Prospects and Challenges of the Chololo Pits Technology In Enhancing Crop Production in Semi-Arid Areas Of Central Tanzania: A Case Study of Chamwino District

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Abstract

This article explores the prospects and challenges affecting farmers practising the use of *chololo* pits[1] due to the semi-arid nature of Dodoma. It investigates the prospects and challenges of *chololo* pits technology in enhancing crop production in the semi-arid Chamwino District. Data was collected through documentary review, household interviews, focus group discussions, key informant interviews and field observation. Findings indicate that improvement of the soil water holding capacity (77.7%, n=337), economic use of fertilizers (74.4%, n=337) and increases in cereal yields (70.6%, n=337) were the major prospects for enhancing crop production. Labour intensity (43%, n=337), required skills (29%, n=337) and difficulty to maintain (13.5%, n=337) were the major challenges of *chololo* pits in enhancing crop production in the study area. Other minor prospects were reducing soil erosion, concentrating nutrients and protecting seeds and humus from being washed away, while shortage of fertilizer and waterlogging were the minor challenges of *chololo* pits. The study recommends that the government, in collaboration with NGOs and CBOs, should use more efficient tools to supplement the use of the hand-hoe (agriculture research institutions, COSTECH and SIDO should take lead on this). Also, further research should be conducted, and climate smart agriculture (CSA) and scaling up the *chololo* pits technology should be advocated.

Keywords: *sustainability,* chololo *pits, semi-arid, crop production*

1. Introduction

The sustainability of indigenous practices, including *chololo* pits, in crop production has remained a challenge in many parts of arid and semi-arid parts of the world (Mswima & Kaswamila, 2022; Mswima, 2020; Qin et al., 2022; Traore et al., 2021).The moisture limitations due to climate change have brought challenges such as environmental stress, deterioration of vegetation cover, losses in agricultural production, loss of arable land, soil erosion, and increased stress on the economy, amongst others (Nyakudya et al., 2014). Studies have shown that these impacts have reduced overall crop productivity by 30% in Asia, and 13% in Africa (Saylor

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[1] This is a technology employed in Tanzania that help conserve moisture in the soil and improve soil fertility, hence mitigating drought effects and consequently increasing crop production.

et al., 2017). To reverse the situation, different pitting practices have long been used in semi-arid regions worldwide to promote sustainable agriculture and natural resource preservation. These practices include terracing in the Philippines (Acabado, 2009), the Inca terraces in the Andes, ancient terraced fields in China, as well as contour ploughing in the Appalachian Mountains and Swiss Alps. Also, stone bunds trap water in African drylands, and Zai pits in Burkina Faso and Ghana have significantly increased cereal production (Kimaru, 2017). Similar practices have included the Agun pits in Sudan, Kofyarpits in Nigeria, Tumbukiza pits in Kenya (Orodho, 2007) and *chololo* pits technology in Tanzania (Yegon et al., 2016).

The importance of *chololo* pits technology in agriculture in the semi-arid areas of Dodoma stems from its ability to safeguard fertile land, maintain water availability, prevent soil erosion, and enhance crop productivity (Lipper et al., 2014). The *chololo* pits technology has evolved over generations, relying on the indigenous knowledge and wisdom of farming communities in the semi-arid areas of Dodoma (Temu et al., 2022). However, despite their proven efficacy, the adoption of the *chololo* pits technology has faced various challenges, as it requires high human labour input, high amount of manure, and suffers from waterlogging.

This study aims to explore the prospects and challenges associated with the continued use of *chololo* pits technology in agriculture. By critically examining the prospects and challenges of *chololo* pits practice, this article aims to provide a comprehensive analysis of their relevance in contemporary agricultural practices. Furthermore, the findings will shed light on potential strategies to employ to overcome the challenges of the *chololo* pits technology for sustainable agricultural development. Furthermore, they will not only contribute to the existing body of knowledge on soil and water conservation, but also provide valuable insights for policymakers, agricultural practitioners, and researchers. By recognizing the prospects of the *chololo* pits technology and developing effective strategies to overcome challenges, the *chololo* pits technology ensures the conservation and utilization of natural resources in a manner that guarantees sustainable agricultural development for generations to come. Hence, by examining the prospects and challenges of the *chololo* pits practice, this will assist paving the way for a more sustainable *chololo* pits technology and resilient agricultural in the future.

