Original Research Article

Farmers' Perception of Bench Terrace Performance and Effectiveness in Southern Tigray, Northern Ethiopia

ABSTRACT

The southern Tigray region in Northern Ethiopia faces significant agricultural challenges, including soil erosion and water scarcity. To address these issues, bench terraces (BTs) have been introduced as a soil and water conservation measure. These terraces aim to enhance agricultural productivity and create land opportunities for landless youths. This study investigates farmers' perceptions of the performance of constructed BTs in southern Tigray. It aims to understand the effectiveness and challenges associated with BTs and identify socio-economic, environmental, and technical factors from the farmers' perspectives. The research was conducted in the Zatta, Embahasti, and Wegelen watersheds, located in the districts of Ofla, Endamekoni, and Alaje, respectively, where BTs are predominantly practiced.A mixed-methods approach was employed, combining quantitative surveys and qualitative interviews to gather comprehensive data. The research highlights the importance of involving farmers in the design and implementation of conservation measures to ensure their sustainability and effectiveness. Despite the benefits, farmers reported several challenges, including inadequate maintenance, water scarcity, lack of access to infrastructure, and the labor-intensive nature of constructing and maintaining the terraces.While bench terraces are generally perceived positively for their role in soil conservation and productivity enhancement, addressing challenges related to maintenance, water access, and technical support is crucial for their sustained success. Enhanced community engagement and government support are recommended to improve the overall performance and sustainability of bench terraces in the region.

Keywords:Agricultural productivity, Bench terrace, Farmer'sperception,Infrastructure, Sustainability

1. INTRODUCTION

Bench terraces are a globally recognized soil and water conservation method, particularly effective in hilly and mountainous areas[1][2]. These terraces, constructed in steep and high runoff areas, help reduce runoff, increase water infiltration, and enhance soil fertility[3]. Research worldwide has demonstrated that bench terraces significantly improve soil physical and chemical properties[4]. For example, studies in Ethiopia's AnditTid watershed revealed that terraced lands had superior soil moisture content, aggregate stability, and nutrient levels compared to non-terraced lands[4].

The economy of Ethiopia is highly dependent on the agricultural sector which is determined by soil moisture and fertility status. However, numerous studies have shown that wide areas of the highlands in Ethiopia specifically Tigray are in the way of accelerated erosion. An estimate in the mid-1980s showed that 3.7% of the highlands in Ethiopia had been so badly eroded that they could not support cultivation, while a further 52% had suffered moderate or serious degradation [5],[6]. On arable land, soil erosion averages about 42 tonnes ha-1 year-1 and causes an average annual reduction in soil depth of 4 mm [7]. This could rise to 30-40 t/ha/ year on intensively cereal cultivated fields [8]). Because of this extensive degradation of land and climatic variability, frequent droughts and famines have been experienced in Ethiopia, especially in Tigray [9]. Over the past 30 years, agricultural production in Ethiopia has never been enough to feed the population and this gap has been filled by food aid[6]. Land degradation in the form of soil erosion and declining soil moisture is one serious reason for agricultural production insufficiency. Distinguishing land degradation as a chief environmental and socio-economic problem, the government of Ethiopia especially the regional government of Tigray has made several interventions. Large-scale conservation schemes were initiated particularly after the famines of the 1970s[10]. Since then, huge areas have been covered with different soil and water conservation structures and millions of trees have been planted [11]. The approach to how the government intervened has been also claimed by some researchers in the area [11][10]. These are the justifications given by researchers as to why they conclude that the achievement is not comparable to the cost invested.

Bench terrace (BT) is found to be a very important structure for reducing run-off or its velocity and minimizing soil erosion in many countries[12]. In Jamaica, research shows that BT can reduce erosion by 90-95% or more [13]. In Burundi, on a 49% slope of the land, bench terraces (BTs) reduced the soil loss from 150 tons/ha/yr to 5-11 tons/ha/yr[7]. In Sierra Leone, research results show that soil loss from 31% of sloped land was reduced by bench terracing from 41-55 tons/ha/yr to 7- 5 tons/ha/yr[7]. So, BT is considered to be among the most effective structural erosion control and moisture-retaining measurers, particularly suited to societies with areas where there are food shortages or high unemployment rates, with small landholdings size, and in areas where crops require flood irrigation[9][14].

Tigray, northern Ethiopia, is a province of smallholder agriculture in which the intensity of recurrent droughts affects the livelihoods of the agricultural communities and the whole economy[15][8].It experiences considerable variability in rainfall. Research indicates that the region has undergone fluctuations in both temperature and precipitation over the past few decades[16].Even in a year of good rain, the occurrence of floods affects the livelihoods of riparian residents with little capacity to neither protect from the seasonal flood nor mitigate the impact. In the 2000 cropping season of Ethiopia, 87.4 % of rural households operated less than 2 hectares; whereas 64.5 % of them cultivated farms of less than one hectare; while 40.6 % operated land sizes of 0.5 hectares and less[17][5].

The southern zone ofTigray, Northern Ethiopia faces significant agricultural challenges, including soil erosion water scarcity, and a shortage of productive and farming land[18][19]. To combat these issues, constructed bench terraces have been implemented as a soil and water conservation measure. These terraces are designed to reduce soil erosion, enhance water retention, create farming land,and improve

agricultural productivity. However, the success of these interventions largely depends on the perceptions and acceptance of the local farming communities[20].

