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Integrated Rehabilitation Approaches to Improved the Revival of Denuded Rangeland Areas Under Semi-arid of Afar Region

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Abstract
Rehabilitation of denuded rangeland area through integrated approach was done in chifera district, zone one (Awsi Resu) of Afar Regional State. The objectives of the study were to evaluate the effectiveness of different types of soil and water conservation structures & to create awareness among the pastoralists/ agro-pastoralists on how to make soil & water conservation structure for forage production. The experimental treatments were Soil bund (SB), Stone bunds (StB), Stone faced soil bund (SFSB) & Control (C) and Experiential Design was RCBD with three replication. The study was carried out over the last three rainy seasons from 2014/15 and 2016/ 2017. Data were collected from emergence to dry matter yield within three years of the experimental period. Accordingly, the result showed as variation clearly observed among the treatments to revive the denuded rangeland area. There is a significant difference at ($P<0.05$) parameters collected in all water/soil conservation structures in each seasons. A total of 18 species of grasses, 2 species of legumes and 4 species of other herbaceous were identified in the study district. Of the grass species 12(66.7%) species were perennials and 6 (33.3%) species were annuals. Higher numbers of perennial grasses were found in soil faced stone bund (SfSb) structure as compared to control one like Cynodon dactylon, Cenchrus ciliaris, Panicum coloratum, and Chrysopogon pulmolosus are commonly found in soil faced stone bund (SfSb) structure. But mostly annual grasses were found in stone bund (Sb) & control structure like Eragrostis teniufolia, Aristida adoenesis and Tragus beteronianus. The highest dry matter production was harvested from the treatment in soil faced stone bund (SfSb) structure which was 2.5tone/ha and followed by the treatment soil bund (Sb) was 1.37tone/ha. The results also showed that pastoralists also revealed that Stone faced soil bund (SfSb) were more suitable for restoration of degraded areas. Therefore, we conclude that from this finding, stone faced soil bund (SFSB) is more effective method to rehabilitate denuded rangeland areas in semi-arid areas. However, continuous onsite training & practical demonstration was very crucial to enhance the adoption rate of conservation practices.
Keywords: Rehabilitation, soil faced stone bund, stone bund, soil bund, emergence & dry matter yield

Introduction

Rangelands are vast, complex, and diverse resource, including many ecosystems that are fragile and sensitive to disturbance. They are the center of attention for their dwellers, which have accumulated significant knowledge and experience in managing and living in conditions of uncertainty (Sidahmed, 2000). Rangelands are occupied by a large number of pastoral societies who depend on a high degree of livestock for their sustenance. These livestock, in turn, depend exclusively on native vegetation for forage, and the net primary production in these areas is highly variable over time and space. Rangelands occupy about 50% of the world's land area (Friedel *et al*., 2000) and of which more than half of these lie within tropical and sub-tropical areas (NRC, 1990). As elsewhere in the world, dry lands in Africa including Ethiopia are dominated by arid and semi arid climates characterized by low and unreliable rainfall, low soil fertility, high temperature and evapo-transpiration rates (Coppock, 1994).

The Afar Region is located in the North Eastern lowlands of Ethiopia, with the area of about 100,860 km^2 (IB-ANRS, 2000) and the topography of the region varies from hilly escarpment in the western and southern edges with an altitude of 1000-1500 m.a.s.l. to lowland plains that fall in the altitude of 0-100 m.a.s.l. Around 95% of the region has a flat landscape with altitude decreasing towards north eastern parts. More than 95% of the rural population is pure pastoralists, typically transhumant, although there are few parts of the people, which are sedentary in some pocket areas (Philpott *et al*., 2005).

The Region has a total number of 2,546,790 cattle, 2,541,920 sheep, 4,398,590 goats, 884,290 camels, 189,330 donkeys, 900 horses and 3,340 mules (CSA, 2004). The Afar pastoral communities depend on multi-species livestock production. However, camels, sheep, goats, cattle, and donkeys constitute the main productive assets of the local community. The primary feed sources for these large numbers of livestock are rangelands composed of indigenous species of grasses, shrubs and fodder trees. Most of these grass species however, are subjected to continuous threat of genetic erosion and extinction due to rangeland degradation, over grazing, undesirable plant encroachment (like *Prosopis juliflora, Parthenium hysterophorus, Calotropis procera, Tribulis terrestris, Sida ovata, Cryptostegia grandiflora* etc.) (APARI, 2005) and also *Acacia nubica* dominantly invaded the rangeland areas in Chifra district (Mohammed, 2009).

