Culturally Informed Knowledge Transfer Toward Climate-Smart Agriculture Adoption: Insights from Smallholder Farmers in Ethiopia and Zimbabwe

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Abstract

Sub-Saharan Africa has been identified as having the potential to experience a swift and impactful increase in the adoption of climate-smart agricultural (CSA) practices. However, it is important to recognize that cultural factors among social groups modulate and influence knowledge dissemination processes and adoption patterns. This study seeks to provide insight to these perspectives by examining the relationship between knowledge transfer and culture among sub-Saharan African smallholder farmers' adoption of CSA. We implemented the case study methodology to analyze 12 cases from Ethiopia and Zimbabwe. The results indicated that high power distance in both regions affects the efficacy of top-down approaches, indicating a necessary shift towards more participatory methods that involve diverse smallholder farmers in the diffusion of CSA practices. In addition, when the regional culture is predominantly collectivist, it facilitates the diffusion of knowledge among smallholder groups, but it also limits the diffusion of innovation when the initial adoption experience is negative. The findings highlighted the significant role of cultural dimensions in the knowledge transfer process related to adopting CSA practices. Future research and practice should be designed with culture in mind, including direct measurement of culture within adoption contexts to accelerate the adoption rate of CSA.

Keywords: sub-Saharan Africa, case study, farming technology, diffusion of innovations, cultural dimensions theory, smallholder farmers

Introduction

Climate change threatens agricultural production around the world, and developing nations experience significantly more impact than their developed counterparts (Bhattacharya et al., 2023). As a reaction to both mitigate climate change and adapt to its effects, global, national, and regional efforts have promoted climate-smart agricultural (CSA) technology and practice adoption (Giller, 2020). Sub-Saharan Africa has been the focus of many of these efforts for multiple reasons. The region is highly vulnerable to climate change, and its impacts are deeply and broadly felt across the region's nearly 70% livelihood dependency on agricultural production (Giller, 2020). Additionally, the region continues to struggle with food security, and much of the smallholder farm production flows back into local food consumption (Food and Agriculture Organization [FAO], 2013). In fact, most of this region's agricultural production comes from smallholder farms classified by their small parcel size (around one hectare) and familial purpose (FAO, 2018). On average, 79% of smallholder farmer's household income is generated from agricultural production. Because of this vulnerability, sub-Saharan Africa has been recognized for its potential to experience a swift and impactful uptake in CSA practice adoption to make farms more resilient to climate impacts and improve production efficiency (Kombat et al., 2021). However, the decision-making process surrounding adoption is complex, relying not only on multiple factors but also on how they align, often in ways that compete or conflict with one another.

Fundamentally, there is no one-size-fits-all approach for CSA due to the tremendous amount of heterogeneity between farms, even within the same geographic region (Mizik, 2021). Therefore, facilitating adoption requires a tailored and locally informed approach. Additionally, factors such as the length of the payback period of the practice and access to financial and labor inputs influence adoption capacities and perceptions (Mizik, 2021). Farm size, education level, and risk perceptions also determine the propensity to adopt (Kassa & Abdi, 2022; Mujeti et al., 2019), as well as culture, religion, and ethnicity (Jordan & Guerzoni, 2021). Across adoption studies, there is an agreement that the way knowledge, education, and information are shared between social groups influences adoption (Geleta et al., 2023; Githinji et al., 2024). We generally refer to this as knowledge transfer—that is, how, expertise, experience, and knowledge about a technology spread to decision-makers. Possessing knowledge about the potential and relevant innovation is the first step in the adoption process (Rogers, 2003), and knowledge about the benefits of practices and how to reduce adoption barriers can facilitate adoption (Atta-Aidoo et al., 2022). Farmers are exposed to information and influenced by their relationships with individuals in their reference groups, including other farmers, consulting companies, technology companies, and institutions such as Extension (Yami et al., 2024). It is widely understood that positive, palatable, and meaningful interactions with these decision resources can facilitate adoption (Geleta et al., 2023; Zvobgo et al., 2023). Additionally, farmers desire to be similar to or approved by other respected farmers (Atta-Aidoo et al., 2022), revealing influential farmers as a critical source for knowledge transfer and innovation diffusion.

