Participatory Demonstration and Evaluation of Integrated Maize-Forage Production and Soil Conservation through Forage Legumes under Sowing and Grass Strips on Soil Bunds

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Abstract
Dire dawa and Harari are one of the area that are subjected to soil erosion and require immediate soil and water conservation measure. To implement this activity, farmlands that are prone to soil erosion was selected in the study area in close collaboration with DAs and farmers. Two FRGs consisting three trial farmers at Harari and two FRGs, with 6 trial farmers at Dire Dawa were established respectively. The trial was conducted following the procedure of RCBD on three farmers' fields at each site where farmers are used as replication. Soil bunds extending 20m across contour were constructed on each farm of three farmers at Harari and dire dawa respectively. The design of structure was based on the slope of the land which encompasses bund height 70cm and bund width 50cm to protect over toping of flood and increases water retention in the soil. Training was given and farmers, DA's, and woreda experts were participated. Farmers appreciate the integrated physical and biological soil and water conservation measures in terms of design, space and highest. Result indicated that, maize yield, fresh weight of elephant grass, pigeon pea and maize stock biomass data shows an increasing trend across the year. Soil laboratory analysis also shows an increasing trends across yrears especially in the terms of organic matter, available p and total nitrogen. Because of the good bund spacing, and well stabilized soil bund both maize grain and fresh elephant grass and pigeon pea biomass shows an increasing trend across the year.
Keywords: Soil bund, Elephant grass, Pigeon pea, Dire Dawa and Harari Districts.
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1. Introduction

Low productivity of crops due to soil fertility depletion and livestock feed shortage are among the major factors limiting agricultural production in eastern Ethiopia. In the region, because of the undulating topography and low vegetation cover, vast areas of farmland are suffering soil degradation. The problem of soil degradation is exacerbated by deforestation, continuous cropping, crop residue removal, and soil pulverization to create fine seedbed. Particularly important in this respect is the decrease in soil organic matter which is the basis for soil fertility in agricultural systems due to its multiple physical, chemical, and biological functions. In addition, shortage of feed is the key limiting factor for livestock production in the region, and the possibility of producing forage as sole cropping is impractical due to severe shortage of land. As a result, livestock are mostly fed with crop residues. This practice, on top of depleting soil fertility, it supplies livestock with low nutrients and results in low productivity. Hence, to improve the nutritive value residues it is important to supplement with forage legumes as fresh or conserved hay. Apart from their feed values, forage legumes fix atmospheric nitrogen and improve soil fertility. Hence, the shortage of feed could be alleviated through integrating forage production with the existing cropping system. On the other hand, to conserve soil and moisture, farmers usually construct soil bunds along the contour on the farm land. The ever-increasing land use change is aggravating the rates of soil erosion, soil fertility reduction, crop yield decline, and food insecurity (Haregeweyn et al., 2005; Tsegaye et al., 2012).To combat land degradation at a national level, environmental conservation and land rehabilitation effort was started in 1970 s, with a particular focus on the construction of physical structures (bunds, terraces etc.) in the fast deteriorating highland areas of Ethiopia (Abinet, 2011). The intention of these efforts is to reduce soil erosion, restore soil fertility, rehabilitate lands, improve microclimate, and boost agricultural production and productivity. Integration of biological practices with physical structures is highly contributed for the improvement soil fertility and crop production (Abay, 2011; Zenebe et al., 2013). Biological practices are enhancing the overall and cheaper than physical structures, compassionate to rehabilitation lands, protect land from further degradation, and stabilize physical structural for long period (Abinet, 2011; Terefe 2011).Therefore, there is high possibility of integrating food and forage crops production, and soil and water conservation practices to alleviate feed shortage and improve productivity of soil. In this innovation, forage legumes (pigeon pea) is sown under maize in between the soil bunds and grass (elephant grass) is planted on the soil bunds along the contour.

Objectives of the study
General objective
✓ To improve productivity of land and livestock through the integrated conservation and farm management

Specific objectives
✓ To demonstrate integrated maize-forage production, and practices of soil and water conservation practices
✓ To improve soil fertility through the biological and physical conservation practices.