Following this introduction, the article consists of the theory governing the study, knowledge gap, conceptual framework, study area, data collection methods, results and discussion, and conclusion and recommendations.

1.1 Theory Governing the Study

The ecological resilience theory guided this study, which aimed to develop and maintain the resilience of ecology to withstand disturbances and ensure a sustainable use of natural resources. In Dodoma, the ecosystem is significantly impacted by unpredictable rainfall and water scarcity caused by climate change. In response to this situation, farmers have introduced a method known as the *chololo* pits practice. This practice has several benefits, including the reduction of erosion, provision of water for cereals during the dry period, and soil conservation. However, the technology has its challenges, such as the need for extensive labour, frequent maintenance, and the need for high amount of manure. To address these,, it is proposed to incorporate in it other traditional ecological knowledge and practices from local communities. Indigenous and traditional knowledge often offer valuable insights into sustainable land and water management techniques that have been developed and refined over generations. By combining the *chololo* pits technology with scientific knowledge, we can gain valuable insights into achieving sustainable cereals production in the semi-arid region of Dodoma.

1.2 Knowledge Gap

Originally, studies on *chololo* pits technology mainly focused on areas with scarcity of water; and the associated studies confined to arid and semi-arid areas (Maro, 2017; Mkonda & He, 2018; Mswima & Kaswamila, 2022; Mswima, 2020). Furthermore, most of the empirical literature partially focused on *chololo* pits as it associated with other pitting practices in crop production under changing climate (Njau et al., 2016; Salum, 2019; Yegon et al., 2016). Still, most of the latest studies on the *chololo* pits practices for climate change adaptation (e.g., Kimaru, 2021; Kunda et al., 2017; Mkonda, 2020; and Mswima, 2020) were prematurely done to document meaningful results related to weaknesses and strengths of the *chololo* pits for the sustainability of cereal production. Most of the related studies lacked adequate explanation of the factors influencing sustainability, strengths and weakness of *chololo* pits, and the integration of *chololo* pits with other traditional practices for sustainability in cereal production under the changing climate.

1.3 Conceptual Framework for the Study

The conceptual framework adopted concepts from the ecological resilience theory to address the variables of the study. The framework shows that climate change (independent variable) is caused by environmental influences outside and within the study area (background variable). Climate change involves changes to the hydrological cycle through variations in precipitation, temperature, wind and humidity (indicators of climate change). These result in changes in river flow, runoff and underground water recharges, which eventually affect crop production due to water shortage. To reduce the impact of climate change, farmers use the *chololo* pits technology that conserves soil and water for crop production.

The sustainability of the *chololo* pits technology (dependent variable) depends on economic factors such as the cost of clearance, digging and maintenance of *chololo* pits; social factors (land ownership), and environmental factors such as climate change, and institutional factors (policies, laws/ regulations and credit facilities). Farmers use *chololo* pits due to their strength in ensuring soil fertility and preserving water for growing crops. One of the challenges of the *chololo* pits technology is the cost of construction, and it requires a lot of labour to sustain them. Farmers in the study area have come up with strategies for integrating *chololo* pits with science such as capacity building, upscaling of the *chololo* pits practice, ideal plant population, and the use of user-friendly planting tools to sustain the practice. All the strengths and weaknesses of the *chololo* pits technology together form the intermediate variables. The components of the conceptual framework help to guide the study of the sustainability of the *chololo* pits technology in the adaptation of the impact of climate change on crop production. The framework is as provided in Figure 1.