Knowledge transfer can target many of the barriers to adoption (e.g., general awareness, perceived benefits, access to financial resources); however, the farm, farmer, and culture in which they are embedded must be considered when planning and executing this outreach (Baker & Campbell, 2016). Culture sets the background for knowledge transfer and regulates the flow and pattern of knowledge diffusion (Kamoyo & Makocheckanwa, 2018; Kröner & Nocol, 2024). The culture of a community manifests in its communication styles, relationship dynamics, power distance, personal values, and preferred educational styles, among other ways (Hofstede, 2011).

Over one billion people live among the 49 countries in sub-Saharan Africa (Lang-Baldé & Amerson, 2018), and the region is one of the most culturally diverse in the world (Adogame, 2007). There are over 200 religions and ethnic groups, and the area is experiencing extreme migration shifts and demographic changes (Dickinson & Steel, 2024). Even within rural communities, cultures vary and have been changed by migration patterns (Jordan & Guerzoni, 2021).

Many CSA adoption studies have explored culture and knowledge transfer separately (Geleta et al., 2023; Jordan & Guerzoni, 2021; Masere & Worth, 2021; Yami et al., 2024), but only one, to our knowledge (Jordan & Guerzoni, 2021) has investigated these interconnected concepts together in a sub-Saharan African CSA context. The same is true for policy and programming efforts that tend to focus either on knowledge transfer (Ministry of Agriculture and Natural Resources, 2017) or culture (Kugedara et al., 2021). Therefore, there is a need for a more in-depth and timely analysis of the relationship between knowledge transfer and culture among sub-Saharan African smallholder farmers' adoption of CSA. To contribute to this vital area, we performed an unobtrusive case study to draw novel conclusions between knowledge transfer, adoption, and culture to bring together insight from government initiatives and academic research to inform evolving policy, practice, and research.

Theoretical Framework

This study was guided by two theories: Rogers' (2003) diffusion of innovations and Hofstede's (2011) cultural dimensions theory. These theories help frame the investigation of the relationship between adoption, knowledge transfer, and culture.

Diffusion of Innovations

Rogers (2003) described how the adoption of innovations, such as novel practices and technologies, diffuses through society through a series of adoption groups. Adoption begins with a small group of innovators, who have the highest propensity to adopt, followed by early adopters, an early and late majority, and laggards, who are the most resistant to adoption. DOI also outlines the innovation attributes that influence adoption, which include the innovation's relative advantage, compatibility, complexity, trialability, and observability. Additionally, individuals progress through five stages of innovation adoption: first knowledge of the innovation, followed by persuasion, decision (reject or accept), implementation, and confirmation (Rogers, 2003). The diffusion of innovations theory has framed many research studies about CSA practice adoption in the African context, including poultry farming innovations (Matabi, 2017), smart farming technologies (Dixit et al., 2023), and climate-smart practices like mulching, soil conservation, seed selection, and irrigation (Kirungi et al., 2023). Our study focuses on the phases of knowledge and persuasion, where knowledge transfer and change agents play a primary role (Rogers, 2003).

Cultural Dimensions Theory

Culture refers to the shared realities (e.g., values, beliefs, and behaviors) of individuals that distinguish them from other groups (Baker & Campbell, 2016; Hofstede, 2011). Culture influences how individuals make decisions and interact with society and can be distinguished across many boundaries such as organizations, countries, and geographic regions. In a popular and widely utilized theory, Hofstede (2011) reckoned culture into six encompassing factors of power distance, individualism/collectivism, uncertainty avoidance, masculinity/femininity,

long/short term orientation, and indulgence/restraint. Power distance describes how less powerful members of the group expect and accept that power is distributed unequally (either low or high). Individualism versus collectivism relates to the degree to which individuals are integrated into groups and prioritize individual goals versus collective ones. Masculinity versus femininity explicates not only gender roles in society but the society's preference for achievement, assertiveness, and material success (masculinity) versus caring for others, quality of life, and cooperation (femininity). Uncertainty avoidance captures the level of discomfort a society feels with uncertainty and ambiguity, leading to a preference for clear rules and structure. Short- versus long-term orientation depicts the society's focus on future rewards through persistence and thrift (long-term) versus values of the past and present, such as respect for tradition and fulfilling social obligations (short-term). Finally, indulgence versus restraint represents the extent to which a society allows relatively free gratification of basic human drives related to enjoying life and having fun (indulgence) versus regulating it through strict social norms (restraint). These cultural constructs influence how innovations spread through society with previous applications in Zimbabwe (Kugadera et al., 2021) and Ethiopia (Jordan & Guerzoni, 2021). To complement the diffusion of innovations theory with a cultural addition, we utilized Hofstede's (2011) cultural dimensions theory to examine how different cultural factors shape the decision-making process in adopting CSA in Ethiopia and Zimbabwe.