Overgrazing is the main antropic factors leading to the deterioration of the perennial plant cover. Its negative effect is excessive removal of the living parts of the high range value species, which may lead to their extinction. This factor is being more harmful when coupled with the climate aridity effect (drought). Most of the grazing areas of Afar region are exposed to overgrazing because of this the availability of animal feed decline both in quality and quantity, The rainfall pattern in the region is erratic & unpredictable, due to this most of grasses grown in the areas are annuals which stayed only for one to two months after that the vegetation become diminished. As result of this, productivity of the livestock is very low there by affecting the livelihood of the people. So to improve the revival of endanger grass species, implementation of different water conservation practices and evaluate the effectiveness is crucial for future rehabilitation work in the region.

1. Specific Objectives:-

- ✓ To Evaluate the effectiveness of different types of soil and water conservation structures
- ✓ To create awareness among the pastoralists/ agro-pastoralists on how to make soil & water conservation structure for forage production

2. Materials and methods

3.1 Description of Study area

Chifra is one of the wereda's in the Afar Region of Ethiopia & Part of the Administrative zone one (Awsi Resu) **and** climatically characterized as arid and semi-arid agro-ecological area, where livestock production is the main occupation of the community. The average temperature of the area is about 29^{o}C. The rainfall is bimodal with erratic distribution, with the long rainy season between Mid-June to Mid-September and the short rainy season occurs between March and April**.** The average annual rainfall is recorded to be between 400 and 600 mm (APARDB, 2006).

3.2 Experimental Procedures

The experiment was designed as a randomized complete block with four experimental treatments and three replications. Each treatment was established in a 50 x 25m plot area with 2-m spacing between treatments. Therefore, the blocking was aimed at minimizing the between treatment error related to variations in the slope and soil depth. The treatments were Soil bund (SB), Stone bunds (StB), Stone faced soil bund (SFSB) & Control (C). The construction techniques described by Carucci (2000) were employed for the study. All micro-basins had a planting pit and a water collection pit with different arrangements in space. The vertical interval (VI) set to be 1 meter since the intended land slope was between 3 - 5 %. The Horizontal Interval (HI) was calculated as:

$$HI = \frac{VI}{S} x100$$

Where: - HI is horizontal interval in meter
VI is vertical interval in meter
S is land slope in percentage

3.3 Materials used and data collected

3.3.1 Germination Scores

The germination of grasses assessed by randomly placing three quadrants (visual within structures) by giving the scores of (3.5 - 4= poor germination; 3-3.5= fair germination; 2= good germination; 1= excellent germination) for each plot/structure. A score was considered germinated when the radicle length was 2mm or above.

3.3.2 Basal cover

Cover assessed using quadrate (0.5m x 0.5m) by randomly placing in the structures. An area of 0.25 m^2 was selected for detailed assessment, and divided into halves. One of these was further divided into quarters, one of which divided into eighths. All grasses in the selected 0.25m^2 per plot was cut, transferred while kept together, and drawn in the eighth part to facilitate visual estimations of basal covers of living parts. The rating of basal cover was considered 'excellent' when the eighth was completely filled (12.5%) or 'very poor' when the cover was less than 3% (Baars et al. 1997). Then, each percentage multiplied by four to convert to out of 100%.

3.3.3 Herbaceous species composition

The grass species were clustered into 3-groups based on the desirability following indigenous knowledge and ecological status supported by information from literature survey. The desirability rating was based on their long-term response to grazing and palatability. Ecological status, as used here, indicates species composition classified as decreasers, increasers and invaders or pioneers as defined in Tainton (1999). Accordingly, highly desirable species included species that are decreasers and perennials with a high palatability based upon the pastoralists perceptions. The intermediate desirable species are those that increase in abundance with moderate over-utilization, and perennials, which are average or high in terms of their palatability. The less desirable species include those species that increase in abundance with severe or extremely severe over-utilization of range lands. This group includes perennial and annual species that are less palatable (Tainton, 1999).

3.3.4. Dry matter determination

The dry matter production was taken by using quadrant (0.5m X 0.5m) from each plot/structures. Four quadrants were taken from each sample plot and the herbaceous species were divided into grasses and non-grasses by hand separation. The grass species were sorted by species while the non-grass herbaceous was combined as forbs. The samples were oven-dried at 105^0C for 24 hours and weighed in order to determine the dry matter content.

3.3.5. Frequency/Diversity determination

The frequency of herbaceous species was determined by counting the species from each plots and species diversity was measured by recording the number of species (richness) and relative abundance (evenness). Shannon diversity index was used to know the diversity of the species in a given sites.