Materials and Methods
2.1 Description of the study area
This participatory evaluation and demonstration of integrated physical and biological soil and water conservation technology was conducted in (Agricultural Growth Program-II) nationally selected districts of Dire Dawa administration and Harari Region. Dire Dawa Administration is located on distance of 515km from capital city Fin fine in direction of county's Eastern part; it is bordered by Somali, and Oromia regions in all directions. Dire Dawa Administration has both urban and rural set governance system. The climatic condition of Dire Dawa is almost dry land with the maximum and minimum temperature 38^{0c} and 25^{0c} respectively (TVO broadcasting on metrology allocated time). Harari regional state is located on distance of 526 kms from capital city Finfine in direction of country's eastern part; it is all in all bordered by Oromia region and hosts one capital town of Oromia Regional state's zone that is East Hararghe. The climatic condition of the region includes highland, midland and lowland; the soil type exist in the region is different in different ecologies of the region that is clay, loam, sandy and black vertysol types. These selected districts where the potentiality of the program will be succeeded in consideration of residents' problems, potential succession of the technologies these fit problems and solve; including the outcomes prevailed in AGP-I.

Site and farmer's selection
To implement this activity, farmlands that are prone to soil erosion was selected in the study area in close collaboration with DAs and farmers. Dire Dawa administration and Harari regional district were purposively selected by AGP-II nationally. PAs were selected purposively based on the potentiality, appropriateness of the area by considering lodging, slope land escape, access to road, suit for repeatable monitoring and evaluation in progress of sowing to harvesting. One district from Harari region (Sofi) and two district from Dire Dawa administration (Wahile and biyo awale) selected by AGPII. Kile from Sofi were selected purposively. Farmers Were selected purposively based on their interest, innovation he/she has, land provision for this participatory evaluation and demonstration, interest in cost-sharing, willingness to share experiences for other farmers, and studying their profile with the participation of DAs and community leaders. The selected farmers were grouped in form of Farmers Research Group (FRG) with the member of 15 farmers per PAs in consideration of gender issues (women, men and youth). In the form of establishing FRG in each two study areas total of 4 FRGs (FRG/ PAs-from one PA 15 farmers and a total of 60 farmers were grouped in 4 FRG). In the FRG 4 farmers was trial farmers per PAs (3 male trial farmers and 2 female trial farmers) and 10 farmers will work with trial farmers.

Table 1: Summary of selected site and farmers with area coverage of the experiment

Measures	Farmers(NO of FRG)		Area Coverage (m^2)
	Total established	4	
Soil bund (daaga biyyoo)	2, at Dire Dawa	2, at Harar	10mx20 m for each plot
Grass for stabilization Pigeon pea for soil nutrient replenishment		Over bund	60cm width and 70cm height of bund and extending 20m for each (the L of one bund.

Table 2: Summary of selected site and farmers with area coverage of the experiment

District	Pas	No. of trial farmers	FTCs	Area covered
Dire Dawa	Wahil	3	1	20mx 10m for each plots
Sofi	Kile	4	1	
Biyo awale	Adada1	**4**	**1**	
	Total	11	3	

Technology evaluation and demonstration methods/technique.
Participatory evaluation and demonstration of the trial was implemented on farmers' fields to create awareness about the integrated soil and water conservation. The evaluation and demonstration of the trials were followed process of demonstration approach by involving FRGs, development agents and experts at Different growth stage

of the crop and during construction of soil bund. The activity was jointly monitored by FRGs, researchers, experts and development agents.

Data Collection.

Both quantitative and qualitative data were collected through personal field observation, individual interview, Focus Group Discussion by using checklist and data sheet tools. Types of collected quantitative data were number of farmers participated in FRG, grain and biomass yield performance, number of stakeholders participated in training and field days while qualitative data were farmers' perception toward the new technology, awareness created and farmers' technology selection criteria.

Data analysis.

Quantitative data was summarized using simple descriptive statistics (Mean, average, Frequency and Percentage) while the qualitative data collected using group discussion and key informant interviews, field observation and oral histories was analyzed using narrative explanation or PRA (Participatory Rural Appraisal) tools and argument. Finally, data from different sources was triangulated to get reliable information.

