Climate Policy

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tcpo20

Smallholder farmers' engagement with climate smart agriculture in Africa: role of local knowledge and upscaling

Ayorinde Ogunyiola, Maaz Gardezi & Sumit Vij

To cite this article: Ayorinde Ogunyiola, Maaz Gardezi & Sumit Vij (2022) Smallholder farmers' engagement with climate smart agriculture in Africa: role of local knowledge and upscaling, Climate Policy, 22:4, 411-426, DOI: 10.1080/14693062.2021.2023451

To link to this article: https://doi.org/10.1080/14693062.2021.2023451

CLIMATE POLICY
2022, VOL. 22, NO. 4, 411–426
https://doi.org/10.1080/14693062.2021.2023451

Taylor & Francis
Taylor & Francis Group

SYNTHESIS ARTICLE

OPEN ACCESS Check for updates

Smallholder farmers' engagement with climate smart agriculture in Africa: role of local knowledge and upscaling

Ayorinde Ogunyiola [a], Maaz Gardezi [b] and Sumit Vij [c,d,e]

[a]Department of Forestry & Natural Resources, Purdue University, West Lafayette, USA; [b]Department of Sociology, Virginia Tech, Blacksburg, USA; [c]Public Administration & Policy Group, Wageningen University and Research, Wageningen, The Netherlands; [d]Earth & Climate Cluster, Department of Earth Sciences, Vrije University Amsterdam, Amsterdam, the Netherlands; [e]Geneva Water Hub, Institute for Environmental Sciences, University of Geneva, Switzerland

ABSTRACT

Climate-smart agriculture (CSA) is an important discourse among national governments in Africa and international policy circles to increase food productivity, build smallholder farmers' resilience to climate change, and mitigate greenhouse gas emissions. Despite presenting several potential economic and environmental benefits to farmers, its adoption among African smallholder farmers is low. Two important aspects that influence the adoption of CSA are inclusion and exclusion of farmers' local knowledge and how CSA is upscaled among smallholder farmers in Africa. This article uses a systematic review methodology to demonstrate that the existing literature (between 2010-2020) on CSA has substantially addressed issues that hinder its upscaling in Africa, such as heterogeneous farming systems, limited finance, high cost of agricultural inputs, and technology. However, only eight of 30 articles included in the systematic review indicate challenges pertaining to inclusion or exclusion of local knowledge in CSA practices and technologies. Policymakers and academics need to rethink how smallholder farmers' local knowledge can enhance opportunities and fulfil the potential to upscale CSA in Africa.

Key policy insights:

- Implementing stronger land tenure regulatory frameworks are critical for upscaling CSA practices and technologies in Africa.
- Governments and development partners need to implement inclusive financial policies and institutional arrangements in consultation with smallholder farmers to improve upscaling of CSA in Africa.
- Development partners need to approach local knowledge with care and respect, if CSA is to become more inclusive for smallholder farmers in Africa.
- Effective scaling of CSA is vital for climate change adaptation and mitigation in Africa.

ARTICLE HISTORY
Received 15 January 2021
Accepted 23 December 2021

KEYWORDS
Climate-smart agriculture; local knowledge; inclusion and exclusion; upscaling climate action; Africa

1. Introduction

Climate-smart agriculture (CSA) encompasses innovative farming practices and agricultural technologies, such as agro-forestry systems and drought tolerant crops varieties, that aim to address three pertinent challenges of the twenty-first century: climate change adaptation, mitigation, and food security (Newell & Taylor, 2018; Taneja et al., 2014). In the last decade, development partners have ramped up their financial and technical support for effective scaling of CSA in Africa. For instance, between 2016 and 2018, the World Bank approved CSA projects worth US$3.8 billion to support 30 African countries in their pursuit to increase climate resilience and on-farm

CONTACT Sumit Vij sumit.vij@wur.nl
Supplemental data for this article can be accessed https://doi.org/10.1080/14693062.2021.2023451.

livelihoods of almost 5 million farmers (World Bank, 2018). Through small-scale on-the-farm pilot CSA projects and large-scale investments by development partners and the private sector, the African Union Development Agency envisions that by 2025 at least 25 million farming families will have adopted CSA (Shilomboleni, 2020).

Despite the large-scale financial and technical commitments for CSA by the global development community and its potential sustainability and economic gains for smallholder farmers and the environment, there are several critical challenges associated with African smallholder farmers' adoption of CSA (Branca & Perelli, 2020; Chandra et al., 2017). Previous studies highlight that the majority of CSA technologies are expensive and unaffordable for most smallholder farmers in Africa (McCarthy et al., 2011; Zougmoré et al., 2016). For farmers who are willing and able to transition to CSA, other challenges such as inadequate institutional support, including insurance schemes and financing mechanisms, weak regulatory frameworks such as tenure rights and land management frameworks, can hinder their propensity to adopt CSA (Harvey et al., 2014; Neufeldt et al., 2013; Scherr et al., 2012). Studies also show that CSA approaches can be more successfully upscaled in Africa if they are able to contextualize the unique heterogeneous characteristics of smallholder farmers, such as differences in farmers' traditional values, and existing farming systems, such as pastoral farming and root crop production methods (Westermann et al., 2018; Williams et al., 2015). Previous studies have found that age, education, farm size, and farm ownership, have an impact on whether smallholder farmers can or cannot successfully adopt CSA (Chandra et al., 2017; Westermann et al., 2018). Since heterogenous characteristics of smallholder farmers, such as their level of education and local knowledge, can impact their engagement with CSA, it is important to understand how this heterogeneity will allow some, but not all smallholder farmers to build adaptive and mitigative capacities. Indeed, the 'scaling up' of CSA from micro-scale programs and pilot projects to large-scale and regional initiatives constituting large numbers of smallholding farmers requires practitioners and policymakers to address ways in which CSA practices and technologies can build synergistic partnerships with smallholder farmers' traditional farming knowledge and work practices (Karlsson et al., 2018).

Scientific knowledge is characteristic of advanced machinery and technologies of state and non-state actors, such as corporations and universities. Scientific knowledge differs from indigenous knowledge, which is isolated and related to a particular rural community (Agrawal, 1995; Warren, 1989). A critical distinction between scientific and indigenous knowledge is evident in how a phenomenon is observed. Scientific knowledge holds the ability to logically interpret data through abstract principles. In contrast, indigenous knowledge relies on intuitions and evidence to draw interpretation (Agrawal, 1995). In most policy arenas, scientific knowledge is believed to be superior to indigenous knowledge. As a result, scientific knowledge is often used in policy decision-making processes, while traditional or indigenous knowledge is ignored (Steenwerth et al., 2014). In this study, traditional ecological knowledge is defined as practices and beliefs held by humans in relation to non-human nature that emerges, co-evolves, and are often transferred from one generation to another (Berkes, 1993, 2012; Makondo & Thomas, 2018). In traditional agrarian societies, traditional ecological knowledge can form the core of a community's culture of farming, such as various indigenous forms of farm management practices and smallholder farmers' social identities. Our conceptualization of traditional knowledge is also similar to FAO (n.d.) that implies that individuals in 'rural areas are isolated from the rest of the world and that their knowledge systems are static and do not interact with other knowledge systems'. In contrast to scientific knowledge, local knowledge constitutes narratives held by indigenous people and are often not written in textbooks or training manuals (Alexander et al., 2011). Local knowledge is therefore, 'not confined to a particular group of people or to the original inhabitant of an area' (FAO, n.d.). This study defines local knowledge as a set of skills, technologies, and practices that have emerged from the experience of people and communities, attached to history, local culture, and environment, and are identified as norms and embedded in community practices (Beckford & Barker, 2007).

The transition of African smallholder farmers to using CSA requires them to become comfortable with learning new approaches to farming, trusting new knowledge and related advisory support systems, and transacting in new markets. For example, implementing CSA requires some smallholder farmers to adopt genetically modified (GM) crops or participate in new agricultural supply chains. In doing so, smallholder farmers' may have to surrender their traditional ecological knowledge and technological means of controlling weeds, pests, plants, and harvests (Kronik & Verner, 2010; Nyong et al., 2007). For instance, it has been documented that modern weather forecasting and early warning systems using information technology sometimes do not integrate effectively with farmers' traditional ways of understanding or interacting with weather and climate phenomena. In this case, smallholder farmers are relinquishing their local foresting knowledge, such as visually monitoring clouds, in return for using meteorological forecasts to mitigate and adapt to climate variability (Speranza et al., 2010).