Diversity (H') = s∑i = lpilogpi

Where s = the number of species

Pi = the proportion of individuals (ni/N)

Log = log base n

3.4. Statistical Analysis and Interpretation

The data obtained from the vegetation was subjected to ANOVA using the GLM procedure of Statistical Analytical System (SAS) (2001) computer software. A significant difference was detected through ANOVA with $P \leq 0.05$ and Means will be separated by Duncan's Multiple Range Test (DMRT). Shannon-Wiener index was employed to study species diversity in each water conservation structures.

4. Result & Discussion

4.1 Herbaceous species composition

The total herbaceous species recorded in the experimental site was 24**.** These were 18 (75%) species of grasses and 6 (25%) non-grass species**.** The non-grass species comprised 2 species of legumes and 4 species of other herbaceous plants**.** Of the grass species, 12 (66.7%) species of were perennial grasses 6 (33.3%) species were Annual grasses. In the first year of research implementation, *Tribulis terrestris* commonly found in soil faced stone bund (SfSb) structure but most the remaining species are found in less quantity which was less than 10% in all water conservation structures. But in the second year/season of research implementation, *Eragrostis teniufolia,* Chrysopogon *plumolosus, Digitaria milanjana, Andropogon canaliculatus, Brachiaria eruciformis & Tribulis terrestris* were commonly found in soil faced stone bund (SfSb) structure. Among this range species *Chrysopogon plumolosus, Digitaria milanjana & Andropogon canaliculatus* were desirable grass species. Highly palatable & desirable grass species are indicators of good rangeland condition (Van de Koper and Rietkerk, 2000).

Most of desirable species were found in soil faced stone bund (SfSb) structure than the other three water conservation structures. Among desirable grass species *Panicum coloratum, Digitaria milanjana, Andropogon canaliculatus & Tetrapogon cenchriformis* were commonly found whereas in soil bund structure only Chrysopogon plumolosus was commonly found but the remaining two treatments, no range species were found commonly. Regard to highly desirable range species, *Cenchrus ciliaris, Panicum coloratum & Cenchrus pennisetiformis* were found commonly in Soil faced Stone bund (SfSb) structure in the third season of implementation period while in soil bund (Sb) structure *Panicum coloratum & Cenchrus pennisetiformis* were found commonly. This showed that SfSb & Sb structure perennial & palatable grasses were grown well as compare to others. The presence of perennial grasses may indicate that the herbaceous layer was in good condition (O‟Connor and Pickett, 1992).

Table 1:- Herbaceous Species Composition, Use Values and Relative Abundance in Different Water Conservation Structures