Soil analysis

Soil samples before and after were collected and taken to ziway and Bedele soil laboratory and physical and chemical parameter was analyzed.

Table 3 . Soil data of 2016 and 2017

No	Experimental site	Parameters						
		PH H2o(1:2.5)	EC Mmhos/cm	CEC meq/ 100g	Av.p(ppm)	Total nitrogen	Total carbon result %	%OM
	site1	8.01	0.202	41.15	29.18	0.04	0.99	1.71
	site2	7.57	0.500	55.682	24.13	0.028	1.65	2.84
	site3	8.32	0.391	42.452	4.23	0.057	1.56	2.68
	site4	8.740	0.412	44.14	6.10	0.07	1.10	2.03
	site5	8.95	0.449	43.648	11.17	0.04	0.79	1.71
	site6	8.55	0.177	39.73	0.33	0.042	1.03	1.78

Table 4.Soil data of 2018

No	Experimental site	Parameters						
		PH H2o(1:2.5)	EC mhos/cm	CEC meq/ 100g	Av.p(ppm)	Total nitrogen	Total carbon result %	%OM
	site1	8.01	0.202	22.15	29.18	0.071	1.09	1.88
	site2	7.57	0.500	25.682	24.13	0.088	1.95	3.37
	site3	7.32	0.391	28.452	4.23	0.097	1.86	3.21
	site4	8.740	0.412	34.14	6.10	0.087	1.18	2.04
	site5	7.150	0.449	31.648	11.17	0.094	0.99	1.71
	site6	7.55	0.177	39.73	0.33	0.092	2.03	3.51

According to the table above, soil parameter analysis shows an increasing trend especially in terms of, total nitrogen, organic matter and to some extent available p which are the indicator of soil fertility improvement. This finding is also agree with

Mulugeta and Karl (2010) who are reported that the land with physical SWC measures have high total nitrogen as compared to the non-conserved land. This result also coincides with Million (2003) found that the mean total N content of the terraced site were higher than the average total N contents in the corresponding non-terraced/conserved sites.

Design of implementation.

The trials for evaluation and demonstration of improved integrated maize-forage production and soil conservation were implemented on the farmers' fields in the target areas. The trial was conducted following the procedure of RCBD on three farmers' fields at each site where farmers are used as replication. Soil bunds extending 20m across contour were constructed on each farm of three farmers at Harari and dire dawa respectively. The design of structure was based on the slope of the land which encompasses bund height 70cm and bund width 50cm to protect over toping of flood and increases water retention in the soil. Elephant grass (cita in local language) on is planted on the structures for the stabilization purpose. Besides stabilize the structure, grass is provided as fodder for livestock and improving soil fertility. Maize sown between the grass strips (soil bunds) and the legumes (pigeon pea) under sown at 3-4 leaf stage of maize. Distance between the strips was kept at 6 m wide. The grass planted densely at 15 cm between slips at start of the rainy season for better establishment. The alleys between the strips is equally divided into 3 parts (plots) planted to the legumes along with control. The evaluation and demonstration was followed process of demonstration approach by involving FRG farmers as well as other stakeholders. The activity was monitored jointly and followed up by FRG farmers, researchers, district experts and development agents.

Result and discussion.

Two FRGs consisting three trial farmers at Harari and two FRGs, with 6 trial farmers at Dire Dawa were established respectively. The trial was conducted following the procedure of RCBD on three farmers' fields at each site where farmers are used as replication. Soil bunds extending 20m across contour were constructed on each farm of three farmers at Harari and dire dawa respectively. The design of structure was based on the slope of the land which encompasses bund height 70cm and bund width 50cm to protect over toping of flood and increases water retention in the soil.Training was given at both Harari and Dire Dawa and Farmers, woreda's experts DA's, and management officials were participated. Farmers appreciate the technology and decide to practice it and some of them are already started it. This training mainly based on the importance of technology (land saving, increases production and productivity of both land and livestock), construction of the soil bund, spacing, height etc. Mini filed day was organized and local community; Das, Management officials and woreda's experts were participating and share the experience.