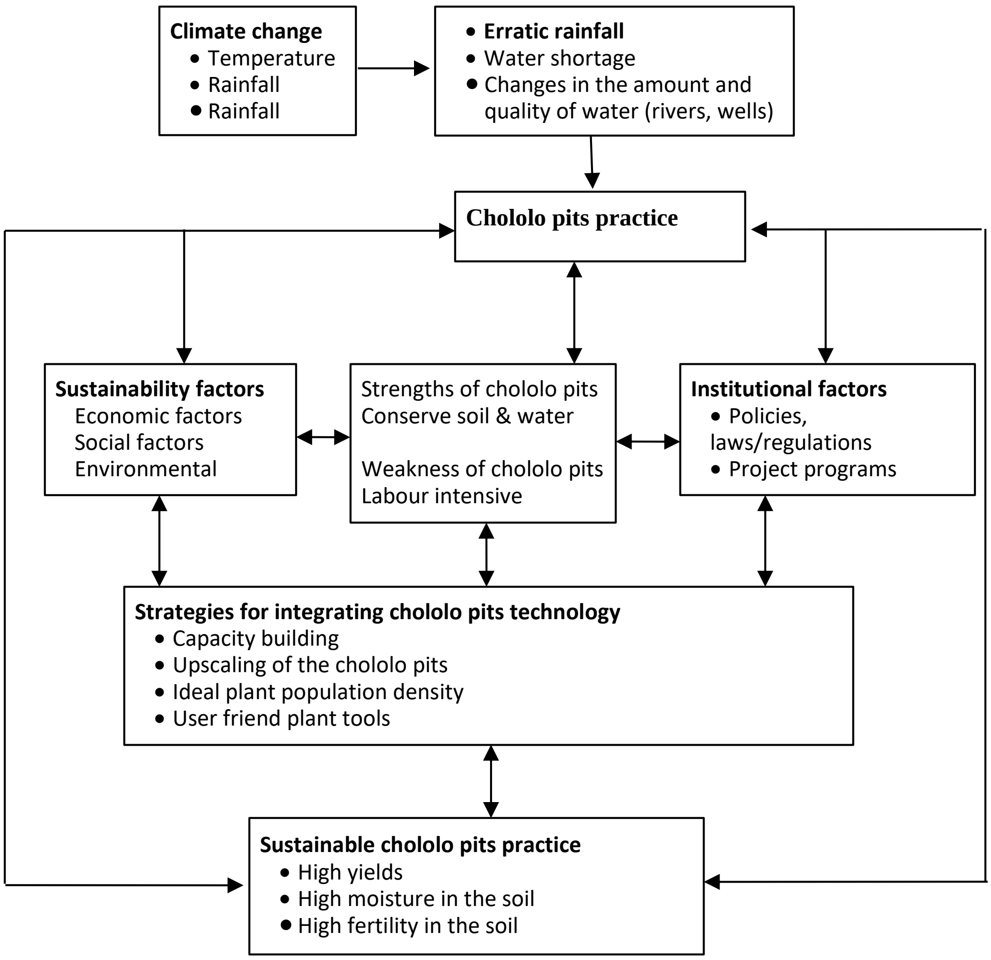

Figure 1: The Relationship Between Climate Change Variables and *Chololo* Pits Practices

Source: Researchers Hypothetical Conceptual Framework (2021)

2. The Study Area

This study was conducted in the Chamwino District and involved four villages, namely Buigiri, Manchali, Handali, and Mvumi (Figure 2). Simple random sampling was adopted in selecting the villages. Boyd et al. (2000) recommend a sampling intensity of 5% of the total number of households in a study site, and that such a sample size should entail a reasonable proportion of units in the sampling frame, but not less than 30 units.