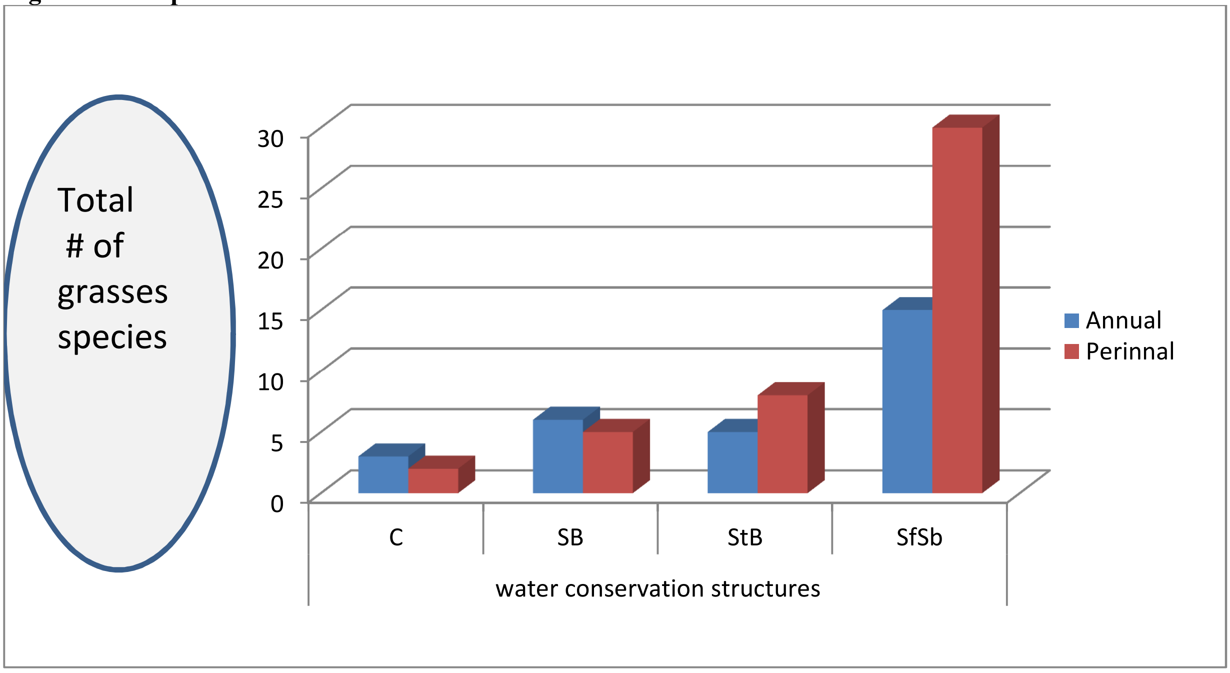
Species names	**Cg**	**Year I**				**Year II**				**Year III**			
		C	**SB**	**StB**	**SfSb**	**C**	**SB**	**StB**	**SfSb**	**C**	**SB**	**StB**	**SfSb**
Cenchrus ciliaris	HD	-	-	-	-	-	-	-	P	-	-	-	C
Dactyloctenium aegypticum	D	-	-	-	P	-	-	-	P	-	-	-	P
Eragrostis teniufolia	LD	P	P	P	P	P	P	P	C	P	P	P	C
Panicum coloratum	HD	-	-	-	-	-	P	P	P	-	C	P	C
Chrysopogon plumolosus	D	-	P	p	P	-	P	P	C		C	P	D
Aristida adoenesis	LD	-	-	-	P	P	P	-	P	P	P	P	C
Cynodon dactylon	HD	-	-	-	P	-	-	-	P		P		P
Tragus beteronianus	UD	-	P	-	P	-	-	P	P		C	P	D
Digitaria milanjana	D	-	P	P	P	-	-	-	C	-	-	-	C
Andropogon canaliculatus	D	-	-	-	-	-	P	P	C		P	P	C
Tetrapogon cenchriformis	D	P	P	P	P	P	P	-	P	-	P	P	C
Brachiaria eruciformis	UD	-	-	-	P	-	-	-	C	P	-	-	C
Cenchrus pennisetiformis	HD	-	-	-	P	-	P	P	P	-	C	p	C
Chloris prieurii	LD	-	-	-	P	-	-	-	P	-	-	-	P
Eleusine multifolia	LD	-	-	-	P	-	-	-	P	-	P	-	C
Brachiaria sp	UD	-	-	-	P	-	-	-	-	-	-	-	P
Lintonia nutans	LD	-	-	-	-	-	-	-	-	-	-	-	P
Teterapogon vilosus	HD	-	-	-	-	-	-	P	P	-	P	P	C
Indigofera spinosa (LG)	LD	-	P	-	P		P	-	P	-	P	-	P
Crotalaria incana (LG)	D	-	-	-				-	P	-	-	-	P
Sida ovata (others/forbs)	LD	P	P	P	P	P	P	P	P	P	P	P	P
Tribulis terrestris (others/forbs)	LD	P	-	P	C	P	-	P	C	P	-	P	C
Blephris ciliaris (others/forbs)	LD	P	P	-	P	P	P	-	P	P	P	-	P
Achyranthus aspera (others/forbs)	LD	-	-	-	P	-	-	-	P	-	-	-	P

Remark: Cg = Categories; HD = Highly desirable; D = Desirable; LD = Less desirable; UD = Undesirable; LG; Legumes, D = Dominant (>20%); C = Common (10-20%); P = Present (<10% of the total herbaceous plant) and - = Absent.

4.2 Life form

Higher numbers of perennial grasses were found on Soil faced Stone bund (SfSb) structure as compare to other structures like *Cenchrus ciliaris, Panicum coloratum, Andropogon canaliculatus, Chrysopogon plumolosus & Tetrapogon cenchriformis* are found in SfSb structure. While stone bund structure also perennial grasses are higher than annual grasses. The Annual grass species which commonly found in stone bund structure like *Cenchrus pennisetiformis*, *Andropogon canaliculatus, Chrysopogon plumolosus & Tetrapogon cenchriformis*. This clearly indicated that the SfSb & Stone bund are created favorable environment for the re-growth of perennial grasses. But in control & soil bund structure, annual grasses were higher in number than perennial grasses. The annual grasses were grown in the above two treatment areas (control & soil bund structure) like *Eragrostis teniufolia & Aristida adoenesis.* It is better to keep in mind the influence of grazing on the plant life form as species may vary significantly in their acceptability to grazing herbivores, not only due to differences in palatability, but also due to phenological differences (e.g. rhizomatous, stoloniferous or tall tufted grasses); grass species composition is an important rangeland condition indicator, (Smit, 1994; Snyman, 1998; Solomon, 2003).