Purpose and Objectives

Other efforts have broadly reviewed the influences on adoption, but less work has specifically reviewed the context of knowledge transfer in the adoption process, particularly in a sub-Saharan Africa context. Even fewer works have utilized a cultural lens to describe the relationship between culture, knowledge transfer, and adoption. Therefore, the purpose of this study was to investigate and compare knowledge transfer landscapes and cultural factors among Ethiopia and Zimbabwe as related to the CSA adoption process. We sought to achieve this purpose through the following objectives: 1) to examine the current resources for knowledge transfer in CSA adoption within Ethiopia and Zimbabwe; 2) to identify the relationship between culture and CSA knowledge transfer among smallholder farmers; 3) to provide future directions for agricultural advisory systems to better provide strategies for CSA adoption in the context of heterogeneous communities.

Methods

Case Study Approach

Our study was guided by a case study approach (Aurini et al., 2016; Creswell & Poth, 2017). Case studies are used to provide in-depth descriptions or explanations of complex phenomena within a certain context (Yin, 2008). We utilized multiple unobtrusive data sources to more fully describe culture, knowledge transfer, and the adoption of climate-smart farming practices (Aurini et al., 2016). These included 12 research articles, with two from each country representing three constructs of interest, including general adoption, knowledge transfer, and culture, in the CSA adoption context. We also utilized official government websites and Google Trends data to support the impetus for our study and provide novel insights.

Case Selection: Ethiopia and Zimbabwe

We first established case boundaries based on Google Trends data to determine which geographic areas were most frequently seeking information about CSA. We analyzed Google Trends data for the following search terms: climate-smart/climate smart agriculture, digital farming, smart agriculture, precision agriculture, artificial intelligence in agriculture, precision farming, smart farming, and agriculture AI. Ethiopia and Zimbabwe emerged as the most common countries searching Google for these terms in the past 20 years (from 2004 to October 2024). Upon investigating these countries further, it became apparent that sub-Saharan Africa is one of the most vulnerable agricultural regions in the world (Kombat et al., 2021; Makate et al., 2019).

Ethiopia and Zimbabwe are no exception, and the small farms that make up their agricultural economies are highly impacted by climate change (Mpala & Simatele, 2024; Zerssa et al., 2021). Extreme weather events such as drought, flooding, and pest invasions disrupt the highly localized food supply chain (Vermeulen et al., 2012) and ripple through other sustainable development goals such as zero hunger, good health and well-being, and clean water and sanitation (Nhemachena et al., 2020). As a response to these threats, academia, federal governments, and international organizations such as the Food and Agriculture Organization (FAO) have published outreach working to increase or guide strategic knowledge transfer about climate-smart practices. In both countries, Extension outreach has faced challenges at multiple levels, including a lack of funding and qualified personnel and perceptions of inefficacy from years of executing a largely unsuccessful top-down approach to knowledge transfer (Hanyani-Mlambo, 2002.; Geleta et al., 2023). Overall, the climate impacts and recent salience of CSA practice adoption across stakeholder groups within Ethiopia and Zimbabwe further emphasize these cases as an area that could benefit from more widespread adoption and research in line with this mission.