Against this backdrop, we use a systematic review methodology to answer the following questions: (1) In the last decade, how has smallholder farmers' local knowledge been included or excluded in CSA practices and technologies in Africa; and (2) how are CSA practices and technology possibly upscaled in Africa? This article uses an interpretive approach to analyze the CSA literature systematically, drawing meanings and interpretations from the literature. This interpretive approach embraces views about a reality that are socially constructed and are important through the actor's understanding of a particular problem, concept or theme and the discourse around local knowledge and effective scaling of CSA innovations in African smallholder agriculture. From the articles reviewed, concepts and themes are not determined a priori, but they emerge from the CSA literature on local knowledge and upscaling in Africa.

The remainder of the paper is structured in the following manner. The next section elaborates on the methodology, detailing the data collection, study selection, analytical approach to data analysis, and the study limitation. The findings of the analysis are presented in section 3, highlighting different themes that emerge from articles included in the review. Section 4 discusses these findings and offers suggestions on literature and implementation gaps with respect to local knowledge and upscaling in the literature in Africa, followed by concluding remarks in section 5.

2. Methods

In this section, we discuss the methods used to retrieve articles related to inclusion and exclusion of smallholder farmers' local knowledge and the possibilities and perils of upscaling CSA in Africa.

2.1 Data collection

To explore the questions this study poses, we conducted a systematic review of literature following the reporting standards for systematic evidence synthesis (ROSES) framework (Haddaway et al., 2018). ROSES provide a meticulous, transparent, and standard guideline to collect relevant literature on a topic related to social-environment interactions (Haddaway & Macura, 2018). Based on this review protocol (see supplementary material 1), we conducted our literature search in Scopus and Web of Science (WoS) databases in August 2020. We searched these databases using several search queries such as (TITLE-ABS-KEY ('climate-smart' AND agric*) AND TITLE-ABS-KEY ('Mitigat*' OR 'Food Secur*' OR 'Adpat*')) in Scopus and (TOPIC: (*climate-smart and agric*) AND TOPIC: ('Mitigat*' OR 'Food Secur*' OR 'Adpat*')). We combined keywords such as 'Africa' and its five regions ('Northern', 'Central', 'Southern', 'East', and 'Western') with other keywords such as 'climate change' and 'agriculture'. For the purpose of this study, the literature search was limited to peer-reviewed studies published in English between 2010 and 2020, and articles were included when there was an apparent reference to either inclusion and exclusion of local knowledge and upscaling CSA in Africa.

2.2 Data screening

Search query results were exported into a repository and rearranged into the following categories: author names, title, publication year, journal, abstract, and document type. The following steps were used to screen the articles and conduct data analysis (see Figure 1). First, we merged results from the two electronic search databases, which yielded 3594 unique records from Scopus (1848 results) and WoS (1746 results). We removed 3155 duplicate articles, while 439 potential articles were left for further analysis. In the second step, we applied our inclusion and exclusion criteria (see supplementary material 1, table 3) to screen the title, abstract, and keywords of each article in which we excluded 389 articles. Fifty (50) articles met our inclusion criteria. We applied the same eligibility criteria to the full text of each study that remained after

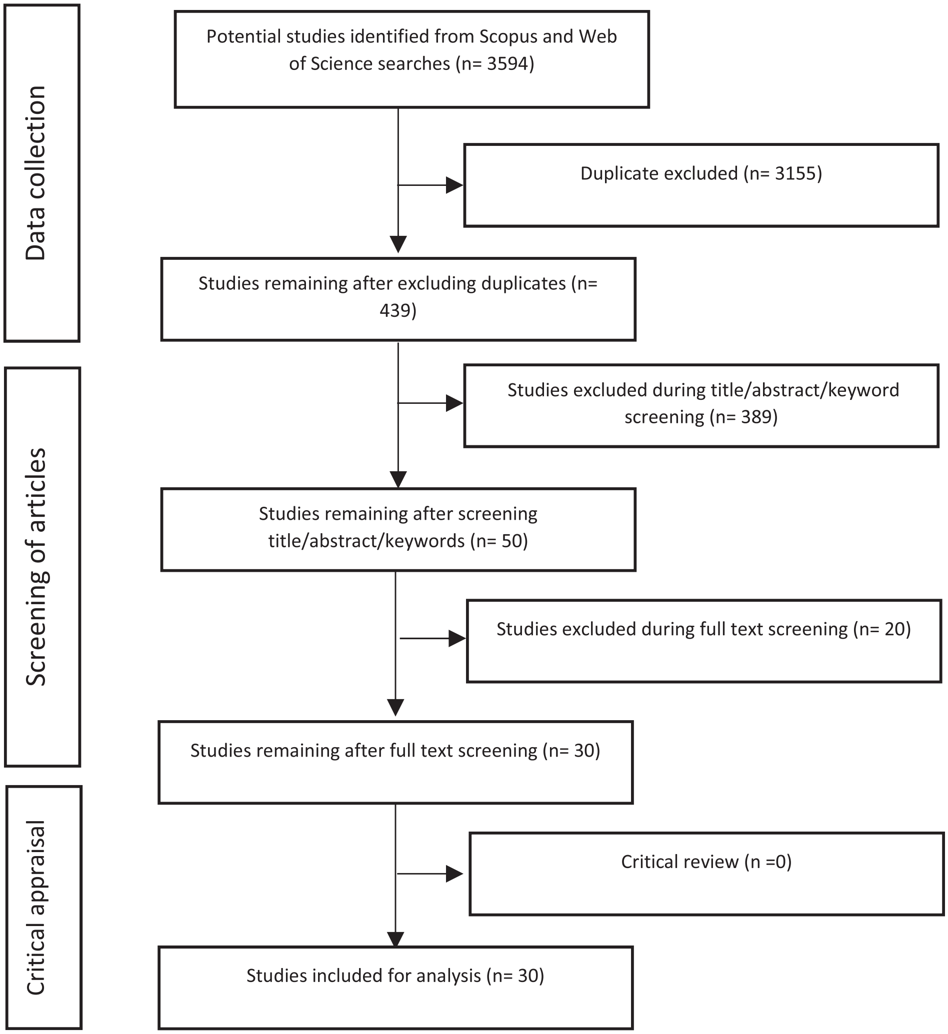

Figure 1. Identification and selection process for systematic review.

the initial screening of title, abstract, and keywords in which 30 articles meet our inclusion criteria. A backward and forward referencing approach was applied. In the backward and forward referencing step, we included references from the articles reviewed to ensure all literature on inclusion and exclusion of smallholder farmers' local knowledge and upscaling of CSA practices and technologies in Africa were part of our study. In the final step, we screened 30 articles for methodological and conceptual strength (Figure 1).

2.3 Analytical approach and data analysis

Our study adopted a qualitative interpretive approach to analyze the selected articles, deductively and inductively. The interpretive approach aims to understand meanings and how social phenomena are constructed by actors (Aukes et al., 2018; Yanow, 2000a, 2000b). The approach builds on the idea that the social world tends to have multiple interpretations (Yanow, 2000b). These multiple interpretations make up the different frames[1] that exist on a particular phenomenon. Scholars think about frames in at least two ways. One perspective postulates that frames encompass 'material assemblages', in other words, a network of schemas that actors use to construct social realities in policy arenas (Wood et al., 2018). This approach to frames only focuses on activating or unveiling representations earlier internalized by a wide range of actors and organizations that are found within a policy landscape. We do not follow this perspective of framing as it only focuses on activating representation earlier internalized by actors. An alternative perspective, and the one used in our analysis, draws on actors' interpretation and sense-making in policy discourse (Dewulf, 2013). This perspective of framing does not only capture different meanings ascribed by actors to a problem or situation, but also unveils their interpretation of it (Vij et al., 2017; Vij et al., 2018). For instance, in the climate change discourse, an interpretive perspective of framing has been used to understand how policy actors frame climate change as an issue of national security, human rights, or environmental injustice (Singh & Swanson, 2017). We used this interpretive framing lens to understand how existing peer-reviewed literature in Africa has problematized inclusion or exclusion of local knowledge and concerns of upscaling initiatives among smallholder farmers. The interpretative approach is holistic and contextual, but is not reductionist. It tends to carry meaning from the perspectives of articles reviewed about a social phenomenon. This interpretive approach contrasts statistical techniques that are employed in positivist research. Hence, interpretive rigor emerges from the systematic and transparent method of (qualitative) data collection and analysis rather than statistical inferences for constructing validity (Babones, 2016; Thompson et al., 1989).