Despite the potential benefits of bench terraces, there is limited understanding of how farmers perceive their performance and the factors influencing these perceptions[21][20]. This gap in knowledge hinders the effective implementation and maintenance of bench terraces, potentially leading to suboptimal outcomes and reduced adoption rates. Therefore, it is crucial to investigate the perceptions of farmers, both beneficiaries and non-beneficiaries, to identify the socio-economic and technical factors that affect their views on the performance of constructed bench terraces.

This study aims to explore the perceptions of farmers regarding the performance of constructed bench terraces in the southernTigray, Northern Ethiopia. Understanding these perceptions is crucial for evaluating the effectiveness of the terraces and identifying factors that influence their adoption and maintenance. By examining the socio-economicand technical aspects of the terraces, this research seeks to provide insights into the benefits and challenges experienced by farmers. The findings will contribute to the development of more effective soil and water conservation strategies, ultimately supporting the sustainableagricultural development of the region.

2. MATERIALS AND METHODS

2.1 Study area

The study was carried out in the southernTigray, Northern Ethiopia, specifically at Zatta, Embahasti, and Wegelen watersheds in the districts of Ofla, Endamekoni, and Alaje respectively where BTs were mostly practiced. The study area ranges from midland (2184 m.a.s.l) to highland (2858 m.a.s.l). The study areas are characterized by undulating topography with an average slope ranging from 36% to 78%. The map of the study area subdistricts and each BT location is shown in (Figure 1) below.

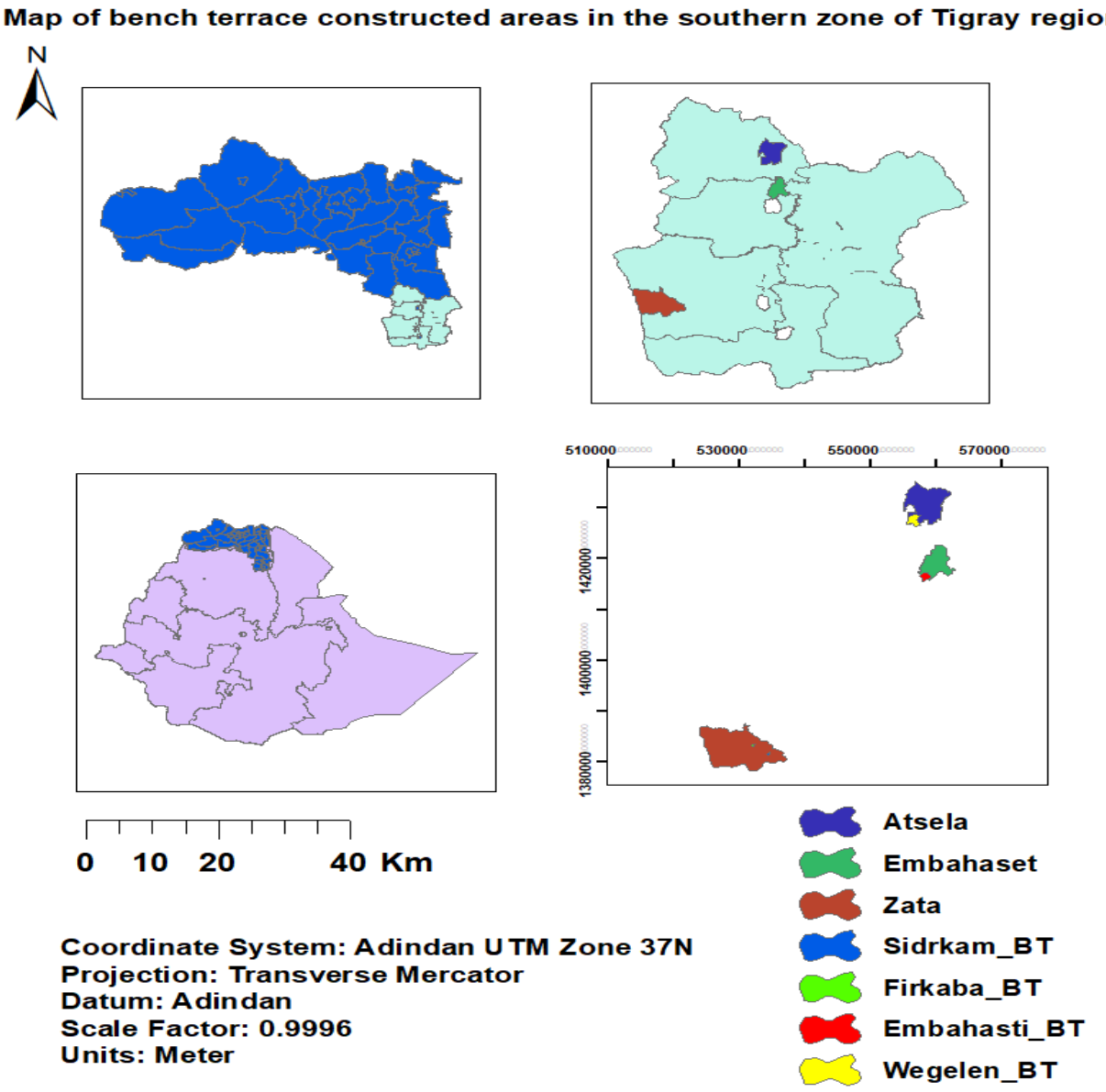


Figure 1 Map of the study area locations

2.3 Methods

A questionnaire was carried out in five subdistricts and twenty farmers were purposively interviewed from each BT to assess beneficiary and non-beneficiary farmer's viewpoints on the performance of BTs. A total of 97 farmers and a sample size of approximately 20 farmers from each bench terrace were selected from both groups.Structured questionnaires and interviews were applied to collect quantitative and qualitative data on farmers' perceptions of the performance of constructed bench terraces.