Case Description

Ethiopia is a country of over 120 million people located in Northeast Africa on the country's "horn." In 2020, agriculture contributed 34.5% of the country's GDP, and 95% of its farms are small (.5 to 2 hectares) and family-owned (FAO, 2013; 2024a). Agricultural production in Ethiopia contributes 80% of the country's emissions, and the agricultural sector is also extremely vulnerable to climate impacts (International Trade Administration, 2024). Ethiopia's largest export is coffee, but most smallholder production goes to local food consumption, including cereals, pulses, oil seeds, and produce (Central Statistical Agency of Ethiopia, 2011). Ethiopia's climate is diverse across the country and ranges from high-humidity rainforests to mountains to dry lands (FAO, 2024b). While Ethiopia is home to a diverse collection of ethnicities, religions, and cultural tendencies, the culture tends to be more collectivist (prioritizing relationships and group associations) with a high power-distance, for instance, little free communication between subordinates and superiors (Baker & Campbell, 2016). Similar to many African societies, it is mainly patriarchal, despite women's contribution to agriculture production through small livestock, poultry, and other markets (Birhan, 2024; Mutombo & Musarandega, 2023).

Zimbabwe, a smaller country geographically and population-wise, has over 16 million inhabitants and is located in southeastern Africa (FAO, 2024c). The population density is much lower here than in Ethiopia, and more of the land is dedicated to agricultural production (33.3 million hectares of its 39 million) (FAO, 2022). Most of this land is used to grow maize, and other crops include wheat, peanuts, and soybeans (Foreign Agricultural Service, 2024).

Zimbabwe's agricultural lands have been identified as having the potential to irrigate 200,000 more hectares to aid in production and the food security crisis (FAO, 2022). Zimbabwe experiences a subtropical climate in its northern half and a hot, arid climate in its southern half. Zimbabweans are also a patriarchal, collectivist society with a high power-distance culture (Mazonde & Carmichael, 2016). Within both Ethiopia and Zimbabwe, the literature and international organizations have urged and promoted outreach and adoption of CSA (Chavula & Turyasingura, 2022; FAO, 2023; Hanyani-Mlambo, 2002). Notably, CSA can aid in climate change adaptation and mitigation, helping establish more resilient operations that also produce less emissions.

Data Collection

For unobtrusive case studies such as this, multiple data sources are preferred to better describe the cases and provide triangulation (Aurini et al., 2016). Therefore, in addition to the Google Trends data, we utilized a purposively sampled set of 12 research articles published in the past five years to represent each construct of interest including adoption, knowledge transfer, and culture. Table 1 outlines the details of the academic articles.

Table 1

Academic Article Details

Article Number & Construct	Author (year)	Data Collection Method	Knowledge Transfer Context Summary	Construct of Interest
			Zimbabwe	
A1	Mutombo & Musarandega (2023)	Surveys, focus groups, and interviews (*N* = ~265)	**Source(s):** AGRITEX officers, NGOs **Channel(s):** Farmer association meetings, farm visits, farmer-to-farmer **Innovation:** Climate smart practices	General adoption
A2	Mujeyi, et al. (2019)	Surveys (*N* = 386)	**Source(s):** Extension, international research organizations **Channel(s):** Workshops and field days **Innovation:** Climate smart practices	General adoption
A3	Zvobgo et al. (2023)	Interviews (*N* = 100)	**Source(s):** Indigenous and local knowledge, Extension **Channel(s):** face to face, technology, neighbor interactions, social groups (community gatherings) **Innovation:** Climate smart practices	Knowledge transfer
A4	Masere et al. (2021)	Literature review and interviews (*N* = 21)	**Source(s):** Extension, master farmers, indigenous knowledge, scientists, sales representatives **Channel(s):** Linear, advisory, facilitation, participatory, radio listening, emails & newsletters **Innovation:** Climate smart technology	Knowledge transfer
A5	Masimba & Zuva (2022)	Survey (*N* = 352)	**Source(s):** Technology start-up companies (e.g., AgriMobi, ZIMACE, Esoko, eMkambo, Eco-Farmer, and e-Hurudza) **Channel(s):** mobile phones **Innovation:** Climate smart technology	Culture

