the public nature of the irrigation infrastructure. In addition, local-level institutions, particularly informal institutions may be interested in promoting adoption and scaling of local-level climate-smart innovation options, e.g. locally adapted crop and livestock species or their innovations. For instance, in Tanzania evidence show that farmers innovate by developing their climate-smart agricultural practices (e.g. in erosion control, livelihoods diversification and changing cropping dates and patterns), which they aim to upscale (ActionAid, 2014). Also, in Ghana, farmers were reported to be more interested in promoting their climate-smart innovations (e.g. suppression of striga using onion residues) (Tambo and Wünschler, 2014).

Important to note, however, is the fact that, in some instances, local institutional arrangements can act as barriers to scaling of innovations. For example, unfavourable institutional arrangements in property rights, cultural views towards innovation, and gender norms may limit spread of innovations in rural communities. As alluded in Meinzen-Dick *et al.* (2013) at times, existing LI beliefs, cultural norms and practices may impede the adoption of certain innovations and hence make it more difficult for farmers to experiment and try new activities. Despite the possible drawbacks of LI, the following points highlight how LI can be important in promoting innovation, adoption and spread of climate-smart innovations through strengthening:

- access to climate-smart information services;
- skills development and capacity building;
- resource mobilization;
- building effective social networks; and
- ensuring visionary leadership.

4.2.1 Local institutions and climate-smart information provision. Access to information on climate-smart innovations like any other agricultural innovations is a necessary step for their adoption. This, therefore, means the ability of LI to convey information on relevant climate-smart agricultural innovations can be very important for adoption and scaling of such innovations. Climate-smart information services are essential as they inform farmers on current trends in climate and on various adaptation measures farmers can take. As derived from literature, state institutions are usually the providers of various information services, including weather and technical information services, mainly through agro-advisory services (Meinzen-Dick *et al.*, 2013). However, a lot of information gaps exist and act as barriers (costs) to the adoption of climate-smart innovations. According to McCarthy *et al.* (2011), the costs of searching for such critical information pose a significant barrier to the adoption and scaling of climate-smart innovations. Precisely, climate information services in agriculture have been reported to be narrowly focused (Levine *et al.*, 2011; Newsham and Thomas, 2011) and they diverge with local farmers' needs (in terms of accuracy, format, scale, preference and content of available products) (Vermeulen *et al.*, 2012). Moreover, formal climate information services have been reported to ignore local farmer perceptions, and differential farmer information needs (Chaudhury *et al.*, 2012;

Meinzen-Dick *et al.*, 2013), and this has made them less effective in availing efficient climate-related information services that can improve adaptation, through adoption and scaling of climate-smart innovations. Enhancing the role of LI, particularly informal institutions in providing climate information services can bridge the gaps, reduce costs of searching for information, and hence provide information which suits local farmer needs. In addition, enhancing the role played by LI can ensure equality in the provision of information by the socioeconomic status of farmers (i.e. wealth or gender). This is plausible because literature has noted that women or poor farmers who are excluded by formal information provision channels often resort to informal networks and exchanges (Meinzen-Dick *et al.*, 2013). For instance, kinship and informal social networks were found to be essential in information dissemination about improved seed and improved fallow in Kenya (Kiptot *et al.*, 2006). To boot, in western Kenya, local institutional partnerships, including churches, women groups, NGOs, youth groups, local leadership, government agencies amongst other local-level institutions were found to strengthen information flow and awareness on agroforestry practices (Qureish *et al.*, 2001).

4.2.2 Local institutions in skills development and capacity building for climate resilience.

It is evident from the literature that LI can also be important in providing skills development and capacity building for farmers with regards to climate-smart innovations and related services (FAO, 2018). For instance, it is alluded in Zilberman *et al.* (2012) that diffusion of technology adoption as an adaptation to climate change is a function of prevailing institutions that can foster or hinder adoption. Prevailing LI can encourage adoption by offering training, improving education and awareness on new or improved climate-smart innovations at the local level. Training needs for farmers have been traditionally provided by formal agricultural extension services in developing countries, including SSA (Aker, 2011; Anderson and Feder, 2007). However, most of the agriculture extension systems have been regarded not fit for purpose particularly when it comes to providing climate adaptation needs for farmers (HLPE, 2012) mainly because climate change itself is a new complex challenge which requires specialized training needs.