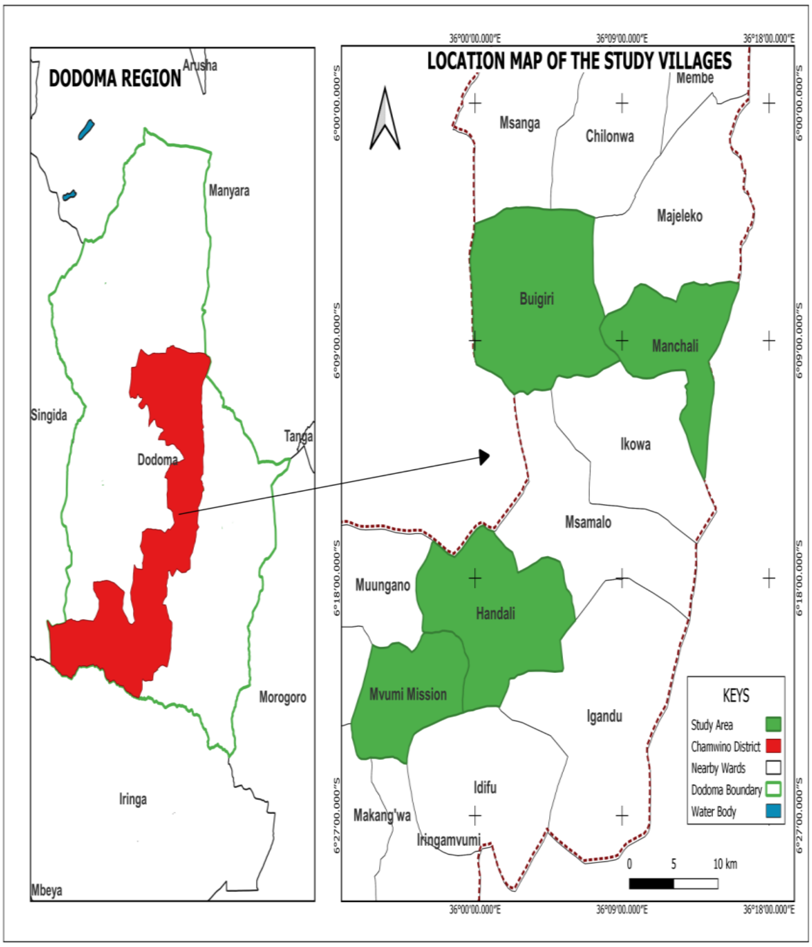

Figure 2: The Study Area

3. Data Collection Methods

The data collection methods of the study included household survey, focus group discussions (FGDs), key informant interviews (KIIs), direct observation and documentary review as detailed below.

3.1 Household Survey

A household questionnaire survey using the Kobo Collect Android Software was used for data collection. Data covered household demographic information, the sustainability of *chololo* pits technology to soil and water conservation, strength and weakness of *chololo* pits, and the integration of *chololo* pits with modern science. The Kobo Collect was used as a tool for data collection because it allows conversion from inefficient paper-based systems to a simple, fast and flexible mobile and web-based platform for data collection, paper-form digitization, agent management and data analysis.

3.2 Focus Group Discussions

A focus group discussion (FGD) is a qualitative method used to gather in-depth insights and information from a small group of individuals regarding their behaviours, experiences, attitudes, opinions and suggestions. FGDs offer the advantage of obtaining data through group discussions on sensitive topics that may be difficult to extract from individuals on their own. Unlike interviews, FGDs allow participants to discuss their beliefs and emotions in detail. This particular study conducted four FGDs, one per village, with heterogeneous groups consisting of both males and females. Each group had five members. The purpose of these discussions was to gather information on the sustainability of *chololo* pits in adapting to climate change, and its impact on cereal production; including its origin, strengths, weaknesses and mechanisms for integrating the practice with modern science. A checklist was used during the discussions, and the researchers took notes and recorded the sessions with permission from the groups. The selection criteria for participants were based on their engagement and experience with *chololo* pits, and the group size of five members per group ensured a balance between diverse perspectives and individual participation. The duration of each FGD ranged from 45 minutes to one hour.

3.3 Key Informant Interviews

Key informants were interviewed at the district and village levels. These key informants included the Agriculture Officer, District Agricultural and Livestock Development Officer (DALDO), District Irrigation Officer, Village Executive Officer, Ward Executive Officer, two experts from Makutupora, two experts from Mpwapwa Research Institute, and two officials from INADES and RECODA. Others were four village executive officers from the villages involved in the *chololo* pits practice. The key informants' interviews were useful in collecting information from knowledgeable and specialists in *chololo* pits practice. The total number of key informants in this study was thirteen (13). The criteria for selecting key informants included occupational positions, experience and knowledge of the *chololo* pits technology, and duration of working and living in the study sites.

3.4 Documentary Review

Secondary data was accessed through books, journals, search engines and official reports. In addition, documents relevant to *chololo* pits practices were accessed.

4. Results and Discussion

The results of the study on the prospects for *chololo* pits technology under the changing climate are as summarized in Table 1.

Table 1: Prospects of the Chololo Pits

Prospects	Respondents (%)				
	Handali (n=91)	*Mvumi Manchali (n=64)*	*Buigiri (n=126)*	*(n=56)*	*Average (%)*
Improve soil water holding capacity	87.6	77.8	67.4	78	77.7
Economic use of fertilizers	68	96.8	50.6	82.1	74.4
Increase cereal yields	59.3	84.3	42.8	96.4	70.6
Reduce soil erosion	39.5	56.2	28.5	64.2	47.1
Concentrate nutrients	30.7	43.7	22.2	50	36.7
Protects seeds and humus against being washed away	20.8	29.6	15.0	33.9	24.8

Notes: *Multiple responses

Source: Field survey, 2021

4.1 Prospects of the Chololo Pits Technology

4.1.1 Improvement of Soil Water Holding Capacity

Table 1 indicates that a significant proportion of participants (77.7%) were of the opinion that the *chololo* pit method had a positive impact on enhancing the soils' water retention capacity. One potential rationale for this observation is that *chololo* pits effectively capture rainfall, allowing water to be held in place; consequently leading to an increased volume of water being stored within the soil profile.

