Impacts of stone bunds on selected soil properties and crop yield in Gumara-Maksegnit watershed Northern Ethiopia

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\textbf{Abstract:} The study was conducted in Gumara-Maksegnit watershed to evaluate the impacts of 5-years old stone bunds on soil pH, Organic matter (OM), available phosphorous (Av. p), cation exchange capacity (CEC), available potassium (K\textsuperscript{+}), soil moisture content (SMC), and crop yield. The experiment has two treatments, three bund positions, and three intra-bund positions with three replications. The experiment has two data sets: (i) 27 data points for treated farmland (three consecutive bunds*three intra-bund positions*three replications) arranged in split-plot design as a main and sub-plots, (ii) a pair of 9 data points of treated and untreated farmland for a paired mean comparison. The result showed that pH was significantly different between the main plots where the highest value (7.07) observed at the lower bund due to sediment accumulation with soluble bases. Meanwhile, OM, Av. p, and SMC were significantly different between sub-plots where the highest mean values observed in the deposition zone. On the other hand, soil properties such as OM, CEC, and SMC were significantly higher in conserved farmland as compared to non-conserved farmland. The grain yield of sorghum (\textit{Sorghum bicolor L.}) and chickpea...
(Cicer arietinum) was significantly different between conserved and non-conserved farmlands. The yield advantages due to stone bund intervention were 8.46% and 28.51% for sorghum (Sorghum bicolor L.) and chickpea (Cicer arietinum), respectively. Therefore, proper implementations of stone bunds in the study area have a pronounced positive impact and should be practiced and applied in adjacent watersheds and similar agro-ecologies.

**Subjects:** Environment & Resources; Conservation - Environment Studies; Ecology - Environment Studies

**Keywords:** farmland; crop productivity; Gumara-Maksegnit watershed; soil conservation; soil erosion

### 1. Introduction

Land and soil are the vital resources to produce goods and services while humans worldwide obtained their food from the land (Pimentel & Burgess, 2013). However, soil erosion is a principal degradation process and one of the most serious threats facing world food production (Addis, Klik et al., 2015; Pimentel & Burgess, 2013). The worldwide annual rate of soil erosion from agricultural land ranges from 22 to 100-ton ha⁻¹ and declines in productivity as much as 15–30% annually (Morgan, 2005).

Soil erosion assessment conducted in Eastern Spain by Rodrigo-Comino et al. (2020) confirmed that the soil mobilization rate for tilled and no-tilled plots was 52.6 Mg ha⁻¹ yr⁻¹ and 31.9 Mg ha⁻¹ yr⁻¹ respectively. Hence, for sustainable agriculture and the environment, new management strategies are required to protect the soil resources against erosion. To mitigate non-sustainable soil losses; surface covers and mulch materials are an efficient solution for the sustainable use of the soil resource (Cerdà et al., 2018; Keesstra et al., 2019).

Similarly, soil erosion is the major environmental problem in Ethiopia resulted in the reduction of productivity of arable lands through removals of the most productive portion of the soil that is a chemically active part such as organic matter and clay fractions (Alemu et al., 2013; Amdemaram et al., 2011; Wolka et al., 2011). The average soil loss from farmland in Ethiopian highlands estimated to be 100 Mg ha⁻¹ yr⁻¹ (FAO, 1984) and 200 to 300 Mg ha⁻¹ yr⁻¹ (Hurni, 1993). Deforestation for crop production, cultivation of marginal lands, and overgrazing are the major factors that increased the vulnerability of agricultural lands to rainfall-driven soil erosion (Adimassu et al., 2014; Addis, Strohmeier et al., 2016).

In response, soil and water conservation practices initiated in Ethiopia during the 1970s and 1980s as a part of efforts to restore the degraded lands and to increase agricultural production (Adimassu et al., 2014; Haregeweyn et al., 2015). Afterward, since 2010 a massive effort has been undertaken by the government of Ethiopia in constructing soil and water conservation structures including stone bund, soil bund, trench, micro basin and check-dam on privately owned and community lands through community mobilization (Dagniew et al., 2017; Tilahun & Belay, 2019; Wolka, 2014).