The collected data were analyzed using Excel and SPSS.

3. RESULT AND DISCUSSION

3.2 Perception of beneficiary and non-beneficiary farmers on BT performance

A total of 97 beneficiary and non-beneficiary farmers were interviewed from five sub-districts to collect data about the performance and effectivenessof BTs.

3.2.1 Category of the Respondents

Table 1 Category of the respondent

Category of the respondents	Frequency	Percent
Beneficiary farmers from the BT	83	85.6
Non-beneficiary farmers from the BT	14	14.4
Total	97	100

Understanding the categories of respondents in a study on bench terracing (BT) can provide valuable insights into the effectiveness and reach of such agricultural practices. The data indicates two main categories: beneficiary farmers and non-beneficiary farmers. Most respondents (85.6%) are beneficiary farmers who have participated in bench terracing programs. This high percentage suggests that a significant number of farmers have received support and resources to implement bench terracing on their land.A smaller portion of respondents (14.4%) are non-beneficiary farmers who have participated in bench terracing construction programs. This group may have not had direct access and benefit from the constructed BTs.

Beneficiary farmers likely had better access to financial assistance, training, and materials needed for bench terracing. This support can come from government programs, NGOs, or community initiatives.Farmers who have adopted bench terracing may have experienced increased crop yields and improved soil quality.

Beneficiary farmers might have had more exposure to the benefits of bench terracing through educational programs and community outreach, leading to higher participation rates. However,non-beneficiary farmers may face financial constraints or lack access to the necessary materials and training for bench terracing.

3.2.2 Participation of respondents in SWC practices

Table 2 Participation of respondent in SWC practices

Have you participated in any SWC practices?			
		Frequency	Percent
	No	4	4.1
	Yes	93	95.9
	Total	97	100

Participation of respondents in SWC activities was excellent which helps to gather as much information as possible about the challenges and opportunities faced on SWC activities. The high participation of respondents could be related to governmental and non-governmental organizations' support, training and technical support, economic incentives, and increased awarenessof environmental management.

3.2.3 Participation of respondents in different types of SWC practices

Table 3 Participation respondents in different types of SWC practices

If you participated which SWC practices?		
	Frequency	Percent
Bench terrace	2	2.1
All	71	73.2
Stone bund and BT	12	12.4
Stone bund, Soil bund, and BT	12	12.4
Total	97	100

All respondents have participated in different types of SWC practices.The participation rates in various SWC practices provide insights into their acceptance and effectiveness among farmers as discussed in [22][23][24]. Bench Terrace (2.1%): This low participation does not indicate the realinvolvement of the respondents on BT because BTs cannot stand alone and are constructed together with soil and stone bunds. In some instances, the low participation rate in bench terracing might be due to the high initial costs and labor-intensive nature of constructing terraces. Despite its benefits in reducing soil erosion and improving water retention, the adoption rate is relatively low.All Practices (73.2%): A significant majority of farmers (73.2%) are engaged in all SWC practices. This high participation rate indicates a strong commitment to comprehensive soil and water conservation strategies, likely driven by the cumulative benefits of multiple practices.Stone Bund and Bench Terrace (12.4%): Combining stone bunds with bench terraces is moderately popular. Stone bunds help in reducing runoff and soil erosion, while bench terraces improve water retention. The combined approach offers enhanced benefits, making it a preferred choice for some farmers.Stone Bund, Soil Bund, and Bench Terrace (12.4%): This combination also sees a moderate participation rate. Soil bunds, like stone bunds, help in controlling erosion and retaining moisture. The integration of all three practices suggests a comprehensive approach to SWC, addressing multiple aspects of soil and water management.

3.2.4 Participation of respondents in BT activities

Table 4Participation of respondents in BT activities

Have you introduced BT in your watershed?			
		Frequency	Percent
	No	3	3.1
	Yes	94	96.9
	Total	97	100

The overwhelming majority of farmers (96.9%) have participated in the introduction of bench terraces in their watershed. This high participation rate suggests strong acceptance and perceived benefits of this practice among the farming community. A small fraction of farmers (3.1%) have not participated in the bench terrace introduction. Understanding the reasons behind this non-participation can help in addressing barriers and improving overall adoption rates. The low participation could be due to awareness and personal factors.

3.2.5 Length of BT implementation

Table 5 Length of BT implementation

If yes how long is the BT after implementation?		
	Frequency	Percent
1 year	19	**19.6**
2-5 year	65	**67**
More than 5 year	13	**13.4**
Total	97	100

The duration for which bench terraces have been implemented can provide insights into their sustainability, maintenance, and long-term benefits as discussed in [25][20][26]. The data indicates varying lengths of time that farmers have maintained their bench terraces.A smaller portion of farmers (19.6%) have implemented bench terraces for just one year. This group is likely in the initial stages of adoption, experiencing the immediate benefits and challenges of bench terracing.Most farmers (67%) have maintained their bench terraces for 2-5 years. This period is crucial for observing the medium-term benefits, such as improved soil fertility, increased crop yields, and better water retention. It also indicates a commitment to the practice beyond the initial implementation phase.A smaller group (13.4%) has maintained their bench terraces for more than five years. This long-term adoption suggests that these farmers have experienced significant benefits and have successfully integrated bench terracing into their farming practices.

