

Strengthening resilience: the role of institutions in facilitating local agricultural adaptation to the impact of climate change in Tanzania

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ABSTRACT: Building resilience in areas susceptible to climatic hazards is widely recognised as a critical strategy. This article offers valuable insights into the contribution of institutions to supporting smallholder farmers in building resilience against the effects of climate change. Data for this article was collected from Manzase and Haneti villages in Chamwino district in Dodoma region, Tanzania. The study adopted a qualitative approach and deployed key informant interviews and focus group discussions for data collection. The result showed that institutions that operate in the villages under study which include agricultural extension agencies, Non-Governmental organisations, private companies and village governments, have played such roles as providing drought-resistant seeds, disseminating seasonal weather forecast information and supporting the establishment of income diversification activities to farmers. Furthermore, the institution facilitated agroforestry farming through natural tree regeneration and ensured access to crop markets and loans for farm inputs. These roles have contributed to reducing crop loss due to drought and rainfall unreliability, enhanced household income, and allowed households access to food during drought-induced crop failure. The study also revealed that institutional linkages are crucial in comprehensively addressing challenges faced by smallholder farmers, thereby building their livelihood resilience. This paper argues that strong institutional support is essential for farmers to build resilience against climate change.

KEYWORDS: adaptation, resilience, climate change, food security, Tanzania

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1. INTRODUCTION

Building resilience is increasingly recognised as a critical strategy in many developing regions vulnerable to natural hazards. This is particularly important because rain-fed farming and livestock keeping are the primary sources of livelihood, but are severely affected by frequent climatic hazards. Sub-Saharan Africa (SSA) is one of the most vulnerable regions to the impact of climate change (Bedeke,2023). This vulnerability is caused by several factors which include: weak institutional capacity to coordinate farmers' response to hazards, high crop sensitivity to changes in weather patterns and limited access to resources and water management technology (Mwamfupe, 2019). Projections in SSA indicate that extreme events such as drought will continue to happen frequently and the growth and development of crop pests and weeds will accelerate (Schneider et al., 2022). These climate-related effects will disrupt crop production and aggravate rural poverty in already vulnerable resource-dependent communities. Thus adaptation measures in such areas are important and in order to reduce vulnerabilities and enhance the resilience of smallholder farmers.

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In Tanzania, vulnerability to climate change impacts is caused by dependency on climate-sensitive livelihood activities such as rain-fed farming and limited financial resources to manage hazards such as droughts. From the 1980s to the 2020s, the country has experienced an increasing frequency of droughts and floods which affect different sectors, mostly farming and livestock keeping (Mabhuye, 2024). Food insecurity due to crop failure and deaths of livestock caused by severe drought have been the major results (Borhara et al., 2020).

The National Climate Change Strategy (NCCS), the Environmental Management Act of 2004 and the National Adaptation Plan of Action (NAPA) are policy frameworks for responding to climate change in Tanzania (Mwamfupe, 2019). The NCCS is a blueprint for promoting, prioritising, and implementing adaptation across various sectors nationwide. However, its success in promoting adaptation and resilience building relies on the actions of local actors in the lower levels of administration, such as local governments and other institutions, to mainstream adaptation in their development, planning and implementation (URT, 2021).

Considering the importance of local institutions in building climate change resilience, research interest in their roles has been increasing (Hovelsrud et al., 2012). The interest is motivated by the following reasons: Firstly, resilience is fundamentally a local concern since vulnerabilities are felt at this level, and the actions to fortify them are implemented at the local level (Intergovernmental Panel on Climate Change (IPCC), (2007). It is, thus, crucial to understand the local institution's roles in order to help build the resilience of vulnerable social groups such as smallholder farmers with limited resources. Secondly, local institutions are often well acquainted with the local environment and practices that have sustained the vulnerable communities for many years (Nalau et al., 2018). Thirdly, climate change adaptation and resilience building are not merely environmental questions; rather, they are challenges embedded in the community's social and economic dimensions. Understanding how local institutions navigate social and economic issues related to climate change is crucial for enhancing adaptation (Ayers, 2010). Furthermore, it is also argued that enhancing ownership of adaptation strategies and ensuring that local-level vulnerabilities are addressed requires an understanding of the role of local institutions as a crucial entry point for adaptation planning (Omukuti, 2020).

Local institutions significantly influence the livelihood activities of smallholder farmers through their roles. However, there is a lack of understanding about how these institutions contribute to the resilience of local smallholder farmers. This paper aims to bridge this gap by identifying local-level institutions that empower communities and describing their roles in climate change adaptation and resilience-building. The paper employs a qualitative approach, using information collected from interviews and focus group discussions.

The paper contributes significantly to the existing research since it sheds light on a topic largely overlooked in previous studies. By focusing on the role of institutions, the paper adds a new dimension to the existing body of research on adaptation to the impact of climate change within economically and environmentally vulnerable semi-arid areas. Previous studies have explored the contribution of livelihood strategies such as migration and tillage practices in facilitating adaptation to the effects of climate change (Afifi et al., 2013; Shemdoe et al., 2009). However, they have not delved into the role of institutions in building resilience to climate change. Understanding the role of institutions is crucial for informing policy on adaptation and resilience-building efforts at the local level. The rest of the paper is organised as follows: Section 2 is the literature review that describes concepts and how they are used in this study, followed by the empirical literature on local-level institutions' roles, and finally, the conceptual framework. Section 3 presents the methodological approaches, section 4 presents the results briefly, and Section 5 presents the discussion that interprets the results and links them with adaptation and resilience. The last section presents the conclusion and recommendations.