A6	Kugedera et al. (2021)	Literature review	**Source(s):** Opinion leaders (e.g., chiefs), community groups, indigenous knowledge **Channel(s):** Rituals, group meetings, ceremonies **Innovation:** Climate smart practices	Culture
			Ethiopia	
A7	Zerssa et al. (2021)	Literature review	**Source(s):** Extension, farmers, NGOs, researchers **Channel(s):** Trials, face-to-face interactions **Innovation:** Climate smart practices	General adoption
A8	Kassa & Abdi (2022)	Surveys, focus groups, and interviews (*N* = 213)	**Source(s):** Development agents, farmers **Channel(s):** N/A **Innovation:** Climate smart practices	General adoption
A9	Yami et al. (2024)	Interviews and field plot data from farmers (*N* = 654)	**Source(s):** Extension, relatives, farmers, funding institutes, researchers, media **Channel(s):** Observations, face-to-face, model farmers, videos **Innovation:** Climate smart practices	Knowledge transfer
A10	Geleta et al. (2023)	Surveys, interviews, and focus groups (*N* = 143)	**Source(s):** Relatives, other farmers, Extension, media, researchers **Channel(s):** Observations, face-to-face, trials, radio, printed materials **Innovation:** Climate smart practices	Knowledge transfer
A11	Jordan & Guerzoni (2021)	Survey (*N* = 1,477)	**Source(s):** Extension agents, experienced farmers, farmer associations **Channel(s):** N/A **Innovation:** Climate smart practices	Culture
A12	Etana et al. (2020)	Surveys, focus groups, and interviews (*N* = 810)	**Source(s):** Farmers, Extension agents **Channel(s):** Face-to-face Extension interaction, observing neighbors' fields **Innovation:** Climate smart practices	Culture

In addition to the academic articles, four official government or FAO website pages describing the existing Extension system and CSA priorities from each country were selected and reviewed. For Zimbabwe, the overall Extension context was represented by Hanyani-Mlambo (2002) and CSA adoption by FAO (2024c). For Ethiopia, the Extension context was represented by the Ministry of Agriculture (2017), and CSA adoption by Jirata et al. (2016). All were from either the country's national government or the FAO.

Data Analysis

Two authors reviewed the 12 academic articles for emergent themes related to the constructs of interest specified *a priori*, which were related to knowledge transfer (e.g., source, channel, innovation, and main recommendation) (Rogers, 2003) and culture (e.g., power distance, individualism vs. collectivism, masculinity vs. femininity, uncertainty avoidance, long-term vs. short-term orientation, and indulgence vs. restraint) (Hofstede, 2011). The two authors used these constructs to document examples from each article in separate Excel documents. The constant comparative method (Creswell & Poth, 2017) was employed at the initial stage of the review process to compare documents. Clarifications were made, and the remaining articles were independently reviewed. Upon comparing the Excel documents, high levels of similarity were

found between each coder's interpretation and classification of examples. We also realized the underrepresentation of the indulgence vs. restraint construct and removed it from analysis and reporting, similar to Kugedera et al. (2021). Then, examples from the findings of 12 selected studies were categorized into sub-themes within each construct based on frequency and similarity of examples, which functioned similarly to codes in qualitative review. Both authors agreed to the categorization. The website materials were reviewed and annotated to facilitate discussion by drawing connections between academic research findings and more field-based, official publications.

Findings and Discussion

Due to the similarity of findings between Ethiopia and Zimbabwe, we reviewed the research objectives collectively across both countries to bring together diverse cultural, adoption, and knowledge transfer perspectives that can guide future decisions for research and practice.

Context of CSA knowledge transfer among smallholder farmers in Ethiopia and Zimbabwe

We conceptualized the key components of knowledge transfer about CSA practices into constructs of source, representing the origin of the knowledge; channel, denoting the medium through which the information is conveyed; and innovation, referring to the specific farming applications being diffused.

The most common sources mentioned in the study cases were Extension agents or AGRITEX officers (n = 9; 75%) who used a top-down approach to facilitate knowledge transfer, which has been known to exclude many less-connected farmers and, therefore, increase distances and discrepancies between social groups. This finding veers from suggestions in literature to increase participatory methods and avoid top-down approaches due to the skepticism of Extension personnel's capacity and efficacy (Munzhedzi, 2020). Many studies also discussed the importance of and preference for information from other farmers or indigenous knowledge (n =10; 83%). Face-to-face interactions were a highly preferred channel across the literature, followed by observations or trials, club and organizational meetings, workshops, and field days, which should enhance the innovations trialability and observability and accelerate adoption (Rogers, 2003). Also mentioned were radio listening, mobile phones, printed materials, video resources, and rituals/ceremonies. NGOs, scientists, sales representatives, weather reporting agencies, community leaders (e.g., chiefs), and the media were also mentioned.