In Western Zimbabwe (Nyami Nyami area located in Kariba Rural district council), various local-level institutions (such as Christian Care, Red Cross, government extension and Save the Children) have been reported to offer training and skills development in climate change adaptation work (Mubaya and Mafongoya, 2017). Civic organizations and NGOs, in partnership with local traditional leadership, were noted to have contributed to the training of farmers in climate change management. LI were also reported to be actively improving the adaptive capacities of the rural people by offering various services including the drilling of wells, provision of water and sanitation services and offering disaster response preparedness services (Mubaya and Mafongoya, 2017). Such actions improve the adaptive capacities of local community people, including farmers. Also, churches have been reported to be active participants in capacitating farmers to adapt to the changing climate. For instance, in Kenya, church leaders are reported to be at the forefront in educating communities on climate change adaptation (Nzwili, 2014) in addition to advocating for external help from the developed world in climate change management. Also, research institutions such as ICRAF in Zimbabwe, Mozambique, Malawi and Zambia were noted as key participants in training farmers and local change agents in agroforestry technology establishment and management (Setimela and Kosina, 2006). Further, evidence exists in SSA of local community-level institutions improving capacities and skills of farmers for climate change adaptation. For instance, innovation platforms (IP) and cooperatives are reported to be improving capacities for farmers in problem identification and proffering of

sustainable solutions to identified problems in farming communities (Abebaw and Haile, 2013; Ajayi *et al.*, 2018; Verhofstadt and Maertens, 2014).

4.2.3 *Local institutions and resource mobilization for climate-smart innovation adoption.*

Further, it is evident from the literature reviewed that enhancing the role of LI in climate-smart agriculture work can also assist in resource mobilization, which is critical for the adoption of climate-smart innovations by farmers. It is evident in the available literature that access to resources significantly explains the adoption of agricultural technologies (Lansing and Markiewicz, 2011; Legese *et al.*, 2009), which is also true for climate-smart innovations. It, therefore, implies that for effective adoption and scaling of innovations in poor communities there is need for sustainable resources support. As much as LI (through social capital and networks) critically help in sourcing resources locally, as climate change effects worsen, it may be necessary to consider adoption of a diverse set of climate-smart innovations, or new set of innovations which require more resources. In this case, external support will be required to improve farmers' capacity to adopt new innovations. This explains why Church leaders in Kenya have joined other stakeholders in advocating for support from developed countries (who have immensely contributed to carbon emissions) in local climate change management (Nzwili, 2014). LI can also help external institutions to align their interventions with local needs, which enhance the effectiveness of such external interventions. According to Agrawal (2010), all external interventions in climate change adaptation for rural communities need local institutional collaborations for the effectiveness. However, the level of collaboration with LI will depend on the type of innovations to be adopted by farmers (Meinzen-Dick *et al.*, 2013). For instance, adoption actions at individual farmer level, e.g. adoption of stress-adapted crop and livestock species may not require much in terms of institution coordination when compared to higher level (community level innovations) e.g. building of a community water reservoir. At such levels, collective action institutions involving both formal and informal institution collaborations are most appropriate.

Some notable examples exist across SSA, where LI have influenced resource mobilization in farming communities. LI, such as farmer cooperatives, community groups, community financing schemes, women savings groups, among others, have been reported important in mobilizing resources for climate change management. For instance, in Malawi, credit savings groups have been reported to be key in mobilizing inputs and resources for small and medium enterprises, including farmers (Chipeta and Mkandawire, 1992; GOM, 2006). Further, farmer cooperatives in Rwanda and Ethiopia were reported to be key in enhancing farmers' access to farming inputs and other resources (Abebaw and Haile, 2013; Makate, 2019; Verhofstadt and Maertens, 2014). However, as reported in Preker *et al.* (2001), the main weakness of some LI such as community financing schemes are the low volume of resources that can be mobilized in poor communities, the frequent exclusion of the very poorest members from participation in such groups, limited management capacity and relative isolation from more comprehensive benefits from resource providers (e.g. formal banks).

To sum up, the local level institutions play a key role in structuring access to and control over resources, in addition to facilitating access to resources outside of communities.