2. LITERATURE REVIEW

2.1. Local institutions

As opined by Uphoff & Buck (2006), local institutions are established or designed by local communities or external entities that work with the local community to organise their collective action to

achieve defined goals. These institutions may be formal entities with predefined written rules or informally organised entities composed of norms and voluntary codes of conduct that guide member interaction (Banerjee et al., 2012). Be they formal or informal institutions, their rules and enforcement mechanisms are critical in shaping how society functions. Furthermore, local Institutions can be classified as public, private, or civic depending on how they are governed and the motives for their existence (Agrawal, 2008). Public institutions typically operate under the government bureaucracy, while private institutions are individually owned and driven by profit motives. Civic ones include Non-governmental or hybrid organisations such as farmers' cooperatives (Agrawal, 2008). This paper focuses on institutions as formal organisations rather than uncodified customs or traditions. In the context of climate change, such institutions are deemed as drivers of change that also influence the adaptive capacity of communities and households (Agrawal, 2008). They are described as vehicles and enablers of livelihood resilience, reducing vulnerability and maintaining sustainable livelihoods (Smit & Wandel, 2006).

2.2. Resilience

The concept of resilience encompasses diverse interpretations. The meanings vary based on the field of study, purpose, and context. It has roots in socio-ecological theory but its usage has been adapted in many disciplines such as engineering, agriculture and climate change. Initially, resilience described the capacity of materials to return to their normal situation or equilibrium after a displacement (Norris et al., 2008). In that case, materials are considered resilient if they can be bent and bounce back rather than break when stressed (Bodin & Wiman, 2004). In the context of climate change, resilience is the ability of systems, people or organisations to absorb shocks, recover from them and maintain their functions. From these definitions: ability of material, people or organisations to “return to normal” or “recover” after being stressed has featured repeatedly. This view has also been echoed by the IPCC (2007), which defined resilience as the ability of social or ecological systems to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation and the capacity to adapt to stress and change.

Resilience in the context of climate change has been closely related to adaptation (Smit & Wandel, 2006; Nyamwanza, 2012) and is often used together with adaptation. Supporting this view, Paavola (2008) and Tompkins & Adger (2005) have argued that resilience and adaptation can interchangeably refer to the ability of actors to shield themselves and recover from adverse climate change impacts. Despite the prominent characterisation of resilience as the ability to recover and return to normal from the adverse impact of climate change, critics have argued that resilience building should not merely seek to return to basic structure or recover from stress. Instead, resilience building should create pathways for improving lives beyond pre-disruptive conditions (Dodman et al., 2012). This is especially true in most rural communities in developing countries such as Tanzania, where returning to normal or recovering from shock may still be undesirable as it may mean enduring poverty. Even before livelihood disruption by climate change impacts such as frequent droughts and rainfall variability, most rural farmers produced for subsistence and had low incomes. They could barely meet the basic needs for food and other necessities. Therefore, in exploring the role of institutions in building resilience against climate change effects, this paper adapts an approach to resilience, focusing on coping with added shocks and addressing challenges that constrain smallholder farmers' livelihoods (Dodman et al., 2012). Addressing challenges faced by rural communities such as limited access to adequate food and income, makes the households resilient and more capable of dealing with shocks, including those that emanate from the effects of climate change.

2.3. Roles of institutions in resilience building

Literature indicates that various institutions, such as agricultural extension agencies, non-governmental organisations, and private firms, have played significant roles in enhancing adaptation and building resilience against the effects of climate change. These roles include climate change risk reduction, such as disseminating weather and climate information and facilitating technology transfer by enabling

the adoption of drought-resistant seeds and innovative farming practices. Other roles include supporting income diversification activities and enhancing access to crop markets and credit.

With regard to technology, institutions have facilitated the development and adoption of improved seeds. In semi-arid areas, the common ones include drought-tolerant sorghum, millet, and groundnut seeds. Such varieties are crucial in managing frequent droughts (Shiferaw et al., 2014; Morahanye, 2020). They provide decent harvests under conditions of reduced rainfall (ibid). Some improved sorghum varieties perform better in water-stressed environments than in well-watered conditions (Mwamahonje et al., 2021), thus allowing farmers to have stable crops during drought. This scenario ensures the availability of stable food and income sources. While research institutions develop the seeds, non-governmental organisations and agricultural extension agencies, have disseminated the improved seed to farmers (Islam & Nusrey-Bray, 2017). Drought-tolerant varieties ensure farmers are resilient to drought and rainfall variability.

Institutions also catalyse farming practices crucial for climate mitigation and adaptation. Community-based organisations (CBOs) and Non-governmental organisations (NGOs) implement agroforestry practices such as agro silviculture that involve the integration of trees and shrubs on cropland. They do this by providing funds and disseminating knowledge on the practice to farmers at the local level (Bettles et al., 2021; Blanco, 2006). Agroforestry practices benefit ecosystem services, such as soil enrichment, climate mitigation through carbon storage and livelihood diversification through the sale of wood or timber. These benefits reduce vulnerability by providing alternative income and enhancing resilience to climatic hazards such as drought (Awazi, 2022).

Concerning weather and climate information, institutions such as agricultural extension agencies and Non-governmental organisations provide farmers with forecasts on meteorological parameters including temperature, precipitation and drought conditions (Maponya & Mpandeli, 2013; Ozor, 2011). This information is an essential tool for adaptation as it enables farmers to make informed decisions about crop varieties and planting dates. Kumar et al. (2020) argued that two weeks' advance information could reduce crop damage by 60 to 80 percent during harvest. However, two challenges inhibit the potential for climate information in adaptation and resilience building against the effects of climate change. The two challenges are: firstly, capacity of local institutions to produce reliable rainfall forecasts, and secondly, the challenges regarding the efficient use of climate and weather information among small-scale farmers.

To reduce dependency on traditional crops prone to drought, Institutions have facilitated the diversification of income-generating activities by introducing backyard horticultural gardens and keeping small ruminants as an alternative to traditional crops such as maize (Kuhl, 2018). Such activities provide an alternative source of income and a buffer against climate-related risks. Institutions also support farmers' access to farm implements, credit and ready-crop markets. Access to markets allows farmers to sell their crops and earn income that can be used to invest in climate-smart technologies such as drip irrigation and improved seeds. These innovations help mitigate the impact of climate change on agriculture (Agrawal, 2008). Credit from financial institutions and access to farm implements such as tools and machinery improve efficiency and overall yield, increasing income that can be invested in technologies to mitigate climate risks (Feyisa, 2017).