Most of the conservation practices implemented in Ethiopian highlands can reduce soil erosion; improve soil water and basic soil condition that contributes to crop production improvement (Haregeweyn et al., 2015; Addis, Strohmeier et al., 2016). Teressa (2017) and Guadie et al. (2020) reported as the mean values of OC, TN, Av. p, pH, and CEC significantly higher under conserved farmland compared with non-conserved farmland. Similarly, Tanto and Laekemariam (2019) found that 5 years old integrated soil and water conservation was reduced the soil bulk density; and increased soil pH (5.87 to 6.60), organic carbon (1.34 to 1.74%) and available phosphorous (8.06 to 25.23 mg kg⁻¹) by 12%, 30% and 203% compared to non-conserved land, respectively.
On the other hand, Addis, Abera et al. (2019) reported as the land treated with soil and water conservation (SWC) measures has a grain yield advantages from 13% to 19.4% as compared to untreated cultivated land. Whereas, Guadie et al. (2020) found that the field treated by soil bunds and stone-faced soil bunds has a 34% grain yield advantage than untreated fields. In contrast, the construction of SWC practices such as soil and stone bunds reduced crop yield up to 7% for the first few years in Ethiopia for the reduction of effective cultivable land and waterlogging problems (Adimassu et al., 2014; Kassie et al., 2011). Although many studies confirmed the positive impacts of SWC measures on soil properties and crop yield the farmers perceived that the practices did not show a positive impact other than occupying their farmlands (Guadie et al., 2020).

As part of Ethiopian highlands, the study area affected by soil erosion and subsequent productivity losses. To counteract the soil erosion problem in the study area the government and development agencies have invested resources and efforts to promote conservation measures. Among conservation interventions, the stone bund is a well-known conservation practice on cultivated land due to its durability and compatibility of a pair of oxen to plow. However, the study regarding the impacts of stone bunds on soil property improvement and crop yield enhancement was limited. In general, the extent of soil erosion remained unknown in many parts of the world, as most of the research is concentrated in limited areas (Barrena-González et al., 2020). Likewise, the research results published regarding the roles of conservation practices in Ethiopian highlands have been inconsistent and scattered (Haregeweyn et al., 2015; Tilahun & Belay, 2019).

Understanding the impacts of stone bunds on the redistributions of soil materials between the structures and conserved and non-conserved farmlands is critical to look at options for proper planning and implementation of management practices. Therefore, this study aims to evaluate the impacts of stone bunds on soil properties and crop yield between consecutive bunds and intra-bund positions as compared to untreated farmland.

2. Materials and methods

2.1. Description of the study area

A field experiment was conducted at Gumara-Maksegnit watershed in the highland area of northern Ethiopia. Which is geographically located between 12°23' 53" to 12° 30' 49" north latitude and 37° 33' 39" to 37° 37' 14" east longitude (Figure 1). According to Addis, Strohmeier et al. (2016), the watershed elevation ranges from 1920 to 2850 m above sea level and the land slope ranges from nearly flat (<2%) to extremely steep (>70%).

Based on the classifications of Hurni et al. (2016), the climate of the watershed is classified as a moist temperate agro-ecological zone and characterized by unimodal rainfall distribution with a mean annual rainfall in the watershed is 1157 mm (Addis, Strohmeier et al., 2016). Whereas, the average monthly maximum and minimum temperatures were recorded as 28.3 °C and 13.8 °C, respectively (Figure 2).

The watershed is characterized by a mixed crop-livestock subsistence farming system (Worku et al., 2015). The total area of the watershed is 5356 ha which is mainly covered by agricultural land (63.5%) followed by forest (24.3%) and grassland 12.2% (Addis, Strohmeier et al., 2016). According to Addis, Strohmeier et al. (2016) the agricultural land in the study area mostly covered by tef (Eragrostis Tef) (30.0%), sorghum (Sorghum bicolor L.) (13.2%), barley (6.9%), faba bean (5.6%), winter wheat (4.3%) and chickpea (Cicer arietinum) (3.5%). Whereas, the total area of the sub-catchment is 24 ha of which 15 ha is agricultural land mostly devoted to producing tef, sorghum, and chickpea. The soil types are predominately Cambisol and Leptosol which are found in the upper and central part of the watershed, whereas Vertisol is found in the lower catchment (Addis, Klik et al., 2015).
2.2. Experimental setup