In analyzing the documents for this review, we read each article, marking out portions and paragraphs referring to inclusion and exclusion of local knowledge and upscaling CSA practices and technologies. We then interpreted the marked excerpts. Informed by a former systematic analysis of climate change adaptation policies, we analyzed the text in several steps (Ford et al., 2011). First, we classified each excerpt as either relevant to inclusion and exclusion of smallholder farmers' local knowledge and/or to upscaling CSA in Africa. Next, we deduced what each sentence was referring to. While analyzing the data, we considered final themes that emerged from our interpretation, such as participation strategies, institutional arrangements, and barriers to upscaling. We further arranged these interpretations and meanings into a table format, categorizing them by authors that refer to inclusion and exclusion of local knowledge or upscaling CSA in Africa.

2.4 Potential pitfalls and strategies to overcome them

Two potential pitfalls were identified for this study and a strategy was used to address one of them. First is with the choice of keywords used for searching. For instance, we searched for articles that used terminologies such as 'local knowledge' and 'upscaling'. However, not all articles that explore smallholder farmers' local knowledge and upscaling in Africa use these terms explicitly in their title, abstract, and keywords. We resolved this issue by creating alternative words for local knowledge, such as 'indigenous knowledge' and reading the main text and checking within the relevant articles' references to ensure that we do not miss relevant papers. For instance, Makate (2019b) used the term 'indigenous knowledge' in their paper instead of the term 'local knowledge'. Another issue in our search process related to all reviewed articles being written in English. Due to limited time and resources, the research only includes and interprets English language literature on CSA and excludes non-English literature.

3. Results

Our search identified 30 studies that addressed (1) inclusion and exclusion of local knowledge and (2) upscaling CSA practices and technologies in Africa (see supplementary material for all references). Articles addressing key issues evolved between 2012–2020. Most of the studies (n = 18) are classified broadly under Africa as more than

Table 1. Regions represented in the identified 30 studies.

Region	Records
East Africa	7
Southern Africa	3
West Africa	2
Articles classified broadly under (Africa)*	18

* We aggregated studies that focused on more than one country and region broadly under Africa. (North and Central Africa regions were individually not represented in the studies reviewed).

one country, or region was the unit of analysis or case study (see Table 1). East Africa is the most represented in these studies, with Kenya (n = 3) being the dominant country studied. Other countries represented in East Africa include Ethiopia and Uganda. Southern Africa is represented by countries such as Malawi, South Africa, and Zimbabwe. West Africa is the least represented, with coverage of only Ghana and Nigeria. Other regions (Central and North Africa) are not represented at all as studies found within these regions did not meet the inclusion criteria. Specifically, articles from central and northern regions were excluded as they did not discuss the interaction of different knowledge systems (local, indigenous, and scientific knowledge) and upscaling.

3.1 Meta data for articles included in the review

A summary of the articles, according to inclusion criteria, is provided in supplementary material 2. Details of articles included for data analysis are grouped according to author, title, journal, date of publication, and discipline. These articles were written by authors from diverse fields and disciplines, from agricultural sciences to sociology (Figure 2). We considered all forms of research – with different agrarian systems – and by authors representing different fields of agriculture under the broad category of agriculture.

3.2 Emerging themes

From the qualitative interpretive analysis that was part of the systematic review, eight themes emerged to explore local knowledge and upscaling CSA in Africa (Figure 3). These themes are: (a) Barriers or constraints to CSA adoption; (b) Assumption of homogeneous farmers; (c) Institutional support, arrangement, and financial mechanism; (d) Gender approaches to upscaling; (e) Participation approaches for inclusion of local knowledge; (f) Farmers' right to ownership of land and inputs; (g) Building social capital and social networks; and (h) Agricultural advisory support services. Table 1 in supplementary material 2 details articles reviewed with their corresponding themes. Out of the 30 studies reviewed, 21 demonstrated constraints to farmers'

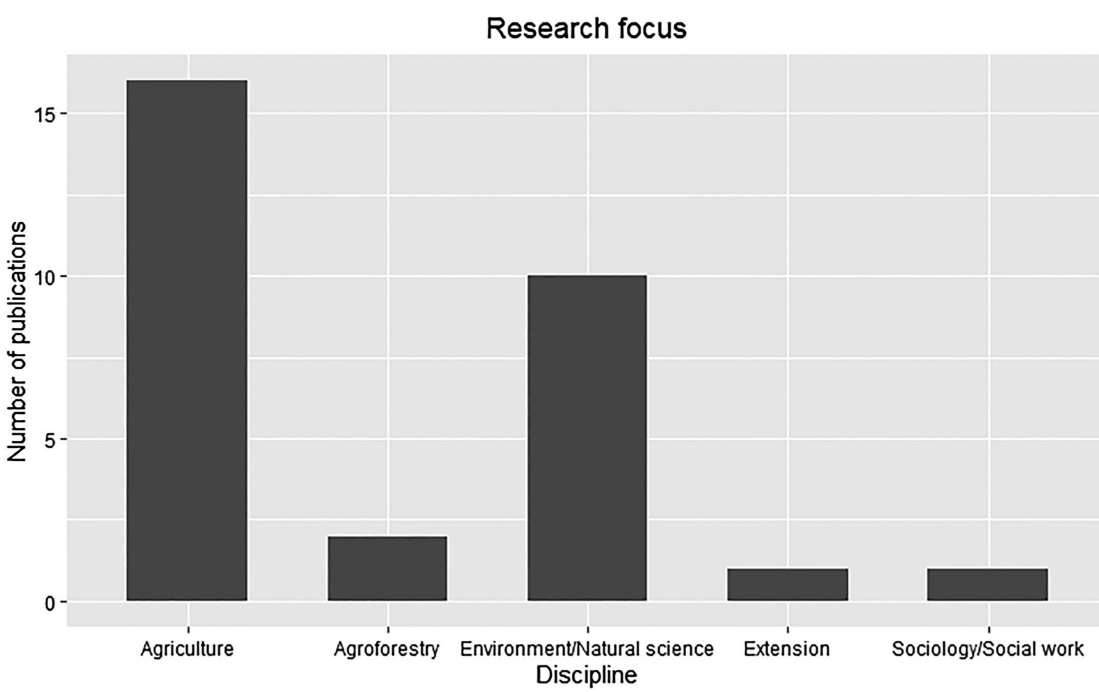

Figure 2. Categorization of articles by discipline.

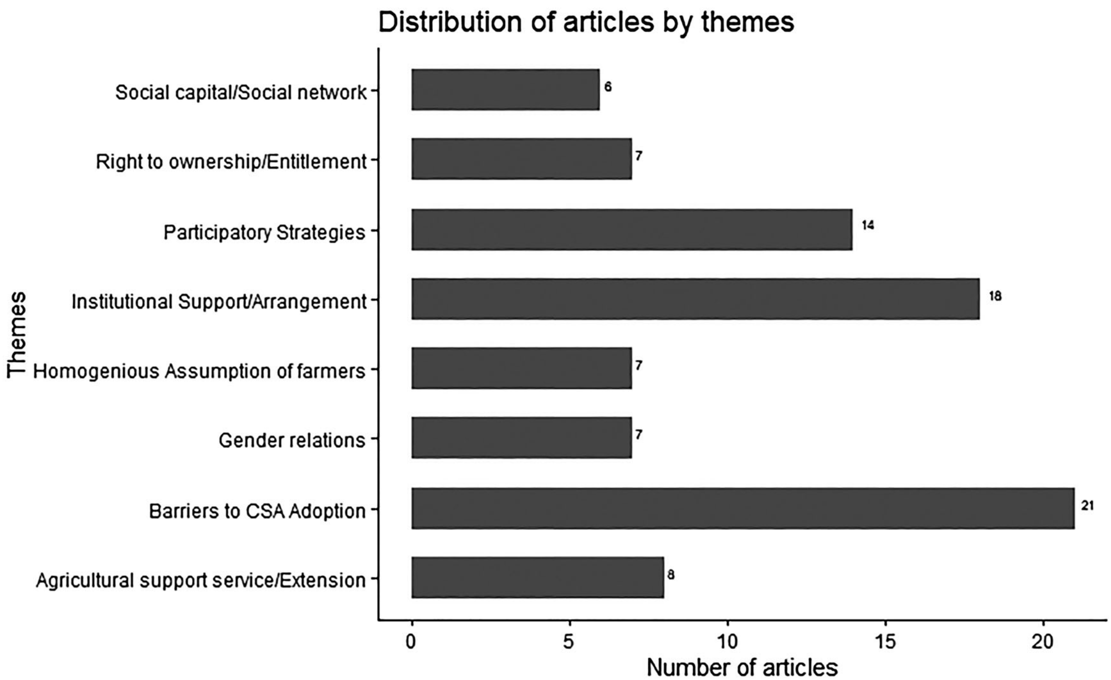

Figure 3. Themes emerging from the review.