To effectively address the challenges of climate change, literature shows that it is critical to establish linkages between various institutions (Robinson et al., 2018). These institutions include government agencies, research organisations, non-governmental organisations, and community groups. Through collaborating and sharing resources and expertise, these institutions can work together to improve and implement climate change resilience-building strategies. The collaborative approach ensures a comprehensive response to climate change, considering diverse perspectives and leveraging the strengths of each institution (Wilby, 2020). Collaboration also helps to evade duplicate efforts and create efficient use of resources, leading to effective outcomes in building climate resilience.

2.4. Conceptual framework

The following conceptual framework (Figure 1) provides a structured approach to analysing the role of local institutions in building resilience to climate change effects. This framework was developed

based on a literature review on institutions and climate change adaptation. The components of the framework represent the themes this study sought to address. The framework has the following components: existing institutions, roles of institutions, institutional linkages and resilience building. The last component, resilience building, is a cross-cutting theme embedded in the discussions on the role of institutions and their linkages.

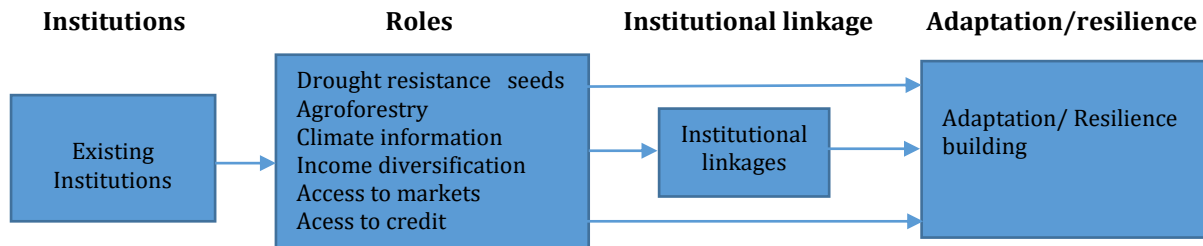


Figure 1. Conceptual framework on institutions for resilience building to climate change effects and variability.

Source: Authors construct based on review of literature.

3. RESEARCH METHODS

3.1. Study area description

This study was conducted in Chamwino district of Dodoma region in Tanzania (Figure 2). The district is situated within the semi-arid central plateau at latitude 6° 15' South and longitude 35° 42' East.

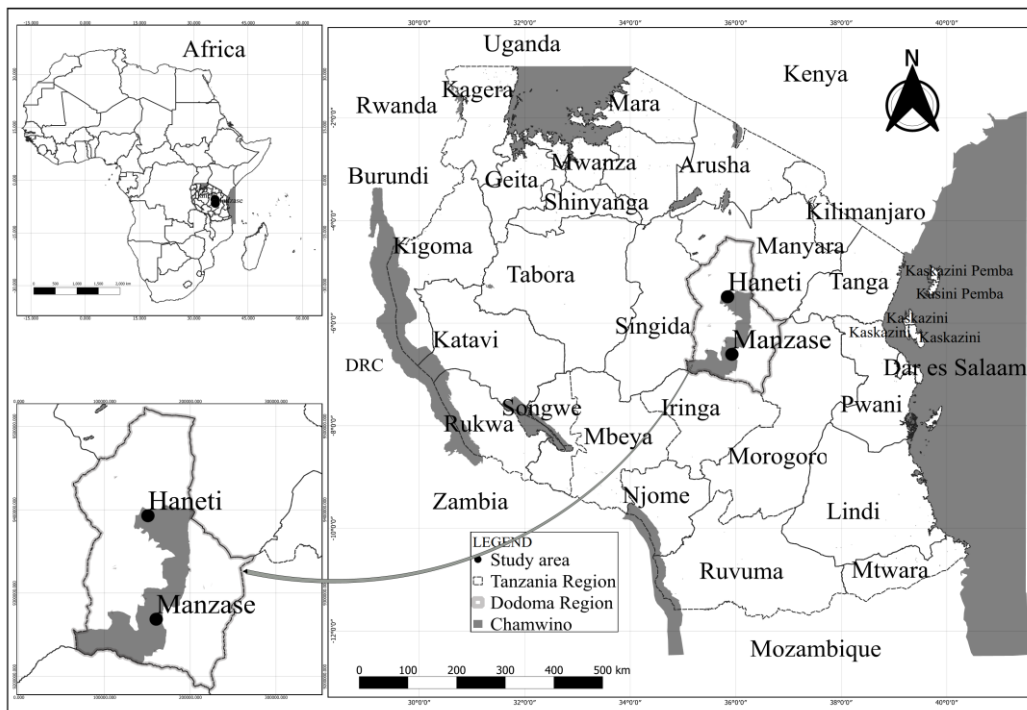


Figure 2. Study villages in the Chamwino district.

Source: Ardhi University GIS Lab (2024).

Chamwino experiences a semi-arid climate characterised by a long dry and a single wet season from late December to mid-April (Mdemu, 2021). Rainfall is scarce and unpredictable, with an annual average of 400 to 500 mm. Temperatures are relatively high, typically ranging from 20°C to 30°C, though they can rise to 35°C during peak heat periods. The district is part of the larger savanna landscape, dominated by baobab trees and dry land shrubs. A few seasonal rivers and streams flow during the rainy season but permanent rivers are scarce (Kahimba et al., 2015).