Most of the studies included a litany of climate-smart practices within their scope, including drought-resistant crops, diversifying crops, more resilient or productive crop selection, hybrid seed selection, crop rotation, compost and manure use, mulching, minimal tillage, adjusting planting dates, diversifying livestock, seed retention, irrigation and water retention, and tree planting to reduce runoff. One of the 12 selected studies specifically investigated a CSA technology (i.e., mobile phone use) (Masimba & Zuva, 2022), and another investigated CSA technology broadly with no examples of application (Masere & Worth, 2021). Many global efforts are specifically focused on CSA technology adoption, such as smart farming or precision agriculture technology that rely on devices and data (Hanyani-Mlambo, 2002). However, our findings revealed that within Ethiopia and Zimbabwe, CSA innovations are less technological and more practice-based, and while these innovations were influential, the findings also reflected the limitations of developing agri-technology in this context (Adenle et al., 2015). All of the practices included have shown to positively influence mitigation efforts, improve the shock resilience of the farm, and/or improve production and profit (FAO, 2016). One public document

(Hanyani-Mlambo, 2002) noted Extension agents are only equipped to recommend technologies introduced 15 to 20 years ago, which could illuminate the high presence of more primitive CSA practices rather than technologies. Although these practices may have lower levels of complexity than technology (Rogers, 2003), they each require various financial and labor inputs and have varying timelines of return on investment that must be communicated to farmers or risk perceived failure. Extension in Ethiopia has been challenged to move beyond short-term campaigns and prioritize a long-term planning approach both internally and for their constituents (Ministry of Agriculture, 2017). As Ethiopia and Zimbabwe are both developing countries with relatively low technological infrastructure (FAO 2022; 2024a), CSA practices are expected to evolve toward more technological complexity and application (Moyo & Salawu, 2017). Basic technology adoption (i.e., smartphones or computers) should be prioritized for farmers because short-term communication on these platforms can efficiently reach more rural and hard-to-access (e.g., inefficient roads, low farmer density, etc.) farmers (FAO, 2016).

The dynamic between culture and CSA knowledge transfer

Based on Hofstedes's (2011) explication of cultural dimensions, we recorded explicit and implicit descriptions of these cultural dimensions exemplified or in action in included cases and related them to adoption-focused knowledge transfer of CSA.

Power Distance

Both Ethiopia and Zimbabwe are high power distance countries (Birhan, 2024; Mazonde & Carmichael, 2016), and this was exemplified in the preference for farmer-to-farmer interactions rather than a top-down approach. Thus, even though the top-down promotion of CSA is predominant, many farmers believe it is ineffective, perhaps due to the perceived power distance paired with perceptions of inefficacy. Many of the public documents described the inefficacy of Extension in its early days, with a loss of experienced staff between 1981 and 1985 (FAO, n.d.), although they also claimed their efforts have moved beyond these perceptions with the implementation of more agents, with more training, using a more participatory approach. However, the more recent academic findings still describe distrust between farmers and Extension agents (Etna et al., 2020; Masere & Worth, 2021). The need to shift away from top-down approaches was mentioned across the public documents, with one article aptly describing how with top-down approaches, the "flow of information frequently stopped at the contact farmer/group level" (Hanyani-Mlambo, 2002, p. 2). Additionally, farmer-to-farmer interactions seem to have been researched and considered by practitioners in a unidimensional way, assuming a low power distance, when in fact, power distances also exist between farmers (Etna et al., 2020; Silvert et al., 2022). This perception of equality among farmer groups can impede the intentional development of linkages between central or master farmers and more impoverished or otherwise disconnected farmers that will be essential to an impactful participatory approach.