The FGD results showed that most villages in the study area had the view that *chololo* pits could retain extra moisture; and that the spaces between them function as micro-catchments. For instance, in Buigiri Village, one interviewee emphasized this aspect during a group discussion, in the following statement:

> *Kilimo cha kutumia mashimo ya Chololo kinaongeza kiwango cha maji na unyevunyevu wa udongo kwa ajili ya kuzalisha mazao* (Farming by employing *chololo* pits technology increases moisture retention in the soil for crop production)

Likewise, in a focus group conversation held in Mvumi Village, it was contended that the use of *chololo* pits in semi-arid regions contributes to the improvement of soil capacity to preserve rainwater. These techniques of collecting rainwater serve as highly beneficial adaptation strategies to promote sustainable crop yields and enhance resilience in the face of severe weather conditions. This outcome implies that plants gradually utilize the water, guaranteeing its availability for optimal plant growth. Consequently, the adoption of *chololo* pit practices prove to be valuable as a means of adapting to climate change, and achieving sustainable crop production.

Gamba et al. (2020) had comparable findings from their research. They observed that the implementation of *chololo* pits resulted in elevated soil moisture levels, significantly influencing the growth and yield of cereals. These outcomes demonstrate that *chololo* pits possess a remarkable capacity to retain rainwater that would otherwise be lost through runoff. By collecting and retaining water within the pits, it remains in the soil for a longer duration; and facilitates various physical, biological, and chemical processes, including the utilization of fertilizers.

4.1.2 Economic Use of Fertilizers

The outcomes regarding the reduction of fertilizer usage through the implementation of *chololo* pits for sustainable crop production is shown in Table 1. The findings indicate that a significant proportion of participants (74.4%) held the view that the utilization of the *chololo* pits technology had facilitated the cost-effective utilization of manure. One plausible explanation for this is that the fertilizer is directly applied at the specific location where the seeds are planted, rather than being uniformly distributed across the entire field and integrated into the soil several days prior to planting. This explanation is substantiated by statements from INADES officials and ward enforcement officers, who gave the following explanation:

> *The chololo pits technology allows the use of manure directly on the plants, allowing precise application; and thus avoiding unnecessary fertilizer waste as it is collected in the pits and cannot be easily lost, thus economizing the use of the fertilizers as it is placed in the required place.*

Likewise, according to the findings from focus group discussions (FGDs, the majority of farmers admitted that *chololo* pits effectively concentrated fertilizers around plants roots. This means that the fertilizers are directly applied to the roots, resulting in no loss of fertilizer during the application process. As a result, this approach helps mitigate the decline in soil fertility caused by the impacts of climate change in semi-arid regions, and enhances the ability of plants to adapt to changing climatic conditions. This explanation is supported by a research conducted by Njau et al. (2016) and Yegon et al. (2016) who confirm that the practice of *chololo* pits focuses the fertility of the soil in the immediate vicinity of the crop's root zone. The pits effectively trap debris, including leaf litter from nearby vegetation, which is carried by wind or runoff. The fertility gained from these sediments is further enhanced by the addition of organic and/or mineral fertilizers to the pits. Additionally, the researchers observed an increase in biological activities compared to areas with bare soil. Nevertheless, during field observation in all four villages, the researcher discovered that the use of *chololo* pits significantly reduced the amount of fertilizer required, as it allowed direct application to plant roots. However, the study also revealed that the quality of manure applied in the pits is low due to improper storage in open areas, resulting in nutrient loss. Farmers normally store manure in open places to allow it to dry, but this practice diminishes its nutrient content. To achieve optimal results, it is recommended that manure should be kept in a shaded area to preserve its nutrient content. This practice is crucial for crop production and can serve as an incentive for more farmers to adopt the *chololo* pits technology.