adoption of CSA, such as limited access to finance, inadequate resources, land constraints, inexperience with new commodity markets, and high cost of agricultural inputs. 18 studies highlighted a lack of institutional support systems and mismatched governance arrangements as key drivers for low levels of CSA adoption among smallholder farmers. Eight studies provided solutions for upscaling CSA practices, such as transforming and preparing agricultural support services for digital decision support systems. Six studies highlighted the importance of enhancing smallholder farmers' social capital by cross-fertilizing partnerships between local communities and public and private sector organizations. Concerns regarding insufficient women rights and unequal gender relations featured in seven of the 30 studies reviewed. These articles conceived that greater gender equality can play an important role in scaling up CSA technologies and benefiting women smallholders. 12 studies suggested that participatory technology development approaches can assert greater acceptance and adoption of CSA among smallholder farmers. These studies highlighted that inclusion of smallholder farmers' local knowledge was important in designing and implementing CSA innovations.

3.2.1 Comparison of local farming practices and CSA practices

Traditional farming methods such as intercropping techniques have allowed African smallholder farmers to grow multiple food crops on the same field to maximize income and improve soil quality. In recent times, however, these practices have been 'rebranded' as CSA (Chandra et al. 2018). For instance, recent CSA approaches are highlighting the benefits to smallholders from intercropping maize with early- or late-maturing soybean varieties. Similarly, other practices like agroforestry are not new to the African continent. Yet, new CSA approaches highlight the benefits for smallholder farmers when planting trees or shrubs in their agricultural fields. Table 2 provides some examples of traditional farming practices in Africa in relation to their re-appropriation as CSA.

3.3 Inclusion and exclusion of local knowledge in CSA design and implementation process

Out of the 30 studies reviewed, only 8 mentioned inclusion or exclusion of local knowledge in relation to CSA practices and technologies. Amongst these studies, scholars contended practitioners (such as policymakers and

Table 2. Comparison of traditional farming strategies versus CSA strategies.

Farming practice	Description of practice	Traditional practice	CSA practice	Example of countries where practices are commonly used
Agroforestry	Integration of trees or shrubs with crops or livestock.	Maintaining useful trees on farm plots when preparing a field for cropping (for example, preserving parkland, mango and pawpaw trees).	Planting of trees and shrubs to agricultural landscape (e.g. Improved fallow, Taunga ally cropping, multilayer trees).	Kenya, Nigeria, Zimbabwe, Ghana
Crop rotation	Farming practices where several crops are chronologically planted on the same farmland.	Traditional crop rotation farming (maize and sorghum or maize and soybean).	Crop rotation of maize and soybean.	Nigeria, South Africa, Kenya, Ghana, Malawi
Intercropping	More than two crops are planted on farmlands at the same time.	Planting of pulse crops and grains, such as maize and legumes, maize and beans, maize and sweet potatoes or cowpea.	Intercropping maize with early or late-maturing soybean varieties.	South Africa, Nigeria, Kenya, Malawi, Zimbabwe, Ghana
Irrigation	Controlled application of water to farmland at intervals only when needed.	Localized can sprinklers and surface irrigation.	Climate smart irrigation management, such as drip irrigation tools and sprinklers.	Kenya, Nigeria, Ethiopia, Zimbabwe, Malawi, Ghana, South Africa

extension advisors) to attend to smallholder farmers' local knowledge when helping them implement CSA practices and technologies in Africa. Most studies rationalized the 'inclusiveness' of smallholder farmers' local knowledge on the basis of enhancing overall farm-level adoption practices. For instance, Makate (2019a, 2019b) demonstrated higher levels of adoption among smallholder farmers when their knowledge about crop rotations was used to complement new approaches introduced to them, such as rainwater harvesting and the use of improved seeds. Bridging smallholder farmers' knowledge with new farming approaches can often reduce the time needed for re-training or skill development, which can be financially and technically challenging for governments and non-profit organizations in the Global South (Aggarwal et al., 2018).

Still, reviewed studies did not carefully conceptualize 'inclusion' or 'exclusion' of local knowledge in relation to CSA. Some studies conflated inclusion with the participation of smallholder farmers in knowledge creation and dissemination activities. For instance, community-level projects such as the climate-smart villages (CSV) approach is a key part of the agriculture research for development (AR4D) agenda to address climate change challenges for food security (Aggarwal et al., 2018). These projects promise to enhance the blending of local and scientific knowledge through targeted farmer-to-farmer learning networks (Aggarwal et al., 2018; Fuchs et al., 2019). Other studies, such as Makate (2019a, p. 47), conceptualized inclusion of local knowledge as 'embracing' smallholder farmers' traditional knowledge. It is not clear whether only embracing local knowledge is sufficient. Most new technologies may be incompatible with the heterogeneous social, cultural, and biophysical conditions within the farming communities. There was also little explanation of whether there were appropriate spaces or platforms available to smallholder farmers for sharing their local knowledge or learning new approaches through complementary knowledge creation with the scientific or expert community (Abegunde et al., 2019). The mechanisms for assimilating local knowledge or understanding tensions and synergies between local and scientific knowledge for on-farm decision-making are poorly understood. A better explanation of these interplays between knowledge can be vital for the future upscaling of CSA (Alexander, 2019; Makate, 2019b).

3.4 Upscaling CSA in Africa

Studies reviewed in this paper mostly defined upscaling as an opportunity for expanding CSA coverage to more farms and smallholder farmers in Africa. Makate (2019a, p. 38) defined upscaling as 'the expansion or adoption of proven and beneficial practices and technologies'. Aggarwal et al. (2018) conceptualized upscaling as a two-dimensional approach: horizontal and vertical. Horizontal upscaling is implemented through demonstration sites that connect smallholder farmers to other growers for cross- and co-learning opportunities. The notion of farmer-to-farmer learning includes collaborative spaces, such as self-help groups or agricultural advisory networks that support dissemination of new CSA knowledge to smallholder farmers (Makate, 2019a). Vertical upscaling occurs when research and development initiatives performed at laboratories and field-trials generate evidence for validating and testing the efficacy of practices on the field (Aggarwal et al., 2018). Several studies suggested that agricultural support and extension services, which involve advisory personnel from the public or private sector, can potentially help promote CSA practices and technologies to smallholder farmers (Cattaneo & Lipper, 2016; Duffy et al., 2021; Fentie & Beyene, 2019; Fuchs et al., 2019; McKune et al., 2018; Olorunfemi et al. 2020a,2020b). Both horizontal and vertical upscaling were deemed useful for enhancing the adoption of CSA practices from small-scale pilot projects to larger- and regional-scale initiatives.

Studies also evaluated several challenges and opportunities for upscaling CSA approaches in Africa. Presently, many smallholder farmers are unable or unwilling to use CSA. Some studies suggest that low levels of adoption among smallholder farmers may be a result of the heterogeneous farming system in the region (Abegunde et al., 2019; Notenbaert et al., 2017). Smallholder farmers may find it challenging to adopt practices when dealing with widely different biophysical environments that require site-specific farm management (Abegunde et al., 2019; Cavanagh et al., 2017; Chandra et al., 2017; Notenbaert et al., 2017). Social and institutional factors, such as smallholder farmers' inability to get access to extension services, limited access to finance, inadequate resources, land constraints, market orientation, perception of the new technology, high cost of agricultural inputs, can also hinder their adoption of CSA (Abegunde et al., 2019; Chandra et al., 2017; Fentie & Beyene, 2019; Lee, 2017).