Figure 1: Comparison of life forms on different Structures



4.3 Effect of Treatments on Germination (scores), Basal cover (%), Species Composition & Dry matter yield (ton/ha) during the first season of Implementation Period

Variations of Germination, basal cover, species composition and dry matter yield were observed among treatments during the first season of implementation year. High germination score was observed in two different treatments which were in soil bund & the soil faced stone bund area significantly difference at ($P<0.05$) than the other treatments. In case of Basal cover & species composition, soil faced stone bunds was significantly difference at ($P<0.01$) than other treatments. In soil faced stone bund structure, the basal cover & species composition were highest number compare to other treatments which were 71.9% & 10.0 respectively while basal cover the lowest number scored in control treatment (15.3) but in species composition the remaining three treatments which are stone bund, soil bund & control were no significant difference at ($p>0.05$).

Dry matter yield was significantly highest at ($P<0.001$) in soil faced stone bund structure. Dry matter yield in stone faced soil bud during first year trial was 1.83ton/ha, In soil bund structure, the dry matter yield was 0.75ton/ha but the lowest dry matter yield was record in control one which was 0.05ton/ha. This might be due to moisture stay long time in soil faced stone bund relatively than other treatments. These result coincide with Descheemaeker *et al*. 2009, revealed that water harvesting structures are essential to improve water availability for longer periods, thereby contributing to better survival and growth.

Table 2: ANOVA (LSM and SE) of Different Parameters in Rehabilitation Area in 1st Year of Implementation

R. No	Treatments	Year (2007 E.C)			
		*Germination (scores)	Cover (%)	Species composition	Dry matter yield (ton/ha)
1	Control	3.53 ± 0.19^{b}	15.3 ± 5.1^{c}	2.33 ± 0.8^{b}	0.05 ± 0.0^{d}
2	Soil bunds(SB)	2.66 ± 0.198^{a}	39.8 ± 5.1^{b}	5.3 ± 0.88^{b}	0.75 ± 0.02^{b}
3	Stone bunds (StB)	3.2 ± 0.2^{b}	47.2 ± 5.1^{b}	3.3 ± 0.9^{b}	0.54 ± 0.03^{c}
4	Soil faced stone bunds(SfSb)	2.33 ± 0.18^{a}	71.9 ± 5.1^{a}	10.0 ± 0.88^{a}	1.83 ± 0.033^{a}
	P-value	0.05	0.01	0.01	0.001

- ✓ $^{a-d}$ means with different superscripts letters along column differ significantly ($p<0.05$)
- ✓ *Germination (3.5-4= poor; 3-3.5= fair; 2= good; 1= excellent)

4.4 Effect of Treatments on Germination (scores), Basal cover (%), Species composition & Dry matter yield (ton/ha) during the second season of Implementation Period

Germination score, basal cover, species composition and dry matter yield were significantly difference among treatments during the second season of implementation year. High germination score was observed in two different treatments which were in soil bund & the soil faced stone bund area significantly difference at ($P<0.05$) than the remaining two treatments. But in soil bund & soil faced stone bud structure, there was no significant difference at (P>0.05). The highest scored in soil faced stone bund was 1.95 & in soil bund structure also 2.23.

In case of Basal cover & species composition, soil faced stone bunds was significantly difference at (P<0.05) than other treatments. In soil faced stone bund structure, the basal cover & species composition were highest number compare to other treatments which were 75.5% & 13.3 respectively while basal cover the lowest number scored in control treatment (17.53%) but in species composition the remaining two treatments which are stone bund & control were no significant difference at (p>0.05). Dry matter yield was significantly highest at (P<0.05) in soil faced stone bund structure. Dry matter yield in stone faced soil bud during second year trial was 2.09ton/ha, In soil bund structure, the dry matter yield was 1.04ton/ha but the lowest dry matter yield was record in control one which was 0.06ton/ha. This finding is in line with the results of Gallacher and Hill (2006).