4.1.3 Increases Cereals Yields

The findings in Table 1 indicate that, on average, the majority of the participants from households (70.6%) reported that the implementation of the *chololo* pits technique led to increased yields of cereal crops. This can be attributed to the ability of *chololo* pits to retain moisture, allowing crops to grow for a longer duration during periods of delayed rainfall or drought. Furthermore, the practice facilitates the release of nutrients from decomposed organic matter (humus) present in the pits, which promotes easier nutrient absorption for the growth of cereals such as maize, millet, and sorghum (Temu et al., 2022).

Likewise, the Chamwino agricultural extension officers, along with staff members from the Tanzania Home Economics Associates (TAHEA) and the research community at the Organizational Development Association (RECODA), shared a similar perspective with the households regarding the prospects of *chololo* pits practices as a means to adapt to the impacts of climate change. They believed that this practice regulates soil temperature, thus creating favourable conditions for plant growth. To provide additional insight, an anonymous TAHEA officer expressed the following opinion on the matter:

> *The cholololo pits technology is the best adaptation practice to climate change as it can regulate soil temperature and precipitation that is capable to increase production by 6%, as compared with 19% decline in yield in prolonged drought or poor precipitation.*

This suggests that the *chololo* pits technique is considered the most effective approach for adjusting to the effects of climate change, specifically in terms of enhancing crop yield. To achieve optimal results, it is crucial to apply the appropriate quantity of manure to support the growth of cereal crops.

This pitting practice is supported by various scholars. For example, Temu et al. (2022) reported an increase in cereal production—such as maize production—which improved from 1,593kg/ha under flat cultivation to 3,233 kg/ha under *chololo* pits practice. Also, Kahimba et al. (2014) reported that maize yield increased by 224kg/ha, while millet increased by 670 kg/ha under the *chololo* pits practice in semi-arid Tanzania. The results prove that the *chololo* pit practice has the potential to mitigate the impact of climate change by enhancing crop production, which is crucial for increasing cereal production in the face of climate environmental challenges.

4.2 Challenges

The challenges of the *chololo* pits were assessed based on farmers' opinion. The results discussed are presented in the Table 2.

Table 2: Challenges of Chololo Pits

Challenges	Respondents (%)				
	Handali (n=91)	*Mvumi (n=64)*	*Buigiri (n=126)*	*Manchali (n=56)*	*Average (%)*
Require frequent maintenance	18.7	234	24.6	14.3	20.3
Require high human labour input	62.5	42.7	43.2	50.9	50.1
Necessitate a significant quantity of manure	16.6	25.4	29	28.4	25
Waterlogging	2.2	8.5	3.2	6.4	4.6

Source: Field survey, 2021

4.2.1 High Human Labour Input

The findings in Table 2 show that half of the respondents (50.1%) opined that *chololo* pits require high human labour input. The reason is that *chololo* pits require high human labour for preparing the land, digging of the pits with the required spacing, construction of bunds at each pit, maintenance of pits, and the application of organic fertilizers: all of which are frequently used compared to industrial fertilizers, which are relatively expensive. During an informal discussion with farmers, they claimed that for the five tasks to be performed efficiently, one hectare may require between 20 and 70 people, depending on the soil type.

Furthermore, during the FGDs in Buigiri Village, farmers employing the *chololo* pits technology said the practice requires high human labour input during the digging and pre-planting season; further adding that the *chololo* pits practice also requires constant removal of sand. This was supported by the Ward Executive Officer and Makutupora experts who confirmed that the practice was labour-intensive, as labour is required for digging, planting and filling the pits with ashes, manure and crop remains to hold water and add nourishment to plants. The labour-intensive nature of *chololo* pits farming often leads farmers to confine their practice to a small area of their land. However, experts from organizations like the TAHEA and RECODA have suggested using user-friendly tools and equipment to make the process easier. The process, as already indicated, includes preparing the land, digging the *chololo* pits with proper spacing, constructing bunds around each pit, maintaining the pits, and applying organic fertilizers. In these undertakings, farmers could be assisted to purchase small hand oxen-drawn or engine-driven machines for digging the pits, thus reducing the amount of labour required.

On the other hand, farmers themselves have suggested working in groups to decrease labour demands. By forming farmer groups, they can support each other in tasks such as clearing, digging, and maintaining the *chololo* pits. This collaborative approach would make the process easier and more appealing, encouraging more farmers to adopt *chololo* pits farming for sustainable crop production. Both sets of suggestions focus on enhancing the sustainability of *chololo* pits farming. They aim to improve the technological aspects of the practice, and promote social cohesion among farmers by working together.