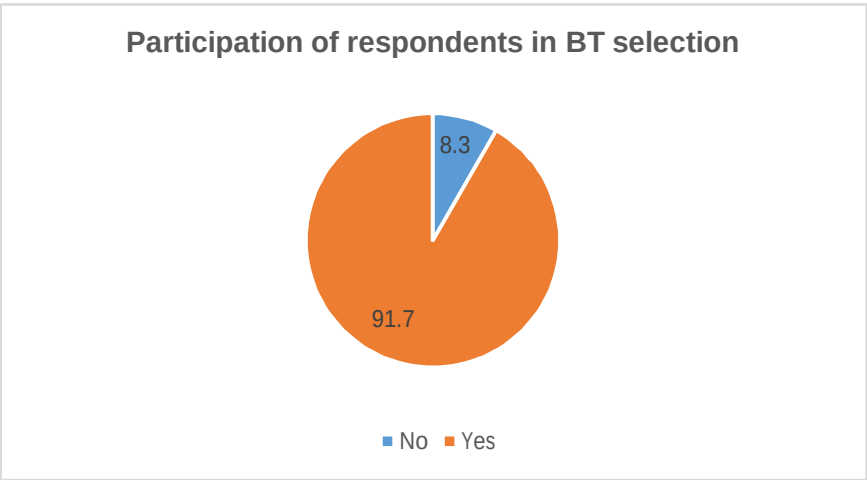
Factors Influencing Duration of Implementation

Initial Success: Farmers who see immediate improvements in crop yields and soil quality are more likely to continue maintaining their bench terraces.

Support and Training: Ongoing support and training from agricultural extension services, government programs, and NGOs can help farmers address challenges and maintain their terraces over the long term.

Economic Benefits: The economic incentives of increased productivity and income can motivate farmers to sustain their bench terraces for longer periods.

The varying lengths of bench terrace implementation among farmers highlight the importance of ongoing support, economic incentives, and community involvement. By addressing challenges and continuing to support farmers, bench terracing can play a significant role in promoting sustainable agriculture and environmental conservation.



3.2.6 Participation of respondents in BT site selection

Figure 2Participation of respondent in BT selection

The participation of farmers in the site selection for bench terraces is crucial for the successful implementation and sustainability of this soil and water conservation practice. Involving farmers in the decision-making process ensures that the terraces are appropriately located and maintained. A significant majority of farmers (91.7%) participated in the site selection for bench terraces. This high participation rate indicates strong engagement and perceived benefits of involving farmers in the process. A small fraction of farmers (8.3%) did not participate in the site selection. Understanding the reasons behind this non-participation can help in addressing barriers and improving overall involvement.

3.2.7 Acceptance of BT beneficiary selection by respondents

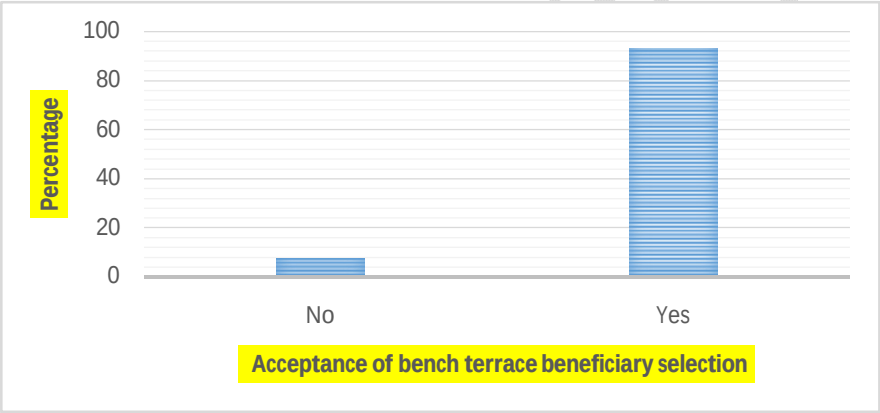


Figure 3Acceptance of BT beneficiary selection by respondents

The acceptance of beneficiary selection for bench terracing (BT) programs is crucial for their success and sustainability. High acceptance rates indicate that the selection process is perceived as fair and beneficial by the community. A significant majority of respondents (92.8%) accept the beneficiary selection process for BT programs. This high acceptance rate suggests that the selection criteria and process are well-received and trusted by the community. This can be due to a transparent selection process, where criteria and decisions are communicated which helps build trust and acceptance among the community members, and ensuring that the selection criteria are fair and inclusive, considering the needs and conditions of different farmers, contributes to higher acceptance rates.

A small fraction of respondents (7.2%) do not accept thebeneficiary selection process. Understanding the reasons behind this non-acceptance can help in addressing concerns and improving the selection

process. This could be because some farmers may perceive the selection process as biased or unfair. Lack of awareness and resource constraints could be also other factors.
Addressing these concerns through transparent communication and involving neutral parties in the selection process, conducting awareness campaigns and informational sessions, exploring additional funding sources, and optimizing resource allocation can help mitigate this issue.