Table 3: ANOVA (LSM and SE) of Different Parameters in Rehabilitation Area in 2nd Year of Implementation

R. No	Treatments	Year (2008 E.C)			
		*Germination (scores)	Cover (%)	Species composition	Dry matter yield (ton/ha)
1	Control	3.50±0.15^{b}	17.53±5.15^{c}	2.66±0.5^{c}	0.06±0.0^{d}
2	Soil bunds(SB)	2.23±0.15^{a}	43.46±5.15^{b}	7.33±0.50^{b}	1.04±0.025^{b}
3	Stone bunds(StB)	3.1±0.2^{b}	50.8 ±5.15^{b}	3.67±0.51^{c}	0.74±0.06^{c}
4	Soil faced stone bunds (SfSb)	1.95±0.152^{a}	75.5±5.15^{a}	13.3±0.509^{a}	2.09±0.1^{a}
	P-value	0.01	0.01	0.01	0.001

- ✓ $^{a-d}$ means with different superscripts letters along column differ significantly (p<0.05)
- ✓ *Germination (3.5-4= poor; 3-3.5= fair;2= good; 1= excellent)

4.5. Effect of Treatments on Germination (scores), Basal cover (%), Species composition & Dry matter yield (ton/ha) during the third season of Implementation Period

High germination score was observed in soil faced stone bund structure, significantly difference at (P<0.05) than the remaining three treatments while soil bund structure, also significant difference at (P<0.05) than the remaining two structure in germination score but the remaining two structures/treatments which are stone bund & control, there was no significant difference at (P<0.05). The highest scored in soil faced stone bund was 1.58 & followed by soil bund structure which was 2.01.

In Basal cover & species composition, soil faced stone bunds was significantly difference at (P<0.05) than other three treatments. In soil faced stone bund structure, the basal cover & species composition were highest number compare to other three treatments which were 77.1% & 17.33 respectively while basal cover the lowest number recorded in control treatment (19.06%) but in basal cover parameter the remaining two treatments which are stone bund & soil bund were no significant difference at (p<0.05). In species composition, all treatments were significantly difference at (P<0.05). In dry matter yield was significantly difference at (P<0.05) in all treatments/structures. The highest score was recorded in soil faced stone bund structure, which was 2.5ton/ha while the lowest score was recorded in control one which was 0.08ton/ha. This result coincide with Ouled Belgacern *et al.* (2006), who confirmed that in the protected (enclosure) areas perennial grasses were increased as compared to overgrazed areas.

Table 4: ANOVA (LSM and SE) of Different Parameters in Rehabilitation Area in 3rd Year of Implementation

R. No	Treatments	Year (2009 E.C)			
		*Germination (scores)	Cover (%)	Species composition	Dry matter yield (ton/ha)
1	Control	3.37±0.1^{c}	19.06±5.592^{c}	2.66±0.3^{d}	0.08±0.0^{d}
2	Soil bunds(SB)	2.01±0.137^{b}	46.2±5.592^{b}	8.33±0.4^{b}	1.37±0.03^{b}
3	Stone bunds (StB)	3.03±0.14^{c}	53.1±5.592^{b}	4.66±0.39^{c}	0.87±0.05^{c}
4	Soil faced stone bunds (SfSb)	1.58±0.14^{a}	77.1±5.592^{a}	17.33±0.385^{a}	2.5±0.1^{a}
	P-value	0.001	0.01	0.01	0.001

- ✓ $^{a-d}$ means with different superscripts letters along column differ significantly (p<0.05)
- ✓ *Germination (3.5-4= poor; 3-3.5= fair;2= good; 1= excellent)

4.6. Effect of Treatments on Germination (scores) during the whole Implementation periods

There was significant difference at (P<0.05) in soil faced stone bund structures in the whole implementation periods in germination. The highest germination score was observed in the third year of implementation time which was 1.58 while the lowest germination score was observed in the first year of implementation period which was 2.33.

In soil bund structure also there was significant difference at (P<0.05) in the whole implementation periods in germination. The highest germination score was observed in the third year of implementation time which was 2.01 while the lowest germination score was observed in the first year of implementation period which was 2.66 but in stone bund & control treatments/structures, there were no any significant difference at (P>0.05) in the whole implementation periods in case of germination score. At time goes, the seeds inside the soil increased & easily germinate without any difficulty. These findings also concede with Mohammed *et al,* 2009.

Table 5: ANOVA (LSM and SE) of Germination (scores) in Rehabilitation Area within the Consecutive Implementation Years

Treatments	1st year (2007 E.C)	2nd year (2008 E.C)	3rd year (2009 E.C)	P-value
Control	3.59 ± 0.19^{a}	3.5 ± 0.15^{a}	3.37 ± 0.1^{a}	No
Soil bunds(SB)	2.66 ± 0.198^{c}	2.21 ± 0.15^{b}	2.01 ± 0.137^{a}	0.05
Stone bunds(StB)	3.2 ± 0.2^{a}	3.1 ± 0.2^{a}	3.03 ± 0.14^{a}	No
Soil faced stone bunds (SfSb)	2.33 ± 0.18^{c}	1.95 ± 0.152^{b}	1.58 ± 0.14^{a}	0.05

✓ a-c means with different superscripts letters along row differ significantly (p<0.05)

4.7. Effect of Treatments on Basal cover during the whole Implementation periods

In soil faced stone bund structures there was significant difference at (P<0.05) in the whole implementation periods in Basal cover. The highest basal cover was observed in the third year of implementation time which was 77.2 while the lowest basal cover was observed in the first year of implementation period which was 71.93. In soil bund structure also, there was significant difference at (P<0.05) in the whole implementation periods in Basal cover. The highest basal cover was recorded in the third year of implementation time which was 46.2 while the lowest basal cover was recorded in the first year of implementation period which was 39.8.