4.2.2 Requirement of a Significant Quantity of Manure

The findings presented in Table 2 indicate that a small portion of the participants (25%) affirmed that the *chololo* pits method necessitates the use of organic manure, specifically cow dung and organic matter, for each hole. They suggested that for each hole, two buckets of manure should be applied, which consequently increased the overall manure or fertilizer requirement per hectare (ha).

During the FGDs, farmers reported that one pit required 0.5kg of cow-dung manure, while *chololo* pits required approximately 40kgs for desired cereal production. With 500 pits per hectare, *chololo* pits demand over 1.2 tons of manure per hectare. Leguminous plants like lablab enhance soil fertility and moisture, benefiting crop growth. Combining planting pits with organic manure positively impacts soils, crop development, and yields. Farmers employ both organic and inorganic fertilizer to increase output and reap economic benefits.

Several studies of the *chololo* pits technology have been undertaken by comparing crop yield under four alternative scenarios: traditional techniques, water harvesting only, fertilizer usage solely, and a combination of water harvesting and fertilizer use. Under these scenarios, investigation was carried out on maize (Barron et al., 2008; Eze et al., 2021; Van Der Werf & Petit, 2002) and sorghum production (Kerubo et al., 2011). The findings of these studies showed that water while collecting alone can increase yields, yield increases even more when combined with fertilizer application. Such increase, like that reported by Lema (2016), is dependent on the overall amount of rain received during the growing season. Barron et al.'s (2008) findings were the exception to this rule: they found that water harvesting alone increased yield more than fertilizer use.

Nevertheless, it was revealed that there is a shortage of manure as each household, on average, can only manage to get one bucket of manure per pit, while the actual requirement for manure is two buckets per pit. This shortage of manure affects the nutrients required for crop growth, hence reducing cereal production at Chamwino. This is supported by Palmas and Chamberlin (2020), who reported that shortage of fertilizer affected the requirements of the *chololo* pits, and became one of the big challenges facing *chololo* pits technology farmers at Chamwino for sustainable crop production. To reduce the shortage, farmers could supplement artificial fertilizer by preparing compost manure.

As noted earlier, cow dung manure is kept in the open (Photo 1), which reduces the nutrients of the manure, which is supposed to be kept under the shade to preserve its nutrients.

Photo 1: Cow Dung Manure in an Open Space at Mvumi
Source: Researcher, 16th September 2021

4.2.3 Frequent Maintenance

The findings in Table 2 indicate that a small proportion of farmers (20.3%) were of the view that the *chololo* pits technology necessitates regular upkeep. *Chololo* pits require frequent maintenance to monitor their condition, deepen them, and replenish them with manure prior to each rainy season. This observation is reinforced by focus group discussions conducted in the study area, where farmers consistently mentioned that the *chololo* pits technology demands frequent maintenance. This viewpoint is further supported by a statement by a participant from Manchali village:

> *During the dry season, the pits are to be filled with sand and grass. Furthermore, maintenance is also required for the bunds between the pits. Additionally, the preparation of the chololo pits is backbreaking: it takes 15–20 days to prepare the pits per hectare.*

As per statements from TAHEA and RECODA officials, it is necessary to regularly maintain the *chololo* pits by removing sand and debris brought by the wind during the dry season, before each rainy season. Such maintenance can be carried out collectively by groups, which helps to alleviate the burden of the maintenance tasks. This approach allows farmers to appreciate the practice more, as it offers the promise of high yields.

This explanation aligns with the findings of Kaboré and Reij (2004), who noted that the frequency of maintenance is a result of the gradual accumulation of sediment in clay soils throughout each season. By the end of the four seasons, these clay soils were approximately three-fourths filled with sediment.

4.2.4 Waterlogging

According to the data presented in Table 2, only a small percentage of the participants (4.6%) thought that the practice of digging *chololo* pit resulted in waterlogging. The study identifies waterlogging as a consequence of excavating pits in low-lying areas with inadequate drainage, as depicted in the Phot 2.