The primary economic activities for about (80%) of the district's inhabitants are smallholder rain-fed farming and livestock keeping (DED, 2020). The main food crops grown include millet, sorghum, and maize to some extent. Crops such as sunflowers and groundnuts are grown for household consumption and markets. Livestock reared include cattle, chickens, goats, and pigs. Although agriculture is the primary source of food and livelihood, the ongoing climatic-related challenges, such as frequent droughts and crop and livestock diseases, have challenged the livelihood sustainability of the district's inhabitants. Frequent droughts in the district worsen crop loss and the depletion of water resources. This situation leads to the recurring problem of food insecurity (Mdemu, 2021). Lack of sufficient food in the district is also associated with higher levels of malnutrition, as attested by a higher prevalence of stunting (44.3%) compared to the national average of 34%, (Makori et al., 2018). Other challenges facing the agriculture sector that constrain farm enterprises' productivity and profitability include unstable market for farm produce, environmental degradation, and inadequate farm implements and inputs (DED, 2020). Other economic activities apart from farming include informal trades such as petty trading in local markets and the sale of handmade products. Households also engage in other off-farm income-generating activities such as charcoal burning, local brew making, and labour selling to well-off farmers within or outside the district. Regarding water and sanitation, 61% have access to clean water, while 45% have no toilet facilities, and the literacy rate is 89% (DED, 2020).

3.2. Study design and approach

This study employed a qualitative approach to explore the role of local institutions in enhancing household resilience to the effects of climate change. Exploring facts on the roles of institutions is better done using a qualitative approach. This is because it can yield in-depth data and more nuanced information regarding the contribution of institutions in climate change adaptation and resilience building. Similar studies on institutions and climate change adaptation have also tended to use a qualitative approach (Mubaya & Mafongonya, 2017; Baudoin, 2014). This is because it captures the complexities embedded in the local area's social, cultural, and economic conditions and how such conditions affect the roles of institutions.

This research employed a multi-stage sampling technique to select the study region, district, and villages. The first step involved selecting regions most affected by drought. Dodoma is selected to represent regions that experience frequent drought (Mayaya & Kipror, 2015). Chamwino district was selected because it is a drought hotspot, characterised by frequent drought-induced crop failure and food insecurity (Mdemu, 2021; Makori et al., 2018). Study villages were also selected based on drought prevalence and food insecurity. However, drought and food insecurity information was obtained after consultation with village leaders, the district agricultural officer, and extension workers. The consultation process led to selecting two villages i.e Haneti, in the western part of the district, and Manzase, in the southern part. The study institutions were purposely selected based on information gathered during the scoping visit. The institutions were approached, and a representative familiar with the activities of the institutions in the villages was appointed to provide the information needed.

3.3. Data collection and analysis

Key informant interviews and Focus Group Discussions (FGD) were used for data collection. Respondents to the interviews were representatives of the institutions that operate in the villages. These institutions play various roles, including those contributing to enhancing adaptation and resilience in the face of climate change effects and variability. The institutions were identified after consultation with the district agricultural development officer during the scoping visit to the district in February 2023. The village leaders and farmers also confirmed the existence of the institutions during interviews and FGDs, respectively. Interview questions aimed to gather information on the roles of institutions in enhancing adaptation and resilience building, as well as their linkages with other institutions. The researcher conducted face-to-face and phone interviews with the representatives of the institutions, each lasting approximately 30 minutes. A total of 6 interviews were undertaken one with representatives of each

institution. These representatives were directly involved in project activities in the villages, making them more knowledgeable and qualified for interviews than others within the institutions.

On the other hand, the FGDs were facilitated by the researcher with the help of two assistants who made arrangements for the meeting and recorded the conversations. One of the assistants was the native speaker of the local language of the inhabitants in the study villages. This ensured that in case of a language barrier during the discussions, he could translate from the native language – *Kigogo* - to *Kiswahili*, the national language, and the lingua franca, which most participants understood. Two FGDs were conducted, one in Manzase and another in Haneti. The two FGDs were sufficient to generate the information needed since they were meant to triangulate the information collected from interviews with representatives of institutions. The FGD was composed of 9 to 10 adults and elders. These participants were considered to have the required information since they had stayed in the village for many years and were, therefore, aware of the environmental and socioeconomic conditions of the villages.

Data collected was analysed using the content analysis method. The following steps were followed to perform the analysis. Firstly, the recorded interviews and focus group discussions were transcribed to ensure that details were accurately captured. Secondly, the transcripts were verified by listening to the audio once more and making necessary corrections. Thirdly, data familiarization was conducted through re-reading the transcripts. Fourthly, codes in short phrases that emerged from the transcriptions were created. Similar codes were grouped to form themes examined for consistency with the study objective (Table 1). The table presents short phrases representing codes that emerged from interviews with representatives of institutions. These codes were combined to form broader themes presented as institutions' roles in enhancing adaptation to climate change effects. The final steps were detailed reporting on the themes.

Table 1. List of codes and themes grouping.

Codes	Themes
Use of hybrid sorghum varieties	Drought resistant seeds
Adapting fast-maturing crops	
Sunflower seeds distribution	
Keeping dairy goats	Alternative income-generating activities
Selling milk in local markets	
Vegetable production and selling	
Formation of farmer's groups	Access to markets
Direct purchase from farmers	
Crop Purchase contract	
Integration of trees with crops	Agroforestry and tree planting
Use of trees for soil conservation	
Training on tree regeneration	
Communication with banks	Access to credit
Contract farming as collateral	
Financial management training	
Sharing weather information	Weather and climate information
Education on timely planting	
Planning and preparedness	
Collaborating with NGOs	Institutional collaboration
Partnering with village government	
Engaging agricultural extension workers	

Source: Author's analysis

4. RESULTS

4.1. Existing institutions and their coordination mechanisms

Institutions that operate within the study villages to facilitate activities that build resilience to the impact of climate change were identified. Among these, two public institutions were identified: The

Agriculture Extension Agency, which falls under the Ministry of Regional Administration and Local Government, and the village government. The village extension workers represent the extension agency at the village level and are responsible for promoting and disseminating best practices and technology for farming and livestock keeping. The extension workers work closely with the Village Executive Officer (VEO) who acts as their immediate supervisor. However, extension workers receive guidelines and report to the district agricultural officer for technical aspects of extension work. The study villages have three extension workers: one in Manzase and two in Haneti. On the other hand, the village government is responsible for local governance and community development affairs and is headed by an elected chairperson. At the same time, the village executive officer (VEO) is a local government-appointed officer in charge of the village's administrative affairs and reports to the ward executive officer (WEO).