4.2.4 *Local institutions in network building.* LI also assists in building useful networks (linkages), which can be crucial in enhancing the adoption of climate-smart innovations. Social capital is shown to explain adoption of climate-smart interventions in literature (Isham, 2002; Teklewold *et al.*, 2013), and for this reason, development interventions in rural communities have been found to rely on networks and group-based approaches in tackling different kinds of problems (Meinzen-Dick *et al.*, 2013). For the same reasons, agricultural research and development institutions in SSA are promoting participatory

approaches (e.g. integrated agricultural research for development through IPs) (Mango *et al.*, 2015) to improve useful linkages/networks of farmers with key-value chain actors. Effective networks will ensure that farmers are linked to key agricultural value chain actors, e.g. input and output markets and that the farmers receive necessary information about innovations. Informal institutions (IK, norms and kinship ties) are an alternative in cases where formal institutions have failed to serve community needs in building useful linkages for agricultural technology transfer (Matuschke, 2008; Newsham and Thomas, 2011). In addition, the promotion of farmer to farmer extension models in scaling agricultural technologies in SSA by research and development partners provide more evidence on the importance of LI in building networks for improving climate change management (Ajayi *et al.*, 2018). Such extension models bank on farmer social networks to enhance adoption and spread of technologies in smallholder agriculture. The overall implication is that, at the local community level, institutional linkages, social networks and social capital can be vital in facilitating and supporting adoption and scaling of proven climate-smart innovations.

4.2.5 Local institutions in governance and political advocacy for climate-smart agriculture. LI can also be important in ensuring adequate leadership for climate change management projects in rural communities (Makate, 2019). The importance of LI can be in the form of creating a conducive environment for climate change management work or direct support towards climate change management interventions. Furthermore, LI, such as churches, traditional leadership, schools and other societal groups, can enhance climate change management work through lobbying for political will and support from political players (Ajayi *et al.*, 2018). Political support is essential in expanding and sustaining climate-adapted innovations adoption and scaling projects (FAO, 2009; Kohl and Cooley, 2003). Important to note, however, is that the focus should be on building coalitions of political stakeholder support and commitment as political parties come and go while adoption and scaling up works are long-term processes. If not managed carefully, political advocacy can bring risks to the adoption and scaling process. In literature, some scaling projects failed to get political support by current leaders because scaling initiatives were initiated by political rivals (Roothaert and Kaaria, 2004). LI should, therefore, provide adequate leadership and support in lobbying for sincere support by political players in climate change management works, for effectiveness. In leadership, attributes such as accountability, vision, among others, are essential as well. In cases where local leadership lacks vision and accountability, LI can be pure sources of inertia and corruption (Lowndes, 1996), which can act against successful adoption and spread of climate-smart innovations.

5. Indigenous knowledge (IK) and climate-smart agricultural innovations

5.1 Indigenous knowledge and its characteristics

5.1.1 What is indigenous knowledge? IK is the institutionalized local knowledge built upon and passed on from one generation to another, usually by word of mouth (Osunade, 1994). Various organizations have come up with various working definitions for IK. For instance, Convention on Biological Diversity (2001) defines traditional knowledge as the knowledge, practices and innovations of indigenous and local communities around the world. The United Nations Educational Scientific and Cultural Organization (UNESCO) (2002) defines IK as the understandings, skills and philosophies developed by societies with long histories of interaction with their natural settings. Similarly, the World Intellectual Property Organization (2004) defined IK as the skills, know-how, innovations, practices passed on from generation to generation in a traditional context and that form part of traditional lifestyle of the indigenous people and communities.

5.1.2 Characteristics of indigenous knowledge. All the definitions of IK support the idea that IK is developed from experience gained over time and is adapted to local community cultures and their environment. Also, traditional knowledge is transmitted orally from one generation to another, and it tends to be collectively owned. IK is often in the form of stories, proverbs, folklore, cultural values, rituals, beliefs, community laws, local languages and agricultural practices (Convention on Biological Diversity, 2001). IK is also key to decision making on aspects of day to day life for the rural people.

5.2 Role of indigenous knowledge in the adoption and scaling of climate-smart agriculture innovations

How can IK be useful in the adoption of climate-smart agriculture innovations in smallholder farming in SSA? It is unanimously agreed in literature that utilization of IK by rural communities in poverty-stricken areas in SSA has helped them to thrive in extremely harsh environments in the past (Hart and Mouton, 2005; Van Veldhuizen *et al.*, 1997). Historically, IK is said to have contributed significantly to developments in agriculture worldwide, such as domestication of crops and livestock, conservation of agrobiodiversity resources, development of animal traction and exchange of plant and animal species (Mettrick, 1993). This implies that IK can be critically important for scaling climate-smart innovations in smallholder agriculture. Policymakers and other stakeholders interested in improving adoption of CSA innovations need to understand that, rural communities have been adapting to climate change even before in various innovative ways and that external interventions can only be successful if they build on what already rural farmers have been doing to adapt to climate. According to Altieri (2004), traditional farmers have developed diverse and locally adapted agricultural systems for centuries, and have managed them with indigenous practices that were often effective in ensuring food security and sustainability (Altieri, 2004).