In case of stone bund & control one, there was a significant difference at (P<0.05) in Basal cover percentage in third and/or second year s implementation periods with first year implementation period but there was no any significant difference at (P>0.05) in between the third & second year implementation period basal cover percentage. The basal cover of individual species varied considerably between grazed & protected area while the time goes. Similarly, Vogel & Van dyne (1996) found that nether moderate grazing nor complete protection from grazing caused a significant change in total basal cover.

Table 6: ANOVA (LSM and SE) of Basal Cover (%) in Rehabilitation Area within the Consecutive Implementation Years

Treatments	1st year (2007 E.C)	2nd year (2008 E.C)	3rd year (2009 E.C)	P-value
Control	15.3 ± 0.54^{b}	17.5 ± 0.53^{a}	19.0 ± 0.5^{a}	0.05
Soil bunds(SB)	39.8 ± 0.61^{c}	43.4 ± 0.6^{b}	46.2 ± 0.62^{a}	0.01
Stone bunds(StB)	47.2 ± 0.62^{b}	50.8 ± 0.61^{a}	53.1 ± 0.6^{a}	0.01
Soil faced stone bunds (SfSb)	71.93 ± 0.33^{c}	75.5 ± 0.32^{b}	77.2 ± 0.3^{a}	0.001

✓ a-c means with different superscripts letters along row differ significantly (p<0.05)

4.8. Effect of Treatments on Species composition during the whole Implementation periods

In soil faced stone bund structures there was significant difference at (P<0.05) in the whole implementation periods in species composition. The highest species composition was observed in the third year of implementation time which was 17.3 while the lowest species composition was observed in the first year of implementation period which was 10.0. In soil bund structure, there was a significant difference at (P<0.05) in species composition in third and/or second years implementation periods with first year implementation period but there was no any significant difference at (P>0.05) in between the third & second year implementation period species composition.

In case of stone bund structure, there was a significant difference at (P<0.05) in species composition in second and/or first year implementation periods with third year implementation period but there was no any significant difference at (P>0.05) in between the second & first year implementation period in species composition while in control one, there was no any significant difference at (P>0.05) in species composition the whole implementation periods. The results of this study further demonstrated that, proper management like resting would help, the range sites re-bounce (recover) easily which is in agreement to reports of Ould Sidi et al. (2002); Gallacher and Hill(2006); Azaiez et al. (2008).

Table 7: ANOVA (LSM and SE) of Species composition in Rehabilitation Area within the Consecutive Implementation Years

Treatments	1st year (2007 E.C)	2nd year (2008 E.C)	3rd year (2009 E.C)	P-value
Control	2.3 ± 0.19^{a}	2.6 ± 0.193^{a}	2.7 ± 0.2^{a}	No
Soil bunds(SB)	5.3 ± 0.33^{b}	7.3 ± 0.333^{a}	8.3 ± 0.3^{a}	0.01
Stone bunds(StB)	3.3 ± 0.1^{b}	3.67 ± 0.19^{b}	4.67 ± 0.2^{a}	0.05
Soil faced stone bunds (SfSb)	10.0 ± 0.608^{c}	13.3 ± 0.61^{b}	17.3 ± 0.6^{a}	0.01

✓ a-c means with different superscripts letters along row differ significantly (p<0.05)

4.9. Effect of Treatments on dry matter yield during the whole implementation periods

In soil faced stone bund structures there was significant difference at (P<0.05) in the whole implementation periods in dry matter yield. The highest dry matter yield was observed in the third year of implementation time which was 2.5ton/ha while the lowest dry matter yield was observed in the first year of implementation period which was 1.82ton/ha. In soil bund structure, there was significant difference at (P<0.05) in the whole implementation periods in dry matter yield. The highest dry matter yield was observed in the third year of implementation time which was 1.37ton/ha while the lowest dry matter yield was observed in the first year of implementation period which was 0.75ton/ha.