3.2.8 Stage of participation in the construction of BT

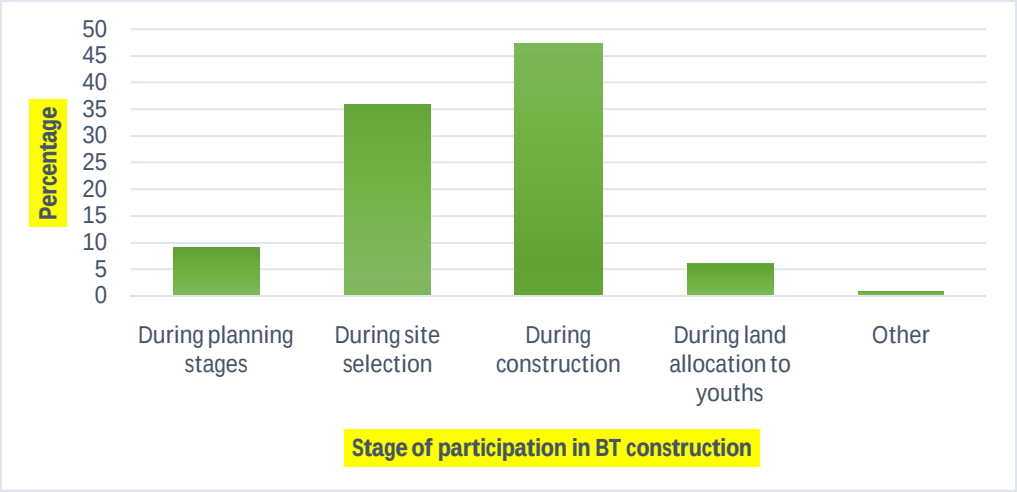


Figure 4Farmer's participation stage in construction of BT

The participation of farmers in various stages of bench terrace (BT) construction is crucial for the successful implementation and sustainability of this soil and water conservation practice. Understanding the distribution of participation across different stages can provide insights into the effectiveness of the process and areas for improvement.

A smaller portion of farmers (9.3%) are involved in the planning stage. This stage includes initial discussions, feasibility studies, and designing the terrace layout. Farmer participation at this stage ensures that their needs and preferences are considered, leading to more effective and acceptable designs. A significant number of farmers (36.1%) participate in the site selection stage. Their local knowledge about soil types, water flow patterns, and areas prone to erosion is invaluable for selecting the most suitable sites for bench terraces. This involvement fosters a sense of ownership and responsibility. Most farmers (47.4%) are involved in the construction stage. This hands-on participation is crucial for building the terraces according to the planned design and ensuring that they are constructed correctly. It also provides farmers with practical skills and experience.

Land Allocation to Landless Youth Stage (6.2%): A smaller group (6.2%) participates in the stage where land is allocated to landless youth. This initiative can help address landlessness and provide opportunities for young people to engage in agriculture, promoting social equity and economic development. A small fraction (1%) of farmers are involved in other stages or activities related to bench terrace construction. This could include activities such as monitoring, maintenance, or community mobilization.

Factors Influencing Participation

Training and Awareness: Providing training and raising awareness about the benefits and processes of bench terrace construction can increase farmer participation across all stages.
Economic Incentives: Financial benefits, such as increased crop yields and reduced soil degradation, motivate farmers to participate in the construction and maintenance of bench terraces.
Community Support: Strong community support and collaborative efforts can encourage higher participation rates. Community-based approaches ensure that farmers feel supported and valued.
Government and NGO Support: Support from government programs and NGOs, including financial assistance, technical support, and resources, can facilitate farmer participation in all stages of bench terrace construction.

Implications and Future Directions

Active participation of farmers in all stages of bench terrace construction promotes sustainable agricultural practices and ensures long-term productivity and environmental health. Insights from participation rates can inform policy development, encouraging the implementation of inclusive and participatory approaches in soil and water conservation programs. Ongoing research into improving bench terrace designs and construction processes can also enhance their effectiveness and adoption rates.

3.2.9 Layout and Design Preparation of BT

Table 6 Layout and design preparation of BT

Was the layout and design of BT prepared for the selected site?		
	Frequency	Percent
No	36	37.1
Yes	53	54.6
I do not have an awareness	8	8.2
Total	97	100

The preparation of layout and design for bench terraces is a critical step in ensuring their effectiveness and sustainability. The data indicates varying levels of preparation and awareness among farmers regarding the layout and design of BT for the selected sites. 54.6% of respondents indicated that the layout and design of bench terraces were prepared for the selected site. This suggests that more than half of the farmers had access to proper planning and technical support, which is crucial for the successful implementation of BT. However, a significant portion of respondents (37.1%) reported that the layout and design were not prepared. This highlights a gap in the planning process that could affect the effectiveness and sustainability of the terraces. A smaller group (8.2%) of respondents were not aware of whether the layout and design were prepared. This indicates a need for better communication and education about the planning process.

Table 7 Layout and design preparation of BT

If the answer is yes who prepared the layout and design for your site?		
	Frequency	Percent
District Expert	1	1
DA or sub-district expert	6	6.2
Trained farmer's technique leaders	42	43.2
All	18	18.6
DA and Trained farmers	25	25.8
District Expert and DA	5	5.2

Total	97	100

It seems that most of the layout and design work was done by trained farmer's technique leaders, followed by a combination of DA (Development Agents) and trained farmers. This indicates a strong reliance on local expertise and practical knowledge, which can be beneficial for ensuring that the design is well-suited to the specific conditions of the area. In addition, the collaboration of DA (Development Agents) and trained farmers likely brings together technical knowledge and practical experience, leading to more effective and sustainable designs.

3.2.10 BT Construction Approach

From where do you start construction of BT (which approach)?