The experiment was conducted in the 2015 and 2016 rainy season on treated and untreated adjacent farmlands. During the first experimental year, the adjacent treated and untreated farmlands covered by sorghum and as a usual crop rotation of the area; chickpea comes after sorghum in 2016. The land treated with 5 years old stone bunds and untreated farmland selected based on their similarities of slope and surface characteristics (Figure 3). Three consecutive stone bunds selected with the average slopes of 4.43, 7.27, and 7.73% for lower, middle, and upper bund positions, respectively and as 7.25% average slope for untreated farmland. Whereas, the average height and spacing between bunds were 0.45 m and 17.5 m, respectively. Based on a given spacing and bund height the stone bunds reduced the slope gradient by 2.57%.
The experiment has two treatments (treated and untreated farmlands), three consecutive bunds (lower, middle, and upper) and three intra-bund positions (A, B, and C) (Figure 4). The experiment has two data sets: (i) 27 data points were assigned for treated farmland (three consecutive bunds*three intra-bund positions*three replications) and arranged in split-plot design, (ii)
other hand, 9 data points (Figure 4) were assigned for untreated farmland to make a paired mean comparison with the data from treated farmland using a paired t-test statistics.

2.3. Soil data and crop yield measurement
The sampling points used as data points to collect the soil and crop data throughout the study period in both treated and untreated farmlands. The required soil and agronomic data collected at 1.5 m apart in both sides (upslope and downslope) of the bund and middle part of two consecutive bunds. Whereas, the data points for untreated farmland located side by side to the data points of treated farmland. The distance between replications estimated at 12 m with some deviations to keep the uniformity of the land surface characteristics. Surface soil samples collected at a depth of 0–20 cm from each sampling point before planting and after harvesting for nutrient analysis. Each soil sample was air-dried at room temperature, homogenized, and passed through a 2 mm sieve before laboratory analysis for different soil parameters (OM content, CEC, available P, and soil pH). OM was determined from organic content by Walkley & Black method (Schnitzer, 1983). The organic content result obtained from laboratory analysis was multiplied by 1.724 to get OM. CEC was measured by using 1 M Ammonium acetate, and pH was measured in distilled water using a 1:2.5 (soil: water) suspension. Av. p content was determined using the Olsen extraction method as described by Van Reeuwijk (2002).

Soil moisture samples were collected using an augur at corresponding data points once a week between June and September in the 2015 and 2016 rainy seasons. SMC was determined using the gravimetric method by measuring initial weight and oven-dried weight at 105°C for 24 hours and is defined as the ratio of the mass of water held in the soil to the dried soil (Klute, 1986). Whereas, the crop yield data was collected from twenty-seven data points with three replications along the slope for treated farmland and nine data points for untreated farmland using a 1 m² steel quadrant. The test crops were sorghum (2015) and chickpea (2016).

2.4. Data analysis procedures
Three consecutive bunds along the slope that are lower, middle, and upper bund positions assigned as the main plot, and intra-bund positions (A, B, and C) considered as the sub-plot. The soil physicochemical properties and crop yield data were subjected to analysis of variance using the general linear model procedure of (SAS version 9.4) at a 5% level of significance and the mean separation for each parameter was made using least significant difference (LSD). Whereas, the data obtained from treated and untreated farmlands were compared statistically using paired t-test using SPSS software.

3. Result and discussions

3.1. Effects of inter and intra-bund positions on soil and crop yield
In the study site, the soil pH was significantly affected by the main plot (bund positions), where the highest value was observed at the lower bund as compared to middle and upper bund positions (Table 1). It may be due to sediment accumulation with soluble bases and organic matter received from upslope through erosion and leaching processes. Amare et al. (2013) also found the highest pH value at the toe slope compared to other positions due to high CEC and exchangeable bases. Similarly, Guadie et al. (2020) reported as the mean value of soil pH was higher in the lower slope (6.65) than the upper slopes (6.01) due to high H⁺ concentration when the slope gradient increased soil pH decreased.