The reviewed scholarship also offered suggestions for enhancing the upscaling in Africa. Abegunde et al. (2019), Makate (2019b), and Notenbaert et al. (2017) suggested that designers' approaches should consider the heterogeneous social, political, and economic conditions of smallholder farmers. These characteristics vary based on different levels of resource endowment, land constraints, market orientation, farming styles, and farm types within different geographic regions of Africa. Scholars also highlighted the importance of participatory approaches for upscaling CSA in Africa. For instance, using open and deliberative approaches to invite perspectives and priorities of multiple stakeholders such as smallholder farmers and laypersons in the design of CSA practices and technologies (Alexander, 2019; Chandra et al., 2017; Fuchs et al., 2019; Murray et al., 2016). Other studies have identified the importance of social networks in enhancing smallholder farmers' adoption practices (Maindi et al., 2020; Makate, 2019a; McKune et al., 2018). Lee (2017) and Maindi et al. (2020) argue that social networks such as saving clubs and religious groups where smallholder farmers learn about information can increase the participation, willingness, and abilities of smallholder farmers to engage in climate-smart projects.

Although the reviewed studies suggested potential solutions to upscaling in Africa, at least two issues remained unclear. First, several solutions for upscaling CSA presented in the reviewed scholarship did not explain the potential trade-offs between technological adoption and environmental systems. CSA technologies and practices, such as rainwater harvesting, minimum tillage, and integrated nutrient management, which might support or disable scaling up in Africa, are strongly dependent not only on the biophysical conditions of the farm, but also on the interactions of smallholder farmer's evolving knowledge and capacity (Chandra et al., 2017; Scherr et al., 2012). There may be negative impacts on crop yield from minimum tillage, especially in wetter years or when soil fertility is low (Morugán-Coronado et.al 2020). Thus, designers and implementers of CSA must consider the heterogeneous capacity and biophysical characteristics of smallholder farms based on their unique geographical and social conditions. Second, while many scholars provided generic institutional solutions for improving CSA's upscaling, the literature offers no detailed or specific description of the kind of institutions and policies needed to upscale CSA (Scherr et al., 2012; Shilomboleni, 2020; Totin et al., 2018; Westermann et al., 2018).

4. Discussion

Salient reflections based on the above-mentioned findings are discussed in this section. While our paper focuses on Africa, we draw on examples and literature from other regions to inform discussion of our research findings. Our findings show that there is a paucity of research on inclusion and exclusion of local knowledge in CSA practices and technologies in Africa. We also found that authors from the extension field have not fully explored the subject matter of local knowledge and how it links to successful upscaling of CSA in the African context. For communities to enhance the resilience capacity of smallholder farmers, vulnerable groups and communities must be included in deliberations on how to best cope with the impacts of climate change (Agarwal, 2001). The first step to ensuring that practices and technologies are useful to achieve mitigation, adaptation, and food security objectives, requires that smallholder farmers' local knowledge becomes an important input in the process of designing CSA or to implementing it on a farm-level. Smallholder farmer's local knowledge needs to be given priority and integrated with scientific knowledge in the discourse and design of CSA technologies and practices. For instance, Andrieu et al. (2019) found that co-designing agricultural innovations, such as new cropping and livestock approaches where scientific knowledge is integrated with local knowledge of smallholder farmers, is useful in recognizing appropriate solutions to tackle climate change.

Climate-risk management decisions predicated on integrating traditional ecological knowledge with scientific knowledge can successfully lead communities to expand their capability to adapt and mitigate climate change (Hosen et al., 2020; Lazrus, 2015). For instance, cases from other regions, specifically studies from Malaysia and Tuvalu, suggest that the integration of traditional ecological knowledge has proven to assist local communities that have maintained their traditional practices to adapt to climate risks that promote socio-ecological resilience and create capabilities for better resources management (Hosen et al., 2020; Lazrus, 2015). Conversely, climate change interventions that do not consider integrating traditional ecological knowledge, such as community heritage in decision-making, can potentially present a secondary disaster (Larusz, 2015).

In environmental management practice, indigenous people are pivotal for successful environmental management as they possess the indigenous and local knowledge necessary for nature's sustainability (Burgos-Ayala et al., 2020). For example, inclusion of traditional ecological knowledge in management practices in Peru has led to an improvement in local well-being (Saylor et al., 2017). Hence, local knowledge in environmental management can lead to a more robust human nature connectedness and a successful policy intervention in communities. Aryal et al. (2016) argue that indigenous knowledge is useful for diagnosing climate change issues as indigenous people can better respond to climate change challenges using different strategies. Therefore, indigenous knowledge is pivotal to further understand and interpret the scientific knowledge of climate change given the site-specific needs and peculiarity of climate variability in communities. Incorporating local knowledge in CSA discourse, design, and practices calls for increased sharing of knowledge through a citizen science approach where stakeholders (scientists, policymakers, resource users, smallholder farmers) share their knowledge to strengthen the drive towards adaptation and mitigation of climate change (Eriksen et al., 2015; Fisher, 2016). Therefore, for CSA to be successful, development partners need to consider a platform for knowledge sharing that concerns the perspectives of smallholder farmers. The inclusion of local knowledge in environmental intervention and practices can reveal hegemonic political interests, destabilizing such agendas of development partners (Eriksen et al., 2015; Fisher, 2016; Tschakert, 2012).

The implication of including local knowledge in environmental management translates to ensuring that the coordination and implementation of policies and practices for mitigation and resilience can be done in a culturally-, socially-, and economically-relevant manner, providing an opportunity to include local knowledge in environmental initiatives to combat climate challenges (Fisher, 2016). Local knowledge and community understanding of environmental management often differ from expert or scientific knowledge; there is a need to ensure collective learning and co-production of knowledge that involves the knowledge of a range of actors (smallholder farmers and development partners) to bridge the gap between values and knowledge of environmental management (Tschakert et al., 2016). Therefore, the integration of local knowledge and scientific knowledge can propel the implementation of CSA to tackle climate change in Africa.

Some research is clear and robust about explaining various social, economic, and political conditions that limit the wide-scale inclusion of local knowledge in approaches. First, development partners do not generally discuss whether or not these technologies and new practices will work well with smallholder farmers. Designing CSA in this way typically ignores potentially valuable local knowledge. Second, practices are often imagined and therefore implemented from a top-down approach where innovative ideas appear from development partners and smallholder farmers are supposed to accept them (Chandra et al., 2017; Notenbaert et al., 2017). These top-down approaches often exclude most smallholder farmers as these technologies do not integrate their unique needs, such as farming styles, climatic conditions, and resource endowment, to combat climate change and address issues of food security (Hellin & Fisher, 2018). Excluding smallholder farmers in policymaking processes or in science-policy dialogues to co-develop CSA approaches potentially hinders implementation of CSA. Scientific recommendations on CSA that excludes smallholder farmers involvement may not address trade-offs anchored in local practices, such as between the costs of adaptation and mitigation of climate change (Steenwerth et al., 2014).

Despite efforts to democratize initiatives, CSA remains dictated by agendas set by development partners and national governments (Chandra et al., 2017). This top-down approach to technology design can be exclusionary for smallholder farmers, as top-down approaches fall short of understanding that innovation is as much a social as it is a technical process. Smallholder farmers' local knowledge is essential because it can serve as both a barrier and a facilitator of adoption practices. Designing initiatives that include smallholders' perspectives, motivations, and values – at the early stages of technological development – can propel initiatives to enhanced social, environmental, and economic sustainability. Different perspectives of key stakeholders – such as smallholder farmers, policymakers, and food system actors – need to be recognized early on to identify what benefits are to be derived and to understand the impact of emerging practices and technologies on local practices (Scherr et al., 2012). Therefore, a bottom-up approach through smallholder farmers' participation is essential to ensure that smallholder farmers are not left out of the CSA design and implementation processes and to ensure that upscaling will occur.