The private companies include Tanzania Breweries Limited (TBL), which implements a sorghum project in Manzase village. Three non-governmental organisations (NGOs), one in Manzase and two in Haneti (see Tables 2 and 3), were identified. These institutions (TBL, LVIA, and Farm Africa) primarily work with farmers who are organized into groups. Leaders of these groups are selected democratically from among the farmers. These institutions do not maintain permanent staff or offices in the villages. Instead, village extension workers are usually trained for specific projects, monitoring the group's activities. They report to the project officers of the respective institutions. While these institutions contribute to strengthening resilience against the impact of climate change and variability through their roles, it is important to note that their roles extend beyond the resilience-building focus. They also serve broader purposes linked to overall development and addressing challenges that smallholder farmers face, including poverty and food insecurity.

Table 2. Institutions in Manzase village.

Institution	Category
Village government	Public
Agricultural extension agency	Public
Tanzania Breweries Limited	Private
The LEAD Foundation	NGO

Source: Focus group discussion (March 2024).

Table 3. Institutions in Haneti village.

Institution	Category
Village government	Public
Agricultural extension agency	Public
Farm Africa	NGO
LVIA (Lay Volunteers International Association)	NGO

Source: Focus group discussions in Haneti (March 2024).

4.2. Institutions roles

4.2.1. Provision of drought-resistant seeds

The result shows that three institutions, Tanzania Breweries Limited (TBL), Farm Africa, and Agricultural Extension Agency, supported farmers with drought-resistant sorghum and sunflower seeds. The seed support is given as a loan to interested farmers from the TBL and Farm Africa. To ensure that farmers manage the crops properly, these institutions also provide sorghum management protocol and agricultural extension services to farmers. The seed loan agreement requires borrowers to repay in kind using part of the crops harvested or in cash after the sale of the crop. Although farmers utilise the seeds due to their drought-resistant capabilities, some are dissatisfied with the seed loan conditions, as one FGD participant narrated:

We get drought-tolerant seeds from TBL; they are very useful because they produce high yield. However, there is one challenge: if the harvest is not good, you still have to pay back the amount of seeds you agreed upon. This is why some people hesitate to enter into a seeds borrowing agreement (FGD participant Manzase).

The village extension worker in Haneti also reported that some farmers were sceptical about the seed loan program, suspecting that the company providing the seeds had an undisclosed agenda. Despite

this challenge, the TBL representative in Manzase village noted that approximately 141 farmers out of 269 had borrowed the seeds. Meanwhile, in Haneti village, 70 farmers out of 234 received sunflower seeds from Farm Africa. The agricultural extension agency also distributes improved sunflower seeds from the Tanzania Agricultural Seeds Agency (ASA). To make them more affordable, these seeds are offered at a subsidised price of Tanzania shillings (Tsh) 3500 per kilogram, compared to market prices of Tsh 6000 per kilogram.

4.2.2. Agroforestry and tree planting

Concerning agroforestry and tree planting, the results show that The LEAD Foundation in Manzase village implements an agroforestry project called Farmer-Managed Natural Regeneration (FMNR), locally known as *kisiki hai* (Living stump). Explaining how the agroforestry project is implemented, the NGO representative narrated that:

We have trained community-based leaders who go door to door to raise awareness of the importance of regenerating trees. We have established a farmer field school to demonstrate the steps in regenerating tree stumps. We encourage farmers to regenerate at least 20 trees per hectare of land.

In explaining the project's success, the respondent explained that about 254 households have regenerated trees in their farms, while 14,284 tree stumps have been regenerated in the villages. To ensure the survival of regenerated trees, the species chosen are native to the area thus making them suitable for the semi-arid ecological conditions. The FMNR, therefore, does not plant new trees. The project has been very successful because it is cost-effective, as hardly any expensive inputs are required. The tree stumps do not need to be irrigated; they grow relatively faster than if the trees were planted afresh and are normally ready for harvesting in one to three years. All that farmers are required to do is to prune the suckers that emerge from the tree stump and allow a few to grow into mature trees. The village governments in Manzase and Haneti encourage tree planting through the environmental committee while enforcing bylaws to prevent indiscriminate tree felling. One by-law prohibits cutting down large trees in the village's reserve land. Those caught felling such trees are fined Tanzanian shilling (Tsh) 50,000 or approximately (\$20) and are required to replace each tree by planting at least one new one.

4.2.3. Weather and climate information sharing

The agricultural extension agency disseminates information on seasonal weather outlook, including rainfall onset and cessation, to farmers in both villages. Interviews with extension workers revealed that dissemination is done in village meetings. A meeting is held before the planting season, around November of every year, to communicate information on forecasted seasonal rainfall. The major challenge, however, is turnout in such meetings:

Turnout to meetings at the beginning of the season is usually very low. To ensure we reach many farmers, we use other opportunities, such as political meetings convened by leaders such as ward councillors, to discuss issues of seasonal weather outlook and provide appropriate advice on planting dates and seeds required (Extension officer, Haneti).

However, it was reported that localised weather information for the district is often unavailable. In most cases, agricultural extension workers rely on general weather forecasts from the Tanzania Meteorological Agency (TMA) to advise farmers on which crops to grow, when to plant and what seeds to use. Farmers also use other media outlets, such as television and radio, to get information on short-term and daily weather advisories.