Literature has shown that indigenous people have been excellent in providing weather-smart information services (Mafongoya and Ajayi, 2017) for agriculture. Literature from SSA confirms the reliance on tree phenology, animal behavior, astronomy and moon movements, just to give a few examples, by indigenous people to predict climate (i.e. onset of rains, and season quality) (Kalanda-Joshua *et al.*, 2011; Mafongoya *et al.*, 2017; Roudier *et al.*, 2014). For example, in Zimbabwe, indigenous people profoundly relied on studying life cycle of trees and animals to predict events of the climate system, including rainfall, wind, floods, temperature and seasonal changes to drought (Chanza and de Wit, 2015). In Muzarabani, Zimbabwe, indigenous people were found to use *munanga* (*Acacia nigrescens*) blossoms to predict early onset of the rainy season, abundance of termite colonies seen collecting biomass into their mounds, the appearance of migratory birds and large number of Christmas beetle (*Anoplognathus* spp.), to be associated with normal or above normal rainfall season, with a possibility of flooding in low lying areas (Chanza, 2014; Chanza and Mafongoya, 2018). Indigenous climate services in the aforementioned literature are highly praised for offering climate services that are at a much-required high resolution (local scale). It therefore means, embracing indigenous weather-smart innovations can complement scientific formal weather services as they are often given at lower resolutions (high temporal and spatial depth) (Mafongoya *et al.*, 2017).

Also, indigenous people have been promoting seed/breed climate-smart agricultural innovations in an attempt to adapt to climate change. For instance, in SSA, rural farmers have always diversified their farming/livelihood systems by including underutilized crop, livestock and insect species (Jiri *et al.*, 2017), and have been promoting local crop and livestock breeds (Liwenga, 2017; Mafongoya and Ajayi, 2017). It, therefore, means scaling

climate-smart innovations can learn and build from what local communities have been doing in adapting to climate in such communities in the past. Likewise, in soil fertility management, farmers have been using traditional methods to improve soil quality, e.g. land fallow (Sanchez, 2002; Vanlauwe *et al.*, 2010). In Lesotho, indigenous farmers have used traditional farming systems, e.g. the *Machobane farming system* (Mafongoya and Ajayi, 2017), to improve soil fertility under climate change.

Further, adoption, scaling and sustainability of water-smart innovations, such as rainwater harvesting, have also benefited from IK systems in SSA (Mbilinyi *et al.*, 2005; Reij *et al.*, 2013). The success of such systems has been mostly because of the compatibility of water-harvesting systems with local styles, LI and local social systems.

Adoption and scaling of innovative practices in natural resources management have also benefited from IK (Luoga, 1994; Luoga *et al.*, 2000). Three key features of IK that are important in indigenous resources management include social organization that control access to natural resources in the community, indigenous utilization techniques for conserving and preserving resources, and the customary norms and procedures for control, acquisition, maintenance and transfer of natural resources (Luoga, 1994; Luoga *et al.*, 2000).

What it means then is that, actions of development partners, both private and public, to enhance adoption and scaling of climate-smart innovations, should first understand and learn from indigenous communities on what they are already doing in terms of climate change management, and then build on such efforts in promoting adoption and scaling of innovations. This becomes more important as it has been found in the past that in areas characterized by modern agricultural practices, traditional practices are often disrupted and IK is abandoned (Altieri, 2004).

6. How indigenous knowledge and role of local institutions can be enhanced for improved resilience to climate change in sub-Saharan Africa

With impeccable evidence that IK and LI play a critical role in the adoption and scaling of climate-smart innovations, the key question will then be how to effectively embrace IK and LI for effective adoption and scaling of climate-smart innovations. This article highlights some important considerations that can enhance role of IK and LI in climate change management.

6.1 Enhancing the role of local institutions

The role of LI can be enhanced in various ways. Useful partnerships amongst LI themselves, for example, is one way of getting the best out of LI in performing their role in scaling climate-smart innovations. In SSA, we have seen the rise of the IP approach (Fatunbi *et al.*, 2016), which aims to promote innovative farming practices through useful partnerships of smallholder value chain actors, including farmers, input suppliers, researchers, marketers, and LI. Such partnerships, through the IP, give voices not only to farmers but also LI, which increases the likelihood of meeting local community needs in terms of climate-smart innovations.