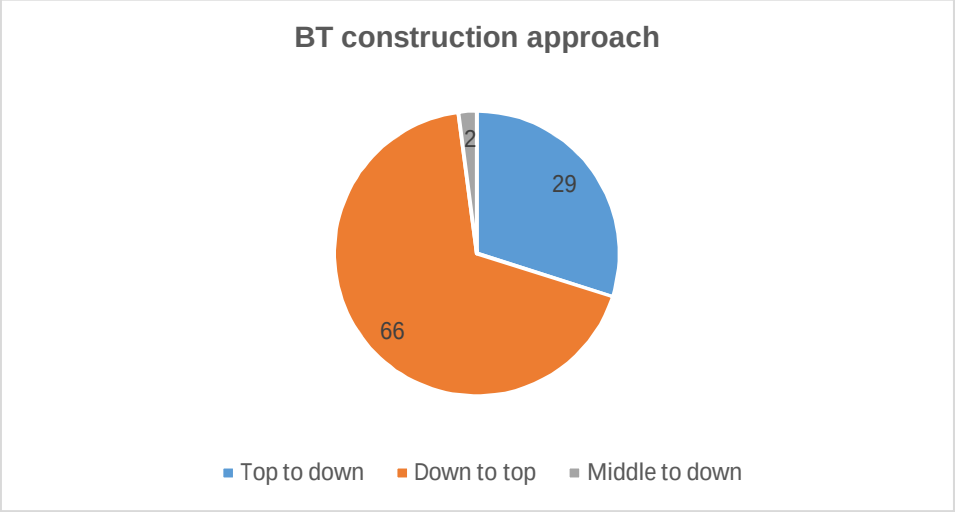


Figure 5BT Construction Approach

Bottom-Up Approach:

Most respondents (66 %) said that the BT construction used the bottom-up approach. This method involves starting the construction from the bottom of the slope and working upwards. It is often favored because it allows for better control of soil and water management as the construction progresses. Additionally, it can be easier to ensure stability and proper alignment of the terraces.

Top-Down Approach:

The top-down approach, stated by 29 % of the respondents, involves starting from the top of the slope and working downwards. This method can be advantageous in certain situations, such as when there is a need to quickly establish terraces to prevent erosion from the top. However, it may require more careful planning to ensure that the lower terraces are properly aligned and stable.

Middle-Down Approach:

Only 2 % of the respondentssaid the middle-down approach, involves starting construction from the middle of the slope and working downwards. This method is less common and might be used in specific scenarios where the middle section of the slope is particularly vulnerable to erosion or where access to the middle of the slope is easier.

Main Considerations for Each Approach

According to[13][25], The following factors are the main criteria for BT selection.

Soil Stability:Ensuring soil stability is crucial in all approaches. The bottom-up approach often provides better control over soil stability as each terrace supports the one above it.

Water Management:Effective water management is essential to prevent erosion and ensure the longevity of the terraces. The top-down approach might require more sophisticated water management strategies to handle runoff from the upper terraces.

Labor and Resources:The choice of approach can also depend on the availability of labor and resources. The bottom-up approach might be more labor-intensive initially but can provide more stable results eventually.

Site-Specific Conditions:The specific conditions of the site, such as slope gradient, soil type, and climate, can influence the choice of construction approach. It is important to tailor the approach to the unique characteristics of the site.

3.2.11 Quality of Stone Used in Construction of BT

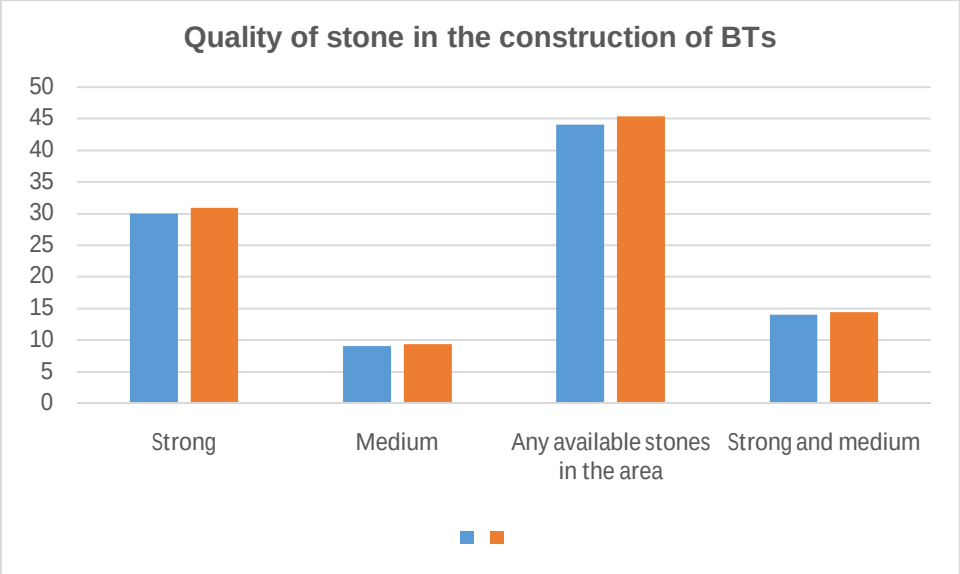


Figure 6Quality of Stone Used in Construction of BT

The largest group (45%) uses any available stones for constructing bench terraces. This approach is often driven by practicality and resource availability, especially in areas where specific types of stones might be scarce. However, using stones of varying quality can impact the durability and effectiveness of the terraces.