4.2.4. Alternative income-generating activities

The result of this study indicates that two institutions, Farm Africa and Lay Volunteers International Agency (LVIA), have supported farmers with dairy goats and horticultural seeds. Explaining the purpose of the dairy goat support, the Haneti village agricultural extension officer revealed that the project aims to provide low-income households with an alternative source of income and enhance their nutrition through milk consumption. Households are given one goat, an exotic breed that produces 1.5 to

3 litres of milk per day. He further reported that 25 households in the ward, five in each hamlet, benefited from the dairy goat project. However, the dairy project was still new, and many beneficiaries had not reaped the benefits since the goats had not yet given birth. One beneficiary, who started milking his goat, commented in the following way:

I milk about one litre per day, which helps me sell the milk and earn a little money for household expenses. The income would be higher if the goat produced more milk (FGD participant Haneti).

Another intervention aimed at supporting households in earning a supplementary income is the LVIA horticultural project. According to the NGO representative in Haneti village, the support aims to help farmers produce African Indigenous Vegetables (AIV) through farm and backyard gardens. He further revealed that the seed support focuses on local varieties such as okra, sweet potato leaves locally known as *matembele*, black nightshade (*mnafu*), and fortified potatoes (*viazi lishe*). A total of 15 households received the seeds, and one group of producers received a solar-powered water pump to irrigate the farm gardens—however, many who grow the AIV as backyard gardens often use hand watering with buckets.

4.2.5. Enhanced access to the market

Tanzania Breweries Limited engages in contract farming with sorghum farmers in Manzase village, providing market assurance for the crop. The contract stipulates the support the TBL will provide, which includes drought-resistant seeds, agricultural extension services, and the purchase of sorghum. Regarding markets for sorghum, interviews conducted with the sorghum project field officer revealed that the market for sorghum grown under the TBL contract is guaranteed to all farmers. This point was echoed by a participant during FGD with the following statement:

When you have a contract with TBL, you know your sorghum has a reliable market, and their price is also fair. They also buy it on time, and you do not need to wait long before you get a buyer (FGD participant Mazase).

The interview further revealed that the market price for sorghum before the commencement of the project in 2019 was about Tanzania shillings (Tshs) 250 to 300 per kilogram. However, the company bought sorghum for Tshs 550, guaranteeing steady income to farmers. To further ensure that farmers receive fair prices for their crops, the company eliminated the middlemen who often exploited farmers by purchasing sorghum at lower prices, as many farmers are typically uninformed of prevailing market prices. To achieve this, the company established sorghum purchase centres in the villages, allowing farmers to bring their crops directly.

4.2.6. Access to credit

Farmers accessed loans from banks using the contract they signed with TBL as collateral. These loans were used to hire farms for landless farmers and those wishing to cultivate more sorghum, rent tractors for cultivation, cover weeding costs and facilitate access to agricultural inputs such as pesticides and fertiliser. For the 2022 season, one farmer's group called Juhudi received a loan of Tanzanian shillings (Tsh) 30 million (USD 15000), allowing every member to get about Tsh 500,000 (USD 250). However, access to credit by farmers has not always been easy as narrated by a participant during FGD:

Even for those in groups, sometimes getting loans from banks becomes difficult. For instance, last year, we did not get the loan we applied for because they said that some groups of farmers could not repay the loan on time, complaining that the harvest was not good (FGD participant Manzase).

The company also offers financial management training where farmers learn, how to make informed decisions about their loans and income earned after the sale of crops. They also learn record keeping and how to manage financial risks related to farming. Additionally, they are connected with wholesale agro-dealers to procure inputs as a group.

4.3. Institutional linkages

Institutions in the study villages interact with each other in their various roles. Interviews with the agricultural extension workers in Manzase and Haneti villages and the village government chairpersons

revealed that the village government has ties with all institutions operating in the villages. This is because of its role in the governance of the village affairs which requires every other institution from within or outside the village to report to the village government for clearance. The village government also provides the necessary support to facilitate institution entry and trust by the community members. On the other hand, the village agricultural extension agency handles matters related to land, agriculture, and the environment. Therefore, institutions that deal with these aspects are connected with the village extension agency.

Regarding the linkage between private companies and non-governmental organisations, it was found that the linkage mainly was in implementing their activities. The TBL, for example, collaborated with Farm Africa to implement a sorghum project. While Farm Africa dealt with sorghum production at the farm level by providing extension services, the TBL mainly focused on seed provision and the sorghum market. It was further discovered that Farm Africa implemented the project on behalf of the World Food Program (WFP) as the project's financier. As hinted earlier, the TBL also helped groups of farmers secure loans from banks through the contracts entered between them. These institutions, the village community, and individual households also maintain certain levels of linkages in their activities. The agricultural extension agency engages with the community during village general meetings and through farm visits. The representatives of the NGO also interact with households in their roles, including creating awareness of their various roles.

5. DISCUSSION

5.1. Drought-resistant seeds

This study has revealed that several institutions provide seeds with drought-resistant capabilities. It has also shown that the acceptance rate among farmers is high, indicating that they are widely used. This suggests that the seeds effectively reduce risks associated with unreliable rainfall or drought. These seeds are specifically developed for semi-arid areas that experience water-stressing conditions and are considered climate-smart crops because they can tolerate intense heat and drought (Chaturvedi et al., 2022). They feature shorter growth cycles, maturing within a relatively short time of about 85 to 120 days. Farmers can sustain steady yields despite unreliable rainfall by planting drought-resistant crops, reducing crop failure and food insecurity risks.

Empirical studies by Phiri et al. (2021) and Hadebe et al. (2017) also demonstrated that these crops improve food security and income due to their flourishing ability with limited rainfall. Utilising drought-resistant seeds, therefore, constitutes an essential adaptation since using them reduces sensitivity to drought and guarantees a harvest regardless of the prevailing weather conditions in a particular season (Gitz & Meybeck, 2012; Phiri et al., 2021). Important policy frameworks for adaptation in Tanzania, such as the National Adaptation Plan of Action (NAPA) and the National Climate Change Strategy (NCCS), also promote the use of drought-tolerant seeds as an important adaptation to drought and rainfall unreliability.