Individualism vs. Collectivism

Collectivism's role in knowledge transfer among smallholder farmers in Ethiopia and Zimbabwe cannot be understated. Knowledge about CSA diffuses among social groups, and sparking this process is often the goal of Extension efforts through approaches like the master farmer training program (Hanyani-Mlambo, 2002). However, the collectivist culture presents a metaphorical double-edged sword. Successful adoption with noticeable benefits (e.g., high yields) has been shown to increase adoption among farmers who witness positive outcomes

(Yami et al., 2024). However, unsuccessful attempts, whether by Extension or farmer trial plots, quickly diffuse through social groups and can cause long-lasting resistance to adoption. One farmer stated,

> In the past years, technologies were changing. We were told to plant in line, mixing together seeds and fertilizers. Farmers who used this method obtained little production than those who have sown in the conventional way. So, farmers concluded that the advice they received was wrong. In the other time, new method of sowing came. It was to spread fertilizer first and then sow the seeds. We tried this method. We were not successful. This year, the third technology came…These issues are responsible for failure of farmers to follow technologies in similar patterns (Etna et al., 2020, p. 14).

Extension agents and other facilitators should be aware of "path dependence" (Etna et al., 2020), a phenomenon that outlines how early exposure to an innovation determines the "path" toward adoption or non-adoption. After the initial exposure, re-adjusting a non-adoption path toward adoption is more difficult. However, some studies did show that membership to a farmer group increased adoption rates (Mutombo & Musarandega, 2023). Collectivist societies may have more open knowledge transfer and resource sharing such as equipment and labor. Alternatively, the articles documented that ethnic and religious heterogeneity between communities may restrict knowledge transfer between groups, even within close geographic proximities (Jordan & Guerzoni, 2021).

Masculinity vs. Femininity

Both countries represent a predominantly patriarchal society, and most of the studies included in our review had a predominantly male sample. Many public documents called for increased attention to female farmers, which was not reflected in the academic articles. A few articles explored the role of men and women in society and noted that women had limited but substantial roles related to small livestock (e.g., chickens and pigs) as well as crafts (Mutombo & Musarandega, 2023). Women tended to rely more on indigenous practices due to men being more included in social networks where information sharing takes place (Kugadera et al., 2021).

Uncertainty Avoidance

Farmers in Ethiopia and Zimbabwe face multiple widely documented barriers to adopting CSA. This presents inherent uncertainty that needs to be lowered before widespread adoption can occur. Mentioned in all articles were the high input costs and low access to credit and financial resources that render farmers unable to invest in technology, equipment, and other inputs (e.g., improved seeds, fertilizer, pesticides). AGRITEX was also under-resourced, with one policy document stating "AGRITEX's financial woes and the government's expectations are like trying to milk a cow without feeding it, a scenario reflected by too many demands and insufficient financial backing" (Hanyani-Mlambo, 2002, p. 4). Also mentioned across all articles was the mention of inadequate awareness and knowledge of the benefits of CSA, perhaps amplified by a perceived inefficacy of Extension. Climate change pressures have also driven certain strategies like diversifying crops and reducing the planting size to reduce risk (Radeny et al., 2022). These barriers were corroborated across all resources reviewed.

Long-Term vs. Short-Term Orientation

The volatile climate and market these countries experience present a tremendous amount of risk in agricultural production. Findings indicated that many farmers prioritize immediate returns on investment to meet local food needs and ensure that their families have food and income, as high CSA input costs and resource constraints force them to take a short-term perspective of innovative farming practices. Extreme droughts and floods also pressure a short-term outlook in which weather forecasts inform short-term decisions such as planting and harvesting. With so much weather variability, it is difficult to develop long-term plans that enhance overall system performance (e.g., soil health, resilience) when immediate results are needed, and plans need to be adjusted as a reaction to weather. Additionally, short-term orientation societies are hallmarked by a respect for tradition and fulfilling social obligations (Hofstede, 2011), which may reinforce the status quo of production practices.

Conclusions, Implications, and Recommendations

This study provides a necessary deep dive into the context of CSA practice adoption among smallholder farmers in Ethiopia and Zimbabwe with a cultural lens on knowledge transfer. Despite the inherent limitations of an unobtrusive case study, by integrating Rogers' (2003) diffusion of innovations and Hofstede's (2011) cultural dimensions theory, we offered a nuanced understanding of how cultural factors may relate to the adoption of CSA practices and provide potential pathways forward.