About 31% of respondents prefer using strong stones. Strong stones are likely to provide better structural integrity and longevity for the terraces, reducing the need for frequent repairs and maintenance. This choice reflects a focus on building more durable and resilient structures.

A combination of strong and medium stones is used by 14% of respondents. This approach can balance cost and availability with the need for durability. By using strong stones in critical areas and medium stones elsewhere, it is possible to optimize both resource use and structural integrity.

Only 9% of respondents use medium stones exclusively. While medium stones might be more readily available or easier to work with, they may not provide the same level of durability as strong stones. This choice might be influenced by local availability or specific construction techniques

3.2.12 Structural Performance of Constructed BTs

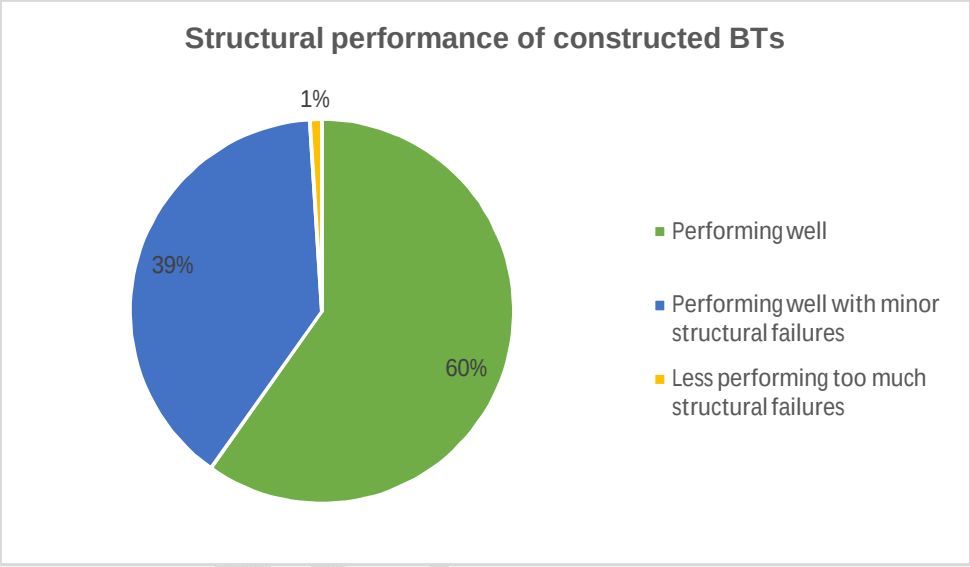


Figure 7Structural performance of constructed BT

The high-performance rate of the constructed BTs (60%) indicated that the design and construction methods used are generally effective. This high-performance rate also suggests that the terraces are successfully controlling soil erosion and managing water runoff, which are key objectives of bench terraces.

A significant portion (39%) of the BTs is performing well but with minor structural failures. These minor issues could include small cracks, slight misalignments, or minor erosion at the edges. While these do not severely impact the overall functionality, they do require regular maintenance to prevent them from becoming major issues.

Only 1% of the BTs are experiencing major structural failures. Major failures could include significant erosion, collapse of terrace walls, or large cracks that compromise the integrity of the terraces. These issues need immediate attention and possibly redesign or reconstruction to restore functionality.

3.2.13 Major Problems of the BT

Table 8 Major Problems of the BT

What are the major problems with the BT site?		
	Frequency	Percent
Lack of infrastructure	84	86.6
Failure of BTs	3	3.1
We have not any problem	8	8.2
Lack of infrastructure and failure of BTs	2	2.1
Total	97	100

The overwhelming majority (86.6%) identified a lack of infrastructure as a major problem. This could include inadequate access to roads, insufficient water management systems, or a lack of tools and equipment necessary for maintaining the terraces. Improving infrastructure is crucial for the effective implementation and sustainability of bench terraces. Without proper infrastructure, even well-designed terraces can fail to deliver their intended benefits[27].

A small percentage (3.1%) reported failures of the bench terraces themselves. These failures could be due to poor construction practices, the use of substandard materials, or environmental factors such as heavy rainfall leading to erosion. Addressing these issues requires better construction techniques, the use of high-quality materials, and regular maintenance.

Interestingly, 8.2% of respondents reported no problems with their bench terraces. This suggests that when properly designed, constructed, and maintained, bench terraces can be highly effective. It would be beneficial to study these successful cases to identify best practices that can be applied more broadly.

A small group (2.1%) reported both a lack of infrastructure and failures of the bench terraces. This combination can be particularly challenging as it indicates systemic issues that need to be addressed on multiple fronts. Comprehensive planning and investment in both infrastructure and construction quality are necessary to overcome these challenges.

3.2.14 Major infrastructural problems of the BT

Which infrastructure is the dominant problem?	Frequency	Percent
Road	1	1
Water source or access	83	85.6
Market and water access	12	12.3
Electricity	1	1

Table 9 Major infrastructural problems of the BT

Total	97	100

The most significant problem, identified by 85.6% of respondents, is the lack of water sources or access. Water is crucial for the effectiveness of bench terraces, as it is needed for irrigation and maintaining soil moisture. Without reliable water access, the terraces cannot function optimally, leading to reduced agricultural productivity and increased soil erosion.

A combined issue of market and water access is noted by 12.3% of respondents. This indicates that not only is water access a problem, but also the ability to reach markets to sell produce. Poor market access can limit the economic benefits of bench terraces, making it harder for farmers to sustain their operations and invest in necessary infrastructure improvements.