However, the soil pH was not significantly affected by sub-plot (intra-bund positions). The result is in line with the study by Amare et al. (2013) who found that the mean value of pH from deposition and loss structural zones was not significantly different in Anjeni watershed. Similarly, Million (2003), VanCampenhout et al. (2006), and Worku (2017) reported that soil pH was not significantly affected by stone bunds and consecutive stone terraces. In general, the pH level of the experimental site is rated as neutral (6.6–7.3) based on the classification described by Pam and
| Treatments                  | pH  | Av. p (ppm) | OM (%) | CEC (cmol/kg) | K⁺ (cmol/kg) | SMC (%) | Sorghum (kg ha⁻¹) | Chickpea (kg ha⁻¹) |
|----------------------------|-----|-------------|--------|---------------|--------------|---------|------------------|------------------|
| Consecutive stone bunds (main plot) |     |             |        |               |              |         |                  |                  |
| Lower bund                 | 7.07<sup>a</sup> | 12.46     | 3.12   | 50.30         | 1.43         | 25.20<sup>a</sup> | 1719            | 1192.8<sup>b</sup> |
| Middle bund                | 6.99<sup>ab</sup> | 11.38     | 2.78   | 50.76         | 1.29         | 24.48<sup>b</sup> | 2028.3          | 1497.5<sup>a</sup> |
| Upper bund                 | 6.88<sup>b</sup>  | 12.04     | 2.40   | 47.94         | 1.21         | 23.59<sup>c</sup> | 2293.2          | 1437<sup>a</sup> |
| CV                         | 1.31 | 49.03      | 20.13  | 6.54          | 1.83         | 37.89   |                  |                  |
| LSD<sub>0.05</sub>         | 0.1198 | 2.93      | 0.4228 | 4.25          | 0.59         | 998.59  |                  | 228.53           |
| Intra-bunds (sub-plot)     |     |            |        |               |              |         |                  |                  |
| Deposition (A)             | 7.03 | 14.22<sup>a</sup> | 2.97<sup>a</sup> | 50.60 | 1.40 | 25.49<sup>a</sup> | 2490.6<sup>a</sup> | 1778.9<sup>a</sup> |
| Middle (B)                | 6.95 | 11.18<sup>b</sup> | 2.44<sup>b</sup> | 49.39 | 1.25 | 23.79<sup>b</sup> | 1615<sup>0</sup> | 1224.6<sup>b</sup> |
| Lose zone (C)             | 6.96 | 10.48<sup>b</sup> | 2.86<sup>b</sup> | 49.01 | 1.28 | 23.98<sup>b</sup> | 1934.9<sup>b</sup> | 1320.8<sup>b</sup> |
| CV                         | 1.14 | 21.36      | 14.13  | 5.5           | 6.06         | 1.71    | 15.7             | 12.1             |
| LSD<sub>0.05</sub>         | 0.082 | 1.17      | 0.2329 | 2.86          | 0.15         | 0.43    | 324.66           | 170.88           |

Av. P = available phosphorous, OM(%) = organic matter, CEC = cation exchange capacity, K⁺ = available potassium, SMC(%) = soil moisture content, the mean values with different small letters (a, b, c) along the same column showed that the significant difference among treatments while the mean values with the same letter are not significantly different.
Murphy (2007). Hence, the level of soil pH in the study site is suitable for crop production as most nutrients for field crops are available at pH level ranges 5.5–7.0.

Meanwhile, Av. p showed a statistically significant difference between the intra-bund positions where the highest value observed in the deposition zone as compared to the middle and loss zones (Table 1 and Figure 5). It may be due to the transportation of soil particles with phosphorous through the erosion process and deposited in the sediment accumulation zone of the bunds. Amare et al. (2013) also justified the variation in Av. p between deposition and loss of structural zones can be due to transportation in the upper parts and accumulation at the lower part.

Whereas, OM content showed a statistically significant difference among the intra-bund position where the highest value recorded at the deposition zone of structural measure as compared to the middle and loss zones (Table 1 and Figure 5). The variations of organic matter could be due to the downward movements of the sediment and biomass to the lower slope through runoff and accumulated at deposition zones of the bunds. The result is in line with the finding by Amare et al. (2013) and Dagnachew et al. (2020) who reported as soil OM was significantly higher at deposition bund position than loss structural zone. According to Bot and Benites (2005), OM accumulation is often favored at the bottom of hills due to the downward movement of runoff and sediment in the landscape to the lowest point in the sub-catchment.