An upscaling approach for CSA in Africa requires that design and implementation processes take into consideration the different farming systems of smallholder farmers. For instance, Sanogo et al. (2017) found in Senegal that participatory tools are useful to analyze vulnerability and to plan adaptation activities and communication for development. This approach considers complex and multifaceted socioeconomic factors – such as culture, politics, economy, and environment – rather than developing technologies that are assumed to be adopted at different scales by farmers in Africa. To ensure CSA is effectively implemented in Africa, a rationale to include smallholder farmers and development partners to participate in CSA decision-making is crucial. Clearly articulating how feedback from smallholder farmers would be integrated into the CSA discourse can help ensure that the voices of smallholder farmers are included in CSA design and implementation in Africa. The current technocratic approach to promotion of CSA by development partners might not lead to the desired upscaling results of these technologies in many parts of Africa (Totin et al., 2018). Upscaling CSA to trigger the desired transformation in agricultural production systems and food systems requires supportive policies, institutions, and financing, which altogether create an enabling environment at local, national, and international levels (Makate, 2019b). Creating enabling environments capable of supporting the implementation of CSA in Africa will require development partners and national governments to promote institutions such as markets, investments, and insurance frameworks that are supportive of the livelihoods of smallholder farmers. Institutions will need to be designed in consultation with smallholder farmers to understand their climate change needs to purposefully improve the implementation of CSA policies and approaches to cushion the effects of climate change. Existing and new participatory, farmer-led knowledge-making initiatives such as CSA rapid appraisal and participatory assessments can be useful in upscaling (Mwongera et al., 2017; Steenwerth et al., 2014; Waters-Bayer et al., 2015). The goal should be for farmers to co-produce knowledge on an equal epistemic basis vis-à-vis scientific knowledge (Iles et al., 2016). Existing participatory frameworks, such as use of field days that embody a platform for the exchange of knowledge on technological innovations, should provide smallholder farmers an opportunity to question and to add to scientific knowledge while contributing their experiential knowledge of specific agronomic or financial problems that arise in practice (Carlisle, 2014; Iles et al., 2016; Holt-Giménez, 2006).

This discussion identifies the urgent need to integrate local knowledge into CSA practices and technologies, which can potentially refine and help upscale CSA innovations. Failure to include smallholder farmers' local knowledge in such practices and technologies can potentially jeopardize efforts to promote food security, agricultural productivity and the ability of smallholder farmers to mitigate and adapt to climate change. The findings from this study can improve our understanding of how consideration of the social context of farmers can lead to building resilience through refinement and upscaling CSA innovation in Africa, rather than prioritizing scientific knowledge over historical farming experiences.

5. Conclusion

This article draws upon CSA literature in Africa for scoping the systematic review and relies on a wider CSA literature in other regions to inform the discussion of our findings. This paper answers two questions: (1) *In the last decade, how has smallholder farmers' local knowledge been included or excluded in CSA practices and technologies in Africa*, and (2*) how are CSA practices and technology possibly upscaled in Africa?* Our review found that a majority of studies have explored the challenges of upscaling CSA in Africa. These include limited access to finance, inadequate resources, and high cost of agricultural inputs. There is, however, a paucity of research on inclusion or exclusion of smallholder farmers' local knowledge in CSA practices and technologies. Still, the studies reviewed found that inclusion of smallholders' local knowledge when designing and implementing CSA initiatives can greatly increase adoption of CSA among farmers. Integrating different epistemic understandings (local knowledge and scientific knowledge) can generate higher levels of trust in CSA among smallholders and can help with scaling CSA in Africa.

Upscaling of CSA approaches in Africa, however, does not happen in an institutional vacuum. There is a greater need to ensure that adequate policies and institutional arrangements, such as through markets and financial mechanisms, are in place with clearly defined parameters on how CSA practices and technologies can be refined through the use of local knowledge and upscaled to smallholder farmers in Africa. We stress the importance of creating CSA practices and technologies that consider the unique characteristics of local practices and farming styles, therefore considering a bottom-up approach to CSA practices and technologies. To enable upscaling and inclusion of local knowledge systems in CSA, the political narratives of CSA will need to guarantee representation of smallholder farmers in agriculture policy and related decision-making processes, not through a dominant representation of development partners. A key to successful upscaling of CSA will be more symmetry in power relations and greater social justice to bring in and amplify the voices of smallholder farmers. This inclusion process will need to be designed with a participatory, bottom-up approach within CSA interventions. We suggest that participatory approaches, such as farmer-led knowledge creation and farmer school programs, can provide opportunities for the co-production of knowledge. This bottom-up approach can potentially ensure that development partners and national governments in Africa do not foster technocratic agendas, but instead place the interests and knowledge of smallholder farmers at the center of the design of practices and technologies to combat climate change. Results of this research calls for a re-think of how the CSA approach in Africa is evolving, as the current technocratic approach to upscaling CSA approaches in Africa might not lead to the desired result of tackling climate change. Successful mitigation and resilience building to climate change in the agricultural sector in Africa will require the co-production of knowledge and integrating smallholder farmers' local knowledge and scientific knowledge.

Note

1. Frames can be understood as important and common narratives that drive both analysis and action in everyday situations. Frames generate multiple meanings from different perspectives on a particular phenomenon facilitating decision makers in making informed decisions about different responses or strategies for action (Dewulf, 2013).

Acknowledgment

This research is based upon work supported by the National Science Foundation under Grant Number 2202706 and 2026431. Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by National Science Foundation [Grant Numbers 2026431, 2202706].

ORCID

Ayorinde Ogunyiola http://orcid.org/0000-0002-1371-9183
Maaz Gardezi http://orcid.org/0000-0003-0915-2652
Sumit Vij http://orcid.org/0000-0001-5252-797X

References

Abegunde, V. O., Sibanda, M., & Obi, A. (2019). The dynamics of climate change adaptation in sub-saharan Africa: A review of climate-smart agriculture among small-scale farmers. *Climate, 7(11), 132*. 1-23. https://doi.org/10.3390/cli7110132.

Agarwal, B. (2001). Participatory exclusions, community forestry, and gender: An analysis for South Asia and a conceptual framework. *World Development*, *29*(10), 1623–1648. https://doi.org/10.1016/S0305-750X(01)00066-3.

Aggarwal, P. K., Jarvis, A., Campbell, B. M., Zougmoré, R. B., Khatri-Chhetri, A., Vermeulen, S. J., Loboguerrero, A., Sebastian, L.S., Kinyangi, J., Bonilla-Findji, O., Radeny, M., Recha, J., Martinez-Baron, D., Ramirez-Villegas, J., Huyer, S., Thornton, P., Wollenberg, E., Hansen, J., Alvarez-Toro, P., & Tan Yen, B (2018). The climate-smart village approach: Framework of an integrative strategy for scaling up adaptation options in agriculture. *Ecology and Society*, *23*(1):14 https://doi.org/10.5751/ES-09844-230114.

Agrawal, A. (1995). Dismantling the divide between indigenous and scientific knowledge. *Development and Change*, 413–439. https://doi.org/10.1111/j.1467-7660.1995.tb00560.x

Alexander, C., Bynum, N., Johnson, E., King, U., Mustonen, T., Neofotis, P., Oettlé, N., Rosenzweig, C., Sakakibara, C., Shadrin, V., Vicarelli, M., Waterhouse, J., & Weeks, B. (2011). Linking indigenous and scientific knowledge of climate change. *BioScience*, 477–484. https://doi.org/10.1525/bio.2011.61.6.10

Alexander, S. (2019). What climate-smart agriculture means to members of the global alliance for climate-smart agriculture. *Future food: Journal on Food, Agriculture, and Society*, 21–30. https://doi.org/10.17170/kobra-2018122073

Andrieu, N., Howland, F., Acosta-Alba, I., Le Coq, J. F., Osorio-Garcia, A. M., Martinez-Baron, D., & Chia, E. (2019). Co-designing climate-smart farming systems With local stakeholders: A methodological framework for achieving large-scale change. *Frontiers in Sustainable Food Systems*, *3*(37), 1–19. https://doi.org/10.3389/fsufs.2019.00037.

Aryal, S., Cockfield, G., & Maraseni, T. N. (2016). Perceived changes in climatic variables and impacts on the transhumance system in the Himalayas. *Climate and Development*, *8*(5), 435–446. https://doi.org/10.1080/17565529.2015.1040718.

Aukes, E., Luls, K., & Bressers, H. (2018). Framing mechanisms: The interpretive policy entrepreneur's toolbox. *Critical Policy Studies*, *12*(4), 406–427. https://doi.org/10.1080/19460171.2017.1314219.

Babones, S. (2016). Interpretive quantitative methods for the social sciences. *Sociology*, *50*(3), 453–469. https://doi.org/10.1177/0038038515583637.

Beckford, C., & Barker, D. (2007). The role and value of local knowledge in Jamaican agriculture: Adaptation and change in small-scale farming. *Geographical Journal*, *173*, 118-–128. https://doi.org/10.1111/j.1475-4959.2007.00238.x.

Berkes, F. (1993). Traditional ecological knowledge in perspective. *Traditional Ecological Knowledge: Concepts and Cases*, *52*(5), 1–31.

Berkes, F. (2012). *Sacred ecology: Traditional ecological knowledge and management systems*. Routledge.