Only 1% of respondents identified road infrastructure as a problem. While this is a relatively small percentage, good road infrastructure is essential for transporting materials needed for constructing and maintaining terraces, as well as for accessing markets. Similarly, 1% of respondents mentioned electricity as an issue. While not directly related to the physical structure of bench terraces, electricity can be important for powering irrigation systems and other agricultural equipment.

3.2.15 Responsibility for Maintenance of the BT

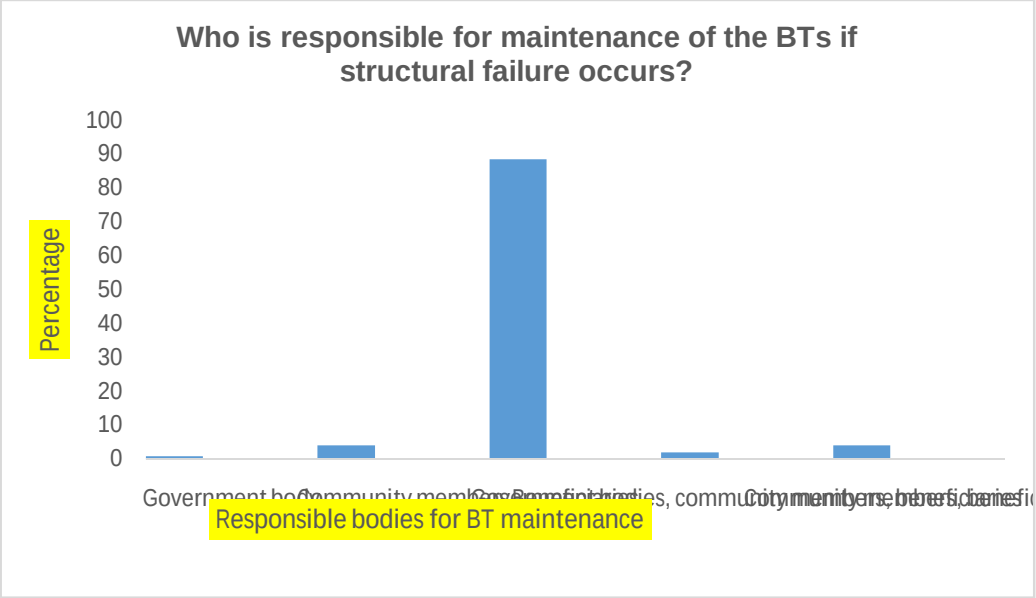


Figure 8Responsibility for Maintenance of the BT

The overwhelming majority (88.7%) of respondents believe that the beneficiaries should be responsible for the maintenance of the bench terraces. This makes sense as the beneficiaries are the ones who directly reap the benefits of the terraces, such as improved agricultural productivity and reduced soil erosion. Their vested interest in maintaining the terraces ensures that they are kept in good condition.

A small percentage (4.1%) of respondents think that community members should be responsible. Community involvement can foster a sense of ownership and collective responsibility, which can be beneficial for the long-term sustainability of the terraces. When the community works together, it can also help in pooling resources and labor for maintenance activities.

Only 1% of respondents believe that government bodies should be solely responsible for maintenance. While government support can be crucial in terms of providing technical assistance, funding, and policy support, the day-to-day maintenance is often more effectively managed by those who are directly using the terraces. A small group (2.1%) believes that the responsibility should be shared among government bodies, community members, and beneficiaries. This collaborative approach can leverage the strengths of each group: government bodies can provide resources and technical expertise, community members can offer local knowledge and labor, and beneficiaries can ensure that the terraces are maintained to meet their needs.
Another 4.1% of respondents think that both community members and beneficiaries should share the responsibility. This approach can enhance community cohesion and ensure that the terraces are maintained effectively, as both groups have a direct interest in their success.

4. CONCLUSION AND RECOMMENDATION

Bench terracing is a crucial soil and water conservation technique, especially in hilly and mountainous regions. It involves creating stepped levels on slopes to reduce soil erosion and improve water retention, which in turn enhances agricultural productivity. The impressive 98% participation rate among farmers indicates a strong acceptance and perceived benefits of this practice. This participation of farmers in all stages of BT construction and maintenance including site selection and layout can reduce the failure of BTs structures and increase their durability and benefits. The preparation of layout and design for bench terraces is a crucial step in their successful implementation. While most farmers reported that this step was completed, there is still a significant portion who did not have this preparation or were unaware of it. Addressing these gaps through training, resource support, and better communication can enhance the effectiveness and sustainability of bench terraces.

The research highlights the importance of farmer involvement in the design and implementation of conservation measures to ensure their sustainability and effectiveness. Despite the benefits, farmers reported several challenges. The most common issues included inadequate maintenance, water scarcity, lack of access to infrastructure, and the labor-intensive nature of constructing and maintaining the terraces. While bench terraces are generally perceived positively for their role in soil conservation and productivity enhancement, addressing the challenges related to maintenance, water access, and technical support is crucial for their sustained success.

In general,enhanced community engagement, proper and participatory layout and design, awareness creation to farmers, ensuring quality control for the BT construction, regular maintenance and monitoring, policy developments, and government support are recommended to improve the overall performance and sustainability of the bench terraces in the region.

Competing Interest

The authors declare that there is no competing interest in this manuscript.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that AI technologies specifically COPILOThave been used during the editing of this original manuscript.

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