In the experimental site, SMC was significantly affected in both main and sub-plots where the highest SMC (25.20%) was observed in the lower bund as compared to the middle and upper bund positions (Figure 4). It might be due to the presence of higher OM and the effects of stone bunds in reducing surface flow velocity and enhanced infiltration. This result is in agreement with the study conducted at Ezha District southern Ethiopia by Shafi et al. (2019) reported as the highest SMC was observed at foot slope (17.28%) as compared with medium (14.21%) and higher (11.96%) slope positions. Similarly, Dagnachew et al. (2020) found that the highest soil water content observed in the lower terrace position (34.90%) than in the middle (27.57%) and upper (20.71%) terrace positions in treated farmlands.
In respect to intra-bund positions, the highest SMC observed at deposition zone (A) as compared to the middle (B) and loss (C) zone. It could be due to soil quality improvement by stone bunds through trapping the sediment and surface runoff that remains for long periods behind the structures and thereby allowing more of it to infiltrate into the soil. The result is in line with the study reported by Klik et al. (2018) revealed as the soil water content in the lower bund zones were significantly higher than in the upper zone due to surface runoff retention and thereby increased SMC. It may be due to the capacity of stone bunds enhancing SMC by storing soil water at deposition zones of the structures (Dagnachew et al., 2020).

Concerning the production impact, chickpea production was significantly different between consecutive bundle positions where the highest value obtained at the middle bund (1497.5 kg ha\(^{-1}\)) along the landscape. According to Agegnehu and Sinebo (2012) chickpea is not performed well under waterlogging and moisture stress conditions, which is constrained by poor drainage when sown early and by drought when sown late. Figure 5 illustrated that the average SMC of the middle bund was more stable than the upper bund and relatively higher than the lower bund position that could be the reason for higher chickpea grain yield obtained at the middle bund.

In respect to intra-bund positions, the highest grain yield obtained at the deposition zone of bund for chickpea (1778.9 kg ha\(^{-1}\)). Chickpea is mostly grown with residual moisture after the main season that is why in this study the higher grain yield was obtained at the deposition zone that received from upslope and able to maintain the highest SMC (Table 1; Figure 5). Similarly, Amare et al. (2013) found that the grain yields of wheat and maize were significantly different between deposition and loss of structural zones.

Meanwhile, the grain yield of sorghum was significantly different between the intra-bund positions where the highest grain yield obtained at the deposition zone (2490.6 kg ha\(^{-1}\)) as compared to the middle (1615 kg ha\(^{-1}\)) and lose (1934.9 kg ha\(^{-1}\)) zones. The results probably due to soils actively eroded from loss zone to the soil accumulation zone, creating spatial variability in terms of moisture and nutrient availability within the inter-conserved space (Challa et al., 2016). Generally, higher mean values of most soil nutrients and grain yield observed in the accumulation zone and gradually declined towards the loss zone. This is due to erosion by water that causes a significant redistribution of soil nutrients and moisture within the space and between the structures while soil materials eroded from the upper structural position and deposited to lower inter-structural positions.

### 3.2. Comparisons of treated and untreated farmlands

The impacts of the stone bund on selected soil properties (pH, Av. p, OM, CEC, Av. K, and SMC) and crop yield (sorghum and chickpea) were evaluated and compared with untreated farmland. The result showed that soil pH, Av. p, and Av. K were not significantly different among treatments, but numerically higher mean values observed at conserved farmland compared with non-conserved farmland. Physical soil and water conservation practices are most effective to maintain the existing soil parameters. Hence, the soil physicochemical properties may not always improve by physical structures alone without biological integration.

On the other hand, OM, CEC, and SMC were significantly different because of the stone bund intervention. The soil OM was significantly higher in terraced farmland than non-terraced farmland with mean values of 2.76% and 2.07%, respectively (Table 2). As a rating standard outlined by Pam and Murphy (2007), OM was found to be medium.

The improvement of SMC and fertile soil deposited behind the structures favor higher crop biomass production and resulted in higher OM content. This result is in agreement with the study by Million (2003) and Tanto and Laekemariam (2019) who reported as the highest values of OM were observed on farmland treated with SWC when compared to non-conserved land. Similarly, Belayneh et al. (2019) found that the higher soil organic matter (4.3%) obtained in conserved plots than non-conserved plots (2.83%).
Table 2. Paired mean comparisons of soil properties and crop yield