In case of stone bund structure, there was a significant difference at (P<0.05) in the whole implementation periods in dry matter yield. The highest dry matter yield was observed in the third year of implementation time which was 0.86ton/ha while the lowest dry matter yield was observed in the first year of implementation period which was 0.54ton/ha. In control one, there was significant difference at (P<0.05) in the whole implementation periods in dry matter yield. The highest dry matter yield was observed in the third year of implementation time which was 0.08ton/ha while the lowest dry matter yield was observed in the first year of implementation period which was 0.05ton/ha. The results of this study further demonstrated that, proper management like resting would help, the range sites re-bounce (recover) easily which is in agreement to reports of Ould Sidi et al. (2002); Gallacher and Hill(2006); Azaiez et al. (2008). The degree of grazing strongly affects the structure, composition, quality and productivity of rangeland vegetation (Herlocker, 1999). This phenomenon is likely to occur where a concentration of large herds of livestock in relatively smaller areas may lead to overgrazing, trampling and hindrance to vegetation regeneration (ASAL, 1998).

Table 8: ANOVA (LSM and SE) of Dry Matter Yield (ton/ha) in Rehabilitation Area within the Consecutive Implementation Years

Treatments	1st year (2007 E.C)	2nd year (2008 E.C)	3rd year (2009 E.C)	P-value
Control	0.05 ± 0.0^{c}	0.06 ± 0.00^{b}	0.08 ± 0.002^{a}	0.01
Soil bunds(SB)	0.75 ± 0.02^{c}	1.04 ± 0.025^{b}	1.37 ± 0.03^{a}	0.01
Stone bunds(StB)	0.54 ± 0.1^{c}	0.74 ± 0.18^{b}	0.86 ± 0.02^{a}	0.01
Soil faced stone bunds (SfSb)	1.82 ± 0.0^{c}	2.09 ± 0.03^{b}	2.5 ± 0.031^{a}	0.01

✓ a-c means with different superscripts letters along row differ significantly (p<0.05)

4.10. Species Diversity among Different Water Conservation Structures

Relatively higher Shannon-Wiener diversity index was found on the soil faces stone bund structure in all seasons of implementation periods. The lower species diversity index had found in control treatment of all implementation periods. Species richness had a similar pattern of species diversity the probable reason for such decrement in species diversity and richness in control & stone bund may be limited time span of moisture stayed in the structures.

Generally, the result imply that control & stone bund structure has limited number in species diversity while soil faced stone bund & soil bund structures has relatively good in species diversity. Farther more, minimal number of range species were found in stone bund structures while in soil faced stone bund structure, the number of range species were maximum. The total species diversity, richness and evenness in soil faced stone bund structure as calculated by the availability, density & abundance of rangeland species was 2.83, 18 and 0.95 respectively. Species richness, diversity (H′) and evenness (E) of the standing vegetations was higher in soil faced stone bund structure.

Table 9 Species diversity (H'), Richness (S) and Evenness (E) of the Rehabilitated Areas with Different Water Conservation Practices

Implementation year	Treatments	H	S	E
1st year	Control	0.68	2	0.82
	SB	1.59	5	0.90
	StB	1.37	4	0.86
	SFSB	2.49	13	0.92
2nd year	Control	1.08	3	0.84
	SB	1.99	8	0.91
	StB	1.38	4	0.88
	SFSB	2.63	15	0.93
3rd year	Control	1.09	3	0.86
	SB	2.12	9	0.92
	StB	1.58	5	0.90
	SFSB	2.83	18	0.95

5. Conclusion & Recommendation

5.1. Conclusion

Generally, from this finding we concluded that the three soil/water harvesting structures have been improved range species composition, basal cover & biomass/dry matter yield production compared with the control one. Soil faced stone bund structure showed better performance in dry matter production than the remaining two structures (soil bund & stone bund). The higher dry matter production was harvested from the treatment Stone faced soil bund (SFSB) which was 2.5tone/ha and followed by the treatment Soil bund bunds (StB) which was 1.37tone/ha. The results also showed that pastoralists also revealed that Stone faced soil bund (SFSB) were more suitable for restoration of degraded areas. Therefore, we conclude that from this finding, stone faced soil bund (SFSB) is more effective method to rehabilitate denuded rangeland areas in semi-arid areas. However, continuous onsite training & practical demonstration was very crucial to enhance the adoption rate of conservation practices.

5.2. Recommendation

The following recommendations were derived from the data of the study and the observations during experimentation period.

- Verification of the best suitable water conservation structure in order to scale up the technology
- Continues awareness rising to the community about the best suit water conservation structure to the area
- Further researcher needs in steeply slop rangeland areas

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