The findings highlight the significant role of cultural dimensions in the knowledge transfer process related to adopting CSA practices. High power distance in both countries affects the efficacy of top-down approaches, indicating a necessary shift towards more participatory methods that involve diverse smallholder farmers in the diffusion of CSA practices. Establishing more trust and respect between farmers and Extension agents by lowering power distance and fostering perceptions of equality will improve the role of Extension agents in enhancing the adoption of CSA practices, as negative experiences can solidify path dependence toward non-adoption. Collectivism can enhance knowledge diffusion within smallholder farmer groups but also poses challenges when initial adoption experiences are negative. To overcome the collectivist culture dilemma in which knowledge transfer does not flow between heterogeneous culture groups, Extension agents can facilitate in-person group meetings where participants come from multi-cultural communities to share and receive insight to leverage multiple sources for CSA adoption (Mukembo & Edwards, 2015). Many academic articles and public documents focus on Extension, positing it as the main carrier of outreach and knowledge transfer. We urge Extension to play a more decentralized, facilitatory role in which they act as change agents to bring together diverse stakeholders and leverage their unique strengths (Yami et al., 2024).

The content of the knowledge transferred should work to reduce uncertainty avoidance and aid in both short and long-term decision-making. The barriers that hindered smallholders from adopting CSA practices include high input costs, limited access to credit, and inadequate awareness of CSA benefits. These barriers are exacerbated by the perceived inefficacy of Extension services, which have historically relied on outdated methods and technologies (Manzeke-Kangara et al., 2024). This study underscores the importance of addressing these barriers through targeted interventions and enhanced Extension services (Lee et al., 2024). Given Extension should function as a reliable resource and trusted connector for smallholder farmers, it is important to overcome these barriers with focused interventions and improved services. Updated training programs for Extension agents are needed (Manzeke-Kangara et al., 2024) and should focus on building trust and reducing power distance.

While Extension cannot address climate change or institutional inadequacies, they can make farmers aware of credit and other financial opportunities and can provide localized low-cost alternative practices. As revealed in our study, farmers need support throughout the adoption phases to maintain a path toward continued adoption, not just the initial startup costs. Incentive programs should create a safety net for failed trials or innovations, which may help improve trust between farmers and Extension agents and make farmers more willing to try another innovation (Zerssa et al., 2021). As incentive programs designed to foster adoption of CSA increase, Extension agents should be equipped with up-to-date information and direct farmers toward these resources. Historically, there have been weak linkages between government, research, and extension (Ministry of Agriculture and Natural Resources, 2017), which will need to be addressed to equip Extension agents with relevant programs, practices, and updates. Also critical is the continued evaluation of all producer-facing programs, which has been lacking in previous years (Ministry of Agriculture and Natural Resources, 2017).

For future academic research, integrating DOI (Rogers, 2003) with CDT (Hofstede, 2011) addresses the inherent limitations of each framework. The diffusion of innovation theory lacks consideration of cultural and contextual factors in the adoption process, whereas the cultural dimensions theory does not explicitly account for the processes of adoption and knowledge transfer. Therefore, the combination of these theoretical frameworks more holistically describes how knowledge transfer and culture relate to adoption and each other. Future studies should explore a model or theory that encompasses these vital constructs in relation to innovation adoption. This study also provides an initial way to operationalize culture in the CSA adoption context with the given examples of each of Hofstede's (2011) dimensions. Future research and practice should be designed with culture in mind, including direct measurement of culture within adoption contexts, similar to the cultural inventory Jordan and Guerzoni (2021) proposed. Furthermore, studies investigating specifically how to increase openness and sharing among communities with cultural differences should be conducted to inform pragmatic efforts to foster knowledge sharing in these and other regions.

The review both explicitly and implicitly revealed an urgent need to consider cultural factors in the knowledge diffusion process. Notably, only the articles selected to represent culture explicitly mentioned cultural dimensions, suggesting they were underrepresented when considering their importance. Overall, we emphasize culture as a vital consideration when researching and practicing in the CSA context in Ethiopia and Zimbabwe, and likely other sub-Saharan countries as well. Meaningful work is urgently needed to enhance perceptions of Extension, including a focus on participatory rather than top-down approaches. We underline the importance of a blended approach that considers diverse decision resources and connects Extension efforts with them. Ultimately, enhancing knowledge transfer with a cultural lens can increase the adoption rates of CSA and enhance the quality of life for people in these regions.

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