| Parameters                  | Treated | Untreated | Mean difference | t-test | df | p-value |
|-----------------------------|---------|-----------|-----------------|--------|----|---------|
|                            | Mean    | STDEV     | Mean difference |        |    |         |
| pH                          | 6.98    | 6.71      | 0.27            | 0.17   | 2.68 | 8       | 0.115*** |
| Av. p (ppm)                 | 11.96   | 11.04     | 0.92            | 1.0    | 1.54 | 8       | 0.263*** |
| OM (%)                      | 2.76    | 2.07      | 0.69            | 0.14   | 5.05 | 8       | 0.037ns  |
| CEC (cmol/kg)               | 46.99   | 39.96     | 9.71            | 0.26   | 66.02| 8       | 0.001*** |
| K⁺ (cmol/kg)                | 1.31    | 1.42      | −0.11           | 0.43   | −0.44| 8       | 0.705ns  |
| SMC (%)                     | 24.40   | 22.88     | 1.52            | 1.13   | 4.13 | 8       | 0.003**  |
| Sorghum (kg ha⁻¹)           | 2059.15 | 1881.19   | 177.96          | 181.12 | 2.95 | 8       | 0.018*   |
| Chick pea (kg ha⁻¹)         | 1441.43 | 963.85    | 470.93          | 286.61 | 4.31 | 8       | 0.003**  |

*Av. p = available phosphorous, OM (%) = organic matter, CEC = cation exchange capacity, K⁺ = available potassium, SMC (%) = soil moisture content, * = significant, ** = highly significant.
The soil in treated farmland showed significantly higher CEC than untreated farmland. The result in (Table 2) showed that the CEC in the trial field rated as very high based on the classification described by Pam and Murphy (2007). This might be the fact that bunds can protect nutrients from erosion and leaching. The result is in agreement with the study by Getnet and Quraishi (2014) and Teressa (2017), in which higher mean CEC values are found in the treated field than in untreated field.

In this study, SMC was highly significantly different among treatments with mean values of 24.4% and 22.88% for treated and untreated farmlands, respectively. Similarly, Klik et al. (2018) found that soil water content was significantly different between stone bunds and non-stone bunds with mean values of 37% and 33.5%, respectively. This could be due to the presence of significantly higher organic matter while soil nutrients improve the soil structure that affects the stocking of the soil water reserves. On the other hand, the reduced runoff velocity gives a time of opportunity for surface runoff to infiltrate into the soil.

Concerning crop production, the result showed that the grain yield of sorghum and chickpea were significantly (p ≤ 0.05) and highly significantly (p ≤ 0.01) varied between treatments (treated and untreated farmlands). The yield advantages due to stone bund intervention were 8.46% and 28.51% for sorghum and chickpea, respectively. The result is in agreement with the study by Kaliba and Rabele (2004), Mekonen and Tesfahunegn (2011) who reported as crop production has a significant positive association with SWC and the yield increment was more than 25%. A significant crop production enhancement perhaps due to improvements of OM, CEC, and SMC (Table 2) as these soil parameters commonly seen as the main indicator for soil fertility.

In contrast, Kassie et al. (2011), found that physical SWC measures resulted in lower yield in Ethiopian highlands compared to plots without conservation measures. Many researchers justified that the main reason for the negative yield impact of physical SWC practices is due to the occupation of a large proportion of productive farmland (Dabi et al., 2017). In this study, the land occupied by stone bunds has taken into account, and based on the field measurement 2.89% of the land occupied by physical structures in the study area. However, the grain yield did not certainly decrease due to land occupied by physical structures.

The results of this study inferred that stone bunds have positive impacts on most soil physicochemical properties and crop yield. However, some of the considered soil parameters were not significantly improved may be due to the age of the structure and conservation approach in general. Hence, to draw a strong inference long-term conservation impact evaluation on soil quality improvement and crop yield enhancement is needed. In addition to soil quality and production role evaluation, the ecological services of conservation practices due attention for further study.

4. Conclusion
Soil erosion is causing soil nutrient depletion and resulting in crop production loss. The stone bunds have been a significant positive role to improve soil properties and crop yield. Most of the soil's physical and chemical properties were significantly affected by inter and intra-bund positions where the highest values observed at lower bund position and deposition zones. Concerning grain yield, chickpea was significantly affected by inter and intra-bund positions where the highest yield was obtained at the middle bund and deposition structural zones. On the other hand, soil properties such as OM, CEC, and SMC were significantly higher in conserved farmland as compared to non-conserved farmland. The grain yield of sorghum and chickpea were significantly different between conserved and non-conserved farmlands. The result revealed that stone bunds have a positive role to maintain and improve soil properties and thereby production enhancement. While the yield advantages due to stone bund intervention were 8.46% and 28.51% for sorghum and chickpea, respectively.
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