In addition, there is a need to improve the capacities of the LI to enhance their effectiveness. That is to say, capacity building LI with the necessary resources (human capital, financial, technology, information, etc.), is also key if they are to be real champions in taking climate-smart innovations to scale. Also, LI must have useful partnerships with the external world for them to be effective in their role. As climate change effects worsen, LI alone may not effectively keep pace with adverse impacts; hence, they will need to have useful and effective partnerships with the external players, to build upon their capacities.

Moreover, to improve the adoption of climate-smart innovations at the community level, there is a need to give LI who are directly linked to farmers a central role in promoting the innovations. LI must be handed central responsibilities in designing, planning and implementing policies, projects and programs meant to scale adoption of the innovations (Meinzen-Dick *et al.*, 2013). Further, LI are also important as they can promote innovation in local communities (ActionAid, 2014; Tambo and Wünscher, 2014). However, for this to happen, and as highlighted earlier, there is need for investment in capacity development/building of LI. It is however, important that external players understand which LI are present in the communities they will be targeting, including their capacities, interests, connections, challenges and strengths before offering external support. With this, they can increase chances of success for their interventions, by complementing activities of LI already working in such communities.

LI must be visible in designing, planning and implementing of projects which aim to improve the adoption of climate-smart innovations. Further, research on what kind of institutional arrangements best facilitate the adoption of climate-smart innovations across space and time should be a priority for evidence-based decision making.

6.2 Getting the best from indigenous knowledge systems in scaling climate-smart innovations

The literature reviewed has shown IK to be critically important for climate change adaptation in rural communities. For instance, Nyong *et al.* (2007) found the sustainability of agricultural projects in local areas to be highly sustainable if local people are seen as partners in the project with joint ownership. It, therefore, implies that IK can never be ignored in efforts to promote sustainable agriculture under the changing climate.

The noble thing to do to get the best out of IK systems in spreading climate-smart innovations will be recognizing its existence and then incorporating it into designs, plans, and implementation frameworks for promoting innovations. Incorporating IK can be done best by seeing local community people and their LI as core stakeholders in climate change management. Agricultural projects for building resilience to climate change should see local communities as equal partners in development. It is highly important that indigenous people should carry greater responsibilities for their development and external partners should only back their efforts. In support, an electric combination of old and new knowledge, in a mixture made and controlled as far as possible by the rural people themselves may yield positive impacts. This can be accomplished by creating the conditions in which traditional rural knowledge can change from being mainly a system of classification to being also a means for setting in motion cumulative change (Swift, 2009).

In addition, capacity building by external partners should emphasize the need to build on what already exists as IK plays a significant role in the sum total of what exists in a local community (Nyong *et al.*, 2007). Also, a bottom-up approach is desirable if development partners are to get the best out of IK systems. If development partners adopt a bottom-up approach, it will ensure high level participation of local communities which hence improve chances of success. Bottom-up approaches will be important as they provide insight to development partners on how communities and households interact. In addition, the bottom-up approach gives a chance to local communities to acquire necessary skills for them to forge their own paths to sustain agricultural development programs.

Most importantly, IK should not be developed or harnessed as a substitute for formal scientific knowledge. The objective should be to find best ways of complementing IK and formal knowledge systems for enhanced climate resilience in smallholder farming. This is plausible because research has found that a hybrid of external institutions and indigenous

practices enhance adaptive capacity and resilience of local communities to climate change (Upton (2012) for an example in pastoral communities).

7. Conclusion

Several concluding points and recommendations are derived from this research:

- First, it is clear from the study that LI are important for climate change management in smallholder farming communities in rural Africa. They have a big role to play in guiding successful adoption and scaling of climate-smart agricultural practices of demonstrated effectiveness. The research and development community should therefore give LI a central role in works aiming to improve adoption and scaling success of climate-smart agricultural innovations in SSA.
- Second, IK is also a backbone of adaptive management in smallholder farming communities in Africa. IK has helped communities adapt to harsh environments in the past and will certainly continue to help them adapt to harsh environments (e.g. climate change) now and in future.
- Third, establishing useful partnerships of LI at community level and also with the external world (outside communities) is likely to enhance their effectiveness. In addition, capacity building of LI and their personnel and improving their access to resources is vital for their effectiveness in promoting adoption of climate-smart innovations.
- Fourth, to get the best out of IK, research and development partners should find ways of complementing IK with scientific knowledge in climate change management works targeting rural communities. The mixture of old and new knowledge, however, should be made and controlled as far as possible by the indigenous people themselves.

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