Photo 2: Chololo Pit Saturated with Water at Buigiri Village
Source: Researcher, 16th December 2021

The explanation above is supported by the agriculture irrigation officer at Manchali Village who gave the following comment:

> *During heavy rainfall, the chololo pits are filled with water, which in turn affects crop growth as salination makes cereals change colour – its leaves turn yellowish, which in turn reduces the ability of plants to produce crops.*

Soil gets waterlogged as water enters the tiny spaces within the soil, leading to a rapid decrease in oxygen levels in areas where plant roots grow, as well as a decline in the activity of soil microorganisms that require oxygen. Additionally, waterlogging causes the destruction of *chololo* pits, as they become submerged in water (as shown in Photo 3). Consequently, farmers are compelled to dig new pits after each planting season, something that can potentially discourage the use of such pits. Furthermore, waterlogging negatively affects plant growth by causing

Photo 3: Destroyed Chololo Pits at Buigiri Village
Source: Author, 22nd September 2021

root decay and excessive water infiltration into soil pores, resulting in a quick reduction in oxygen levels in the root zone and hindering the activities of oxygen-dependent soil micro-organisms. To avoid these challenges, it is recommended that farmers practising *chololo* pit agriculture opt for areas less susceptible to waterlogging when cultivating their crops.

4.3 Measures to Mitigate Challenges Facing the Chololo Pits Technology

The commonly identified challenges facing the *chololo* pits technology to include the need for high human labour input, high amount of manure, and waterlogging. Table 3 lists the type of challenges facing farmers who are using the pits, and the suggested solutions to such challenges.

Table 3: Measures to Curb Challenges of Chololo Pits Practice

Challenges of *chololo* pits	Proposed Strategies/ Measures
High labour input through construction and maintenance	Advocate use of more efficient tools to supplement use of hand-hoes (agriculture research institutions/ COSTECH/ SIDO to take lead on this) – Research and Development
High amount of manure used	Advocate use and Climate Smart Agriculture (CSA)
Water logging	Advocate use and Climate Smart Agriculture (CSA)

Source: Researcher, 2021

5. Conclusion and Recommendations

5.1 Conclusion

This article has analysed the prospects and challenges of the *chololo* pits technology in view of climate change, in the semi-arid area of Central Tanzania. The aim was to explore various prospects and challenges of *chololo* pits. According to the study findings, there are some challenges. For example, the *chololo* pits are difficult to maintain, labour-intensive, require skills, and are occasionally waterlogged. These challenges were found to be affecting the sustainability of *chololo* pits in crop production. Thus, these challenges need to be addressed to achieve the sustainability of *chololo* pits in crop production. One of the ways to address these challenges is the use of more efficient tools to supplement the use of the hand hoe. Agriculture research institutions, COSTECH, and SIDO should to take lead on this, especially in advocating the practice of climate smart agriculture (CSA), and scaling up the *chololo* pits technology.

5.2 Recommendations

Based on the results of this study, it is recommended that the central and local governments should encourage collaboration between agriculture research institutions, such as the COSTECH (Commission for Science and Technology) and SIDO (Small Industries Development Organization), to take the lead in researching and developing more efficient tools to supplement the use of the hand hoe. This can help reduce labour-intensity and increase the effectiveness of *chololo* pits in crop production.

Likewise, the government—in collaboration with NGOs and CBOs—should promote the adoption of CSA practices in conjunction with *chololo* pits technology. CSA approaches can help address the challenges brought by changing climate conditions and enhance the resilience of agricultural systems. This may involve implementing water conservation techniques, selecting climate-resilient crop varieties, and adopting sustainable soil management practices.

Also, by working with local governments, the central government should develop policies that encourage widespread adoption and scaling up of the *chololo* pits technology across the region. This can be achieved through training programmes, workshops, and knowledge-sharing platforms that educate farmers about the benefits and proper implementation of the *chololo* pits technology. Farmer-to-farmer extension programmes should also be established to facilitate knowledge transfer, and promote the adoption of the technology.

Training programmes should be organized to teach farmers the techniques for constructing and managing the pits effectively. Additionally, agricultural extension services can provide enduring support and guidance to farmers to ensure the sustainability of the technology.

Lastly, the government should address the issue of waterlogging associated with *chololo* pits by implementing proper water management strategies. This can include improving drainage systems, incorporating water harvesting techniques, and ensuring efficient irrigation practices. By managing water effectively, the negative impacts of waterlogging can be minimized, thereby improving the sustainability of *chololo* pits.

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