Branca, G., & Perelli, C. (2020). 'Clearing the air': Common drivers of climate-smart smallholder food production in eastern and Southern Africa. *Journal of Cleaner Production*, 1–11. https://doi.org/10.1016/j.jclepro.2020.121900

Burgos-Ayala, A., Jiménez-Aceituno, A., Torres-Torres, A. M., Rozas-Vásquez, D., & Lam, D. P. M. (2020). Indigenous and local knowledge in environmental management for human-nature connectedness: A leverage points perspective. *Ecosystems and People*, *16*(1), 290–303. https://doi.org/10.1080/26395916.2020.1817152.

Carlisle, L. (2014). Diversity, flexibility, and the resilience effect: Lessons from a social-ecological case study of diversified farming in the northern great plains, USA. *Ecology and Society*, *19*(3), 1–9. https://doi.org/10.5751/ES-06736-190345

Cattaneo, A., & Lipper, L. (2016). Incorporating forest landscapes into climate-smart agricultural strategies. *Unasylva*, *67*(1), 246, 12-20.

Cavanagh, C. J., Chemarum, A. K., Vedeld, P. O., & Petursson, J. G. (2017). Old wine, new bottles? Investigating the differential adoption of 'climate-smart' agricultural practices in western Kenya. *Journal of Rural Studies*, *56*, 114–123. https://doi.org/10.1016/j.jrurstud.2017.09.010.

Chandra, A., McNamara, K. E., & Dargusch, P. (2017). The relevance of political ecology perspectives for smallholder climate-smart agriculture: A review. *Journal of Political Ecology*, *24*(1), 821–842. https://doi.org/10.2458/v24i1.20969.

Dewulf, A. (2013). Contrasting frames in policy debates on climate change adaptation. *Wiley Interdisciplinary Reviews: Climate Change*, *4*, 321–330. https://doi.org/10.1002/wcc.227.

Duffy, C., Toth, G., Cullinan, J., Murray, U., & Spillane, C. (2021). Climate-smart agriculture extension: Gender disparities in agroforestry knowledge acquisition. *Climate and Development*, *13*(1), 21–33. https://doi.org/10.1080/17565529.2020.1715912.

Eriksen, S. H., Nightingale, A. J., & Eakin, H. (2015). Reframing adaptation: The political nature of climate change adaptation. *Global Environmental Change*, *35*, 523–533. https://doi.org/10.1016/j.gloenvcha.2015.09.014.

FAO. (n.d.). What is local knowledge. http://www.fao.org/3/y5610e/y5610e01.htm.

Fentie, A., & Beyene, A. D. (2019). Climate-smart agricultural practices and welfare of rural smallholders in Ethiopia: Does planting method matter? *Land Use Policy*, *85*, 387–396. https://doi.org/10.1016/j.landusepol.2019.04.020.

Fisher, K. (2016). Coordinating and situating resilience multiple. *Dialogues in Human Geography*, *6*(1), 32–36. https://doi.org/10.1177/2043820615624066.

Ford, J. D., Berrang-Ford, L., & Paterson, J. (2011). A systematic review of observed climate change adaptation in developed nations. *Climatic Change*, *106*, 327–336. https://doi.org/10.1007/s10584-011-0045-5.

Fuchs, L. E., Peters, B., & Neufeldt, H. (2019). Identities, interests, and preferences matter: Fostering sustainable community development by building assets and agency in western Kenya. *Sustainable Development*, *27*(14), 704–712. https://doi.org/10.1002/sd.1934.

Haddaway, N. R., & Macura, B. (2018). The role of reporting standards in producing robust literature reviews. *Nature Climate Change*, *8*, 444–447. https://doi.org/10.1038/s41558-018-0180-3.

Haddaway, N. R., Macura, B., Whaley, P., & Pullin, A. S. (2018). ROSES reporting standards for systematic evidence syntheses: Pro forma, flow-diagram and descriptive summary of the plan and conduct of environmental systematic reviews and systematic maps. *Environmental Evidence*, *7*, 7, 1-8. https://doi.org/10.1186/s13750-018-0121-7.

Harvey, C. A., Chacón, M., Donatti, C. I., Garen, E., Hannah, L., Andrade, A., & Wollenberg, E. (2014). Climate-Smart landscapes: Opportunities and challenges for integrating adaptation and mitigation in tropical agriculture. *Conservation Letters, 7(2), 77-90*, https://doi.org/10.1111/conl.12066

Hellin, J., & Fisher, E. (2018). Building pathways out of poverty through climate-smart agriculture and effective targeting. *Development in Practice*, *28*(7), 974–979. https://doi.org/10.1080/09614524.2018.1492516.

Holt-Giménez, E. (2006). *Campesino a campesino: Voices from latin america's farmer to farmer movement for sustainable agriculture. Oakland*. Food First Books.

Hosen, N., Nakamura, H., & Hamzah, A. (2020). Adaptation to climate change: Does traditional ecological knowledge hold the key? *Sustainability*, *12*(2), 676. https://doi.org/10.3390/su12020676

Iles, A., Graddy-Lovelace, G., Montenegro M., & Galt R. (2016). *Blindspots and emerging knowledge: The entry of STS into agriculture and food*. In Clark Miller & Ulrike Felt (Eds.), *The science and technology studies handbook*. Cambridge, MA: MIT Press.

Kronik, J., & Verner, D. (2010). *Indigenous peoples and climate change in Latin America and the Caribbean*. Washington: World Bank Publications.

Karlsson, L., Naess, L. O., Nightingale, A., & Thompson, J. (2018). 'Triple wins' or 'triple faults'? Analysing the equity implications of policy discourses on climate-smart agriculture (CSA). *The Journal of Peasant Studies*, *45*(1), 150–174. https://doi.org/10.1080/03066150.2017.1351433.

Lazrus, H. (2015). Risk perception and climate adaptation in Tuvalu: A combined cultural theory and traditional knowledge approach. *Human Organization*, 52–61. https://doi.org/10.17730/humo.74.1.q0667716284749m8

Lee, J. (2017). Farmer participation in a climate-smart future: Evidence from the Kenya agricultural carbon market project. *Land Use Policy*, *68*, 72–79. https://doi.org/10.1016/j.landusepol.2017.07.020.

Maindi N. C., Osuga I. M., & Gicheha M. G. (2020). Advancing climate smart agriculture: adoption potential of multiple on-farm dairy production strategies among farmers in Murang'a County, Kenya. *Livestock Research for Rural Development*, 32(4). http://www.lrrd.org/lrrd32/4/izzac32063.html

Makate, C. (2019a). Effective scaling of climate-smart agriculture innovations in African smallholder agriculture: A review of approaches, policy and institutional strategy needs. *Environmental Science and Policy*, *96*, 37–51. https://doi.org/10.1016/j.envsci.2019.01.014.

Makate, C. (2019b). Local institutions and indigenous knowledge in adoption and scaling of climate-smart agricultural innovations among sub-saharan smallholder farmers. *International Journal Climate Change Strategies and Management*, *12*(2), 270–287. https://doi.org/10.1108/IJCCSM-07-2018-0055.

Makondo, C. C., & Thomas, D. S. G. (2018). Climate change adaptation: Linking indigenous knowledge with western science for effective adaptation. *Environmental Science and Policy*, *88*, 83–91. https://doi.org/10.1016/j.envsci.2018.06.014.

McCarthy, N., Lipper, L., Branca, G., & Security, F. (2011). Climate-Smart agriculture : smallholder adoption and implications for climate change adaptation and mitigation. *Organization*, FAO Mitigation of Climate Change in Agriculture Series 4, 1–19.

McKune, S., Poulsen, L., Russo, S., Devereux, T., Faas, S., McOmber, C., & Ryley, T. (2018). Reaching the end goal: Do interventions to improve climate information services lead to greater food security? *Climate Risk Management*, *22*, 22–41. https://doi.org/10.1016/j.crm.2018.08.002.

Murray, U., Gebremedhin, Z., Brychkova, G., & Spillane, C. (2016). Smallholder farmers and climate smart agriculture: Technology and labor-productivity constraints amongst women smallholders in Malawi. *Gender, Technology and Development*, *20*(2), 117–148. https://doi.org/10.1177/0971852416640639.

Mwongera, C., Shikuku, K. M., Twyman, J., Läderach, P., Ampaire, E., Van Asten, P., & Winowiecki, L. A. (2017). Climate smart agriculture rapid appraisal (CSA-RA): A tool for prioritizing context-specific climate smart agriculture technologies. *Agricultural Systems*, *151*, 192–203. https://doi.org/10.1016/j.agsy.2016.05.009.