Despite these benefits, some farmers were sceptical about using the seeds. Ayamaga (2018) also reported such scepticism, noting farmers' concern over the cost of acquiring these seeds and the fear of becoming dependent on seed supply from the companies instead of the traditional methods. Additionally, to reap the full benefits of improved seeds, some institutional arrangements, such as access to loans for farm inputs, remain challenging for most smallholder farmers in Africa (Beumer & Swart, 2021). This fuels the scepticism some farmers have about using the seeds.

5.2. Agroforestry and tree planting

The agroforestry farming system, as spearheaded by the LEAD Foundation, has been very successful in the village as most farmers have participated in regenerating tree stumps within their farms. Manzase village was named the second most successful in restoring degraded land into an established and sustainable landscape through the *Kisiki hai* initiative. This suggests that the system is advantageous, a reason for widest acceptance. The system offers a range of environmental benefits such as soil quality

enhancement, helping infiltrate rainwater and reducing local temperature. It also provides an opportunity for livelihood diversification through using the trees harvested for charcoal and wood for sale.

Similar benefits of agroforestry have also been reported in studies by Behnassi et al. (2021) and Arakelyan (2017), who claimed that integrating crops with trees helps diversify income, preventing soil erosion and improving livelihood through increasing farm yield. These benefits are crucial for adaptation to climate change effects such as drought. For example, through increased yield and income, a farmer can use income to maintain food security during drought-induced crop failure. Based on the affordability of managing the tree stumps, the FMNR is potentially a sustainable initiative that can restore the productivity of degraded land in semi-arid ecological zones that have also been affected by severe land degradation and soil erosion due to unsustainable farming methods.

5.3. Weather and climate information sharing

Weather and climate information that the agricultural extension agency provides is crucial in shaping short and long-term farmer adaptive actions. Based on seasonal rainfall forecasts, farmers are advised to adjust planting dates appropriately and use the seeds as recommended. This is especially critical in rainfed systems where the start of the rainy season is important to the timing of rain-fed crops. For example, soil moisture will be inadequate for seed sprouting if a farmer plants too early. If they plant too late, rainfall may wash away the seeds (Reason et al., 2005). It is crucial to deliver accurate seasonal climate forecasts to optimise timing and reduce the risk of crop loss caused by a lack of information on planting dates (Bal et al., 2021; Barihaihi & Mwanzia, 2017).

The agricultural extension agency informs farmers about weather forecast patterns in meetings and delivers information that facilitates decisions on crop choices, utilisation and planting dates. Sharing weather forecast information with farmers has also been highlighted in the Tanzania National Climate Change Strategy (NCCS) as important for climate change adaptation. However, one of the challenges is the capacity of agricultural extension workers to mobilise weather information and disseminate it to farmers. In interviews with agricultural extension workers in Haneti, the issue of a lack of district-localized climate information was raised. Nevertheless, localised weather information is generated periodically and made available on TMA electronic platforms only that the officer was unaware of.

5.4. Alternative income-generating activities

Horticulture and dairy goats provided to low-income households are an essential means by which beneficiaries can widen their livelihood options, contributing to building resilience against the effects of climate change. For example, by rearing goats and producing milk, households can earn an income that helps purchase basic needs, including food, thus reducing dependence on single farm income and spreading risks. The dairy goats in the Farm Africa project are an exotic breed reared under a low-input mixed crop system, making it a potentially sustainable venture for households. Dairy goat products, especially milk, have a niche market that can attract better prices per litre than cow milk. This ensures a good income for farmers. Dairy goats have enabled the concerned households to produce milk, sell it in the local market and earn some income while contributing to livelihood resilience.

Studies have also demonstrated that small-scale goat rearing helps improve food security through milk consumption and income generation through milk selling (Al-Atiyat, 2014). However, the full potential of the dairy goat has not been realised in Haneti village because of challenges related to feeding the dairy goats. The village agricultural extension officer reported that farmers kept the goats under a free-range system instead of zero grazing thus affecting milk production. Conversely, the horticultural project has enabled farmers to grow and sell vegetables and fortified potatoes to increase their incomes. Growing various crops, including horticultural crops, helps farmers spread the risk of extreme events such as drought. The choice of horticultural crops also considers the climatic conditions of the villages. These horticultural crops are resilient to drought and are essential for countering seasonal sources of food availability while also providing an alternative source of income for households. Fortified potatoes have been reported to be helpful in both improving food security and providing additional income for low-income households (Laurie et al., 2015).

5.5. Access to market

Farmers who receive seeds from TBL and Farm Africa have a ready market for sorghum and sunflowers. A ready market for the crops is an opportunity to offset the lack of access to a reliable market, one of the production risks that smallholder rural farmers face. The ready market offered by these institutions provides increased income through the reasonable prices that farmers receive. The TBL, for example, purchases sorghum at higher prices than the market price, allowing farmers to earn a decent income. To further enhance farmers' access to the market, the company buys directly from farmers in its crop collection centres in the village without engaging middlemen. This is another initiative to ensure farmers receive the lion's share of the final crop selling price by eliminating traders who often benefit more than farmers. This market opportunity that the TBL and Farm Africa offer is rarely accessible to small-scale farmers. Most of such opportunities are secured by large-scale farmers, and therefore, it tends to exclude small-scale poor farmers because of their lower bargaining power and lack of information (Kuhl, 2018). The higher income that farmers receive is an opportunity to improve access to food, better preserve assets in the face of shocks, increase their capacity to accumulate assets and smooth consumption during shocks (Kuhl, 2018). All of these factors contribute to household resilience.