Neufeldt, H., Jahn, M., Campbell, B. M., Beddington, J. R., DeClerck, F., De Pinto, A., & Zougmoré, R. (2013). Beyond climate-smart agriculture: Toward safe operating spaces for global food systems. *Agriculture and Food Security*, 1–8. https://doi.org/10.1186/2048-7010-2-12

Newell, P., & Taylor, O. (2018). Contested landscapes: The global political economy of climate-smart agriculture. *Journal of Peasant Studies*, *45*(1), 108–129. https://doi.org/10.1080/03066150.2017.1324426.

Notenbaert, A., Pfeifer, C., Silvestri, S., & Herrero, M. (2017). Targeting, out-scaling and prioritising climate-smart interventions in agricultural systems: Lessons from applying a generic framework to the livestock sector in sub-saharan Africa. *Agricultural Systems*, *151*, 153–162. https://doi.org/10.1016/j.agsy.2016.05.017.

Nyong, A., Adesina, F., & Osman Elasha, B. (2007). The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. *Mitigation and Adaptation Strategies for Global Change*, *12*(5), 787–797. https://doi.org/10.1007/s11027-007-9099-0

Olorunfemi, T. O., Olorunfemi, O. D., & Oladele, O. I. (2020a). Determinants of the involvement of extension agents in disseminating climate-smart agricultural initiatives: Implication for scaling up. *Journal of the Saudi Society of Agricultural Sciences*, https://doi.org/10.1016/j.jssas.2019.03.003

Olorunfemi, T. O., Olorunfemi, O. D., & Oladele, O. I. (2020b). Determinants of the involvement of extension agents in disseminating climate-smart agricultural initiatives: Implication for scaling up. *Journal of the Saudi Society of Agricultural Sciences*, https://doi.org/10.1016/j.jssas.2019.03.003

Sanogo, D., Ndour, B. Y., Sall, M., Toure, K., Diop, M., Camara, B. A., & Thiam, D. (2017). Participatory diagnosis and development of climate change adaptive capacity in the groundnut basin Senegal: Building a climate-smart village model. *Agriculture and Food Security*, *6*(1), 1-12. https://doi.org/10.1186/s40066-017-0091-y.

Saylor, C. R., Alsharif, K. A., & Torres, H. (2017). The importance of traditional ecological knowledge in agroecological systems in Peru. *International journal of biodiversity science, Ecosystem Services & Management*, *13*(1), 150-161.

Scherr, S. J., Shames, S., & Friedman, R. (2012). From climate-smart agriculture to climate-smart landscapes. *Agriculture and Food Security*, *1*(1), 1-12. https://doi.org/10.1186/2048-7010-1-12.

Shilomboleni, H. (2020). Political economy challenges for climate-smart agriculture in Africa. *Agriculture and Human Values*, *37*(4), 1195–1206. https://doi.org/10.1007/s10460-020-10126-5.

Singh, S. P., & Swanson, M. (2017). How issue frames shape beliefs about the importance of climate change policy across ideological and partisan groups. *PLoS ONE*, *12*(7), e0181401. https://doi.org/10.1371/journal.pone.0181401.

Speranza, C. I., Kiteme, B., Ambenje, P., Wiesmann, U., & Makali, S. (2010). Indigenous knowledge related to climate variability and change: Insights from droughts in semi-arid areas of former makueni district, Kenya. *Climatic Change*, *100*(2), 295–315.https://doi.org/10.1007/s10584-009-9713-0.

Steenwerth, K. L., Hodson, A. K., Bloom, A. J., Carter, M. R., Cattaneo, A., Chartres, C. J., Hatfield, J. L., Henry, K., Hopmans, J. W., Horwath, W. R., Jenkins, B. M., Kebreab, E., Leemans, R., Lipper, L., Lubell, M. N., Msangi, S., Prabhu, R., Reynolds, M. P., Sandoval Solis, S., … Jackson, L. E. (2014). Climate-smart agriculture global research agenda: Scientific basis for action. *Agric & Food Secur*, *3*(1), 1-39. https://doi.org/10.1186/2048-7010-3-11

Taneja, G., Pal, B. D., Joshi, P. K., Aggarwal, P. K., & T, N. K. (2014). Farmers' preferences for climate-smart agriculture: An assessment in the indo-gangetic plain. *SSRN Electronic Journal*, 91–111. https://doi.org/10.2139/ssrn.2420547

Thompson, C. J., Locander, W. B., & Pollio, H. R. (1989). Putting consumer experience back into consumer research: The philosophy and method of existential-phenomenology. *Journal of Consumer Research*, *16*(2), 133–146. https://doi.org/10.1086/209203.

Totin, E., Segnon, A. C., Schut, M., Affognon, H., Zougmoré, R. B., Rosenstock, T., & Thornton, P. K. (2018). Institutional perspectives of climate-smart agriculture: A systematic literature review. *Sustainability (Switzerland)*. https://doi.org/10.3390/su10061990

Tschakert, P. (2012). From impacts to embodied experiences: Tracing political ecology in climate change research. *Geografisk Tidsskrift*, *112*(2), 144–158. https://doi.org/10.1080/00167223.2012.741889.

Tschakert, P., Das, P. J., Shrestha Pradhan, N., Machado, M., Lamadrid, A., Buragohain, M., & Hazarika, M. A. (2016). Micropolitics in collective learning spaces for adaptive decision making. *Global Environmental Change*, *40*, 182–194. https://doi.org/10.1016/j.gloenvcha.2016.07.004.

Vij, S., Biesbroek, R., Groot, A., & Termeer, K. (2018). Changing climate policy paradigms in Bangladesh and Nepal. *Environmental Science and Policy* , *81* , 77–85. https://doi.org/10.1016/j.envsci.2017.12.010.

Vij, S., Moors, E., Ahmad, B., Arfanuzzaman, M., Bhadwal, S., Biesbroek, R., Gioli, G., Groot, A., Mallick, D., Regmi, B., Saeed, B. A., Ishaq, S., Thapa, B., Werners, S. E., & Wester, P. (2017). Climate adaptation approaches and key policy characteristics: Cases from South Asia. *Environmental Science and Policy*, *78*, 58–65. https://doi.org/10.1016/j.envsci.2017.09.007.

Warren, D. M. (1989). 'Linking scientific and indigenous agricultural systems'. In J. Lin Compton (Ed.), *The transformation of International agricultural research and development* (pp. 153–170). Lynne Rienner.

Waters-Bayer, A., Kristjanson, P., Wettasinha, C., Veldhuizen, L., Quiroga, G., Swaans, K., & Douthwaite, B. (2015). Exploring the impact of farmer-led research supported by civil society organisations. *Agriculture and Food Security*, *4*(1), 4. 1-7. https://doi.org/10.1186/s40066-015-0023-7.

Westermann, O., Förch, W., Thornton, P., Körner, J., Cramer, L., & Campbell, B. (2018). Scaling up agricultural interventions: Case studies of climate-smart agriculture. *Agricultural Systems*, *165*, 283–293. https://doi.org/10.1016/j.agsy.2018.07.007.

Williams, T. O., Mul, M., Cie, O., Kinyangi, J., Zougmore, R., Wamukoya, G., & Campbell, B. (2015). Climate-Smart Agriculture in the African Context. *1-26. Cgspace.Cgiar.Org*.

Wood, M. L., Stoltz, D. S., Van Ness, J., & Taylor, M. A. (2018). Schemas and frames. *Sociological Theory*, *36*(3), 244–261. https://doi.org/10.1177/0735275118794981.

World Bank. (2018). *Scaling up climate-smart agriculture through the Africa climate business plan*. Washington, DC: World Bank.

Yanow, D. (2000a). Seeing organizational learning: A "cultural" view. *Organization*, *7*(2), 247–268. https://doi.org/10.1177/135050840072003.

Yanow, D. (2000b). Underlying assumptions of an interpretive approach: The importance of local knowledge. *Conducting Interpretive Policy Analysis*, 1–27.

Zougmoré, R., Partey, S., Ouédraogo, M., Omitoyin, B., Thomas, T., Ayantunde, A., Ericksen, P., Said, M., & Jalloh, A. (2016). Toward climate-smart agriculture in West Africa: A review of climate change impacts, adaptation strategies and policy developments for the livestock, fishery and crop production sectors. *Agriculture and Food Security*, *5* (26) https://doi.org/10.1186/s40066-016-0075-3.