5.6. Access to credit

Among smallholder farmers in rural areas in Tanzania, cash income is often deficient for covering the cost of fertiliser, farm tools, or improved seeds. Therefore, credit access is critical since it enables farmers to afford the inputs required to improve farm productivity. In Manzase village, the contracts that farmers entered with TBL were used as collateral for accessing loans from microfinance banks. Those who have used the credit wisely for investment in farm inputs have harvested more and earned an income that is also an important asset that can be used to purchase food in seasons when the harvest is inadequate. To ensure that loans are used wisely, the company offered training on financing management to farmers to help them make informed investment decisions, making farm enterprises profitable. Regarding credit and livelihood resilience, studies have shown that Farmers with access to credit are less vulnerable and more likely to be resilient compared to those without access (Awinda et al., 2021; Batung et al., 2023; Weldegebriel & Amphune, 2017).

5.7. Institutional linkages

This study has demonstrated that institutional collaboration is critical in addressing the challenges faced by small-scale farmers. For instance, the mandatory relations that village governments establish with the institutions operating in the villages play a crucial role in fostering acceptance and trust among community members toward external institutions. This collaboration also gives the community members confidence that their government is actively involved in interventions by external institutions. Berkhout (2012) emphasises the importance of local government in facilitating the activities of actors and institutions. However, the author notes that local government can sometimes be a constraint due to conflicting political and economic interests.

This study also shows that private companies and non-governmental organisations collaborate to address chronic problems small-scale farmers face. The institutional collaboration between TBL, Farm Africa, and financial institutions through seed provision, sorghum production protocol, guaranteed market access, and contractual arrangements that help farmers secure loans for agricultural inputs serve as exemplary cases. These collaborations leverage the expertise and resources of each institution to address farmers' challenges comprehensively. By combining agricultural extension, market access, and financial support, these partnerships create an environment that enables farmers to improve productivity and enhance income and food security, which is crucial for building farmers' adaptive capacity. This, in turn, makes them more resilient to various shocks, including those that emanate from the effects of climate change. Institutional linkages, especially in the context of climate change adaptation, are recognised as critical conduits for delivering the necessary resources for adaptive response to climate change effects (Upton, 2012; Agrawal, 2008).

Institutions' interactions with individual farmers have also been observed. However, farmers' opportunities to interact with the village's extension workers are limited since farm visits are rarely conducted for all farmers. Challenges such as lack of transportation and the inability of farmers to implement recommended practices such as using fertiliser and drought-resistant seeds due to limited financial resources further hinder these interactions. Lack of resources for farmers inhibits the uptake of agricultural extension recommendations that could potentially enhance adaptation to drought.

For NGOs and private companies, the level of interaction with individual households is higher, leading to greater success in agroforestry and seed loan projects. These institutions can reach out effectively because they are provided with means of transport and financial incentives. For example, farmers who participated in the TBL Sorghum project and the LVAIs horticultural seed project had opportunities to interact with extension field officers for advice regarding sorghum and horticultural crop production protocols. The same applies to the LEAD Foundation agroforestry initiative, where project community leaders, called champions, significantly reach out to the households in the village to raise awareness about preserving tree stumps.

6. CONCLUSIONS

Smallholder farmers who rely on rain-fed farming in the Chamwino district have encountered environmental and economic challenges. Climate change, accompanied by recurrent droughts, has led to crop failure, exacerbating food insecurity for many resource-poor households. In addition to frequent droughts, low income impedes farmers' ability to afford agricultural inputs which could enhance productivity and improve food security which in turn improves overall living conditions. In efforts to address the challenges farmers face, various institutions have supported farmers in addressing the challenges. Non-governmental organisations, private companies, and governmental institutions alike have played various roles such as facilitating access to drought-resistant seeds to reduce the risk of crop failure due to drought, promoting agroforestry farming, ensuring ready markets for sorghum and sunflower, facilitating access to loans for agricultural input and providing information on weather forecasts.

The study has also demonstrated that the linkages between institutions are crucial to comprehensively addressing farmers' challenges. Securing a reliable crop market and access to credit for farm inputs has been possible due to collaboration among institutions supporting farmers. Based on this result, this study recommends the following: firstly, farmers should reduce scepticism about using drought-resistant seeds and promote full adoption. Notably, extension agencies should create awareness of the usefulness of the seeds among farmers. Adoption of the seeds will help reduce the risk of drought-induced crop failure and improve food security. Secondly, village agricultural extension workers should be empowered to mobilise localised information on weather forecasts to suit local areas. This has to be coupled with efforts to encourage farmers to attend weather information-sharing meetings and utilise the information. Thirdly, sensitisation is needed to enable farmers to fully benefit from the dairy goat project by adhering to the required livestock management systems. While this research delivers valuable insight regarding the role of institutions in climate change adaptation, it is imperative to note that the qualitative approach and the limited sample size may hinder generalisation of findings beyond the study areas. Further research on institutions and adaptation to climate change could opt for large samples and employ quantitative methods to enhance the generalisability of results.

USE OF AI TOOLS DECLARATION

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

AUTHOR CONTRIBUTIONS

All authors contributed equally to this work. All authors read and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Appendix I. Interview questions with representatives of institutions

Study Title: Institutions and adaptation to climate change effects

- i. What kind of support does your institution provide to smallholder farmers for climate adaptation?
- ii. What challenges or barriers does your institution face in reaching smallholder farmers with adaptation support?
- iii. How do you collaborate with different institutions (government, NGOs, private sector) to support smallholder farmers' climate adaptation efforts?

Focus Group Discussion Questions

- i. Identify institutions that, in one way or another, deal with roles that contribute to addressing climate change effects in this village.
- ii. What kind of support does the institution provide to smallholder farmers for climate adaptation?
- iii. What challenges do the institutions you mentioned face in reaching smallholder farmers with adaptation support?
- iv. How do the institutions collaborate with each other to support smallholder farmers' climate adaptation efforts?



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