Table 5. Yield and biomass data of maize and forage at both dire dawa harari 2016

No	Site Name	Average Maize yield (kg/ha)	Maize Stockkg/ha	Average Eg(Kg/ha)	Avrg Fresh ppbiom(kg/ha)	Pa's
1	Adada1	3375	1950	15000	7200	PA1 Dire D
2	wahil	2250	1850	12000	8400	PA2DireD
3	kile	1716.6	1150	19200	9000	**PA1Harari**
4	Average	**2447.2**	**1650**	15,400	8200	

The variation in both grain yield and biomass data are mainly due to soil textural distribution and pervious soil fertility level. The highest record for both grain and biomass yield of maize was taken from site1 (adad1). This is deuto the exesistance of previous good soil depth and fertility status of the filed. The lowest yelied was recorded from 2nd site. This is because of shallow soil depth and also to some extent the availability of termite

Summary of yield and biomass data of planting year 2017

Table 6. Grain and fresh weight biomass yield data at Harari.

No	PA's and kebeles.	grain yield of maize(kg/ha)	Maize stock(kg/ha)	Average biomass of elephant grass(kg)/ha	Average biomass of pigeon pea(kg)/ha	Site name
1	PA#1	28000	2543	19800	10,200	kile
2	PA #2	3,466.7	1550	18,900	8880	Ada1
3	PA#3	3,133.4	2900	11220	9780	wahil
4	**Average**	**3311.13**	**2331**	**6150**	**9620**	

According to the table 2 highest Maize grain yield per hektar, average fresh weight of elephant grass and fresh weight of pigeon pea biomass was collected from PA1 and the lowest data was collected from the 3thrd PA.This variation of data from PA to PA is because of the soil textural distribution and water holding capacity of soil. Water holding capacity, improved soil aggregation, stabilized soil bund and good bund spacing, are the main factor an increment of both grain and biomass yield. The highest record for both grain and biomass yield of maize was taken from Dire Dawa PAs. This is because of the degree of soil excavation/disturbance of soil during bund construction in the field and the extent to which the bund is maintained or stabilized and conserve the necessary amount of moisture. It also depends on the initial soil depth. On the other hand, the lowest yelied was recorded from Harari PAs. This is because of soil textural distribution that affect water holding capacity and also the degree that soil aggregation is improved.

Table 7. Maize yield and forage biomass data at both harari and dire dawa2018

No	Site Name	Average Maize yield (kg/ha)	Maize Stock (kg/ha)	Average Eg(Kg/ha)	Avrge Fresh ppbiom(kg/ha)	Pa's
1	Adada1	3975	2588	20,400	12000	PA1 Dire D
2	wahil	3817	2383	19200	14400	PA2DireD
3	kile	3633	5556	21,000	15000	PA1Harari
4	Average	**3808.66**	**3509**	**20200**	**13800**	

According to the collected data, the highest maize yield and fresh biomass data of animal feed was obtained at dire dawa location. But at kile, the highest elephant grass fresh weight biomass and pigeon pea fresh weight biomass was recorded. This is because of well stabilized soil bund and good bund width and height. Thus why, both maize grain and fresh weight biomass of elephant grass and pigeon pea shows an increasing pattern.

Table 8. The strengthened FRG in 2017

Two FRGs consisting three trial farmers at Harari and two FRGs, with three trial farmers at Dire Dawa were established respectively.

No	List of activities	AGPII districts		Number of FRG strengthened			
1	Participatory Demonstration and Evaluation of Integrated Maize-Forage Production and Soil Conservation through Forage.	Harari(sofi)	This Quarter		Up to date		
			M	F	M	F	
			-	-	30	15	
		Dire Dawa(wahil)	-	-	20	5	
2	Total	2			50	20	

Table 9. The newly established FRG in 2017

No	List of activities	number of FRGs established in 2017				
1	Participatory Demonstration and Evaluation of Integrated Maize-Forage Production and Soil Conservation through Forage.	AGPII districts	Number of FRG strengthened			
			This Quarter		Up to date	
			M	F	M	F
		Dire Dawa) wahil)	-	-	20	5
2	Total	1	-	-	45	

Training

Training was given at both Harari and Dire Dawa and Farmers, woreda's experts, DA's, and Dire Dawa management officials were participated. This training mainly based on the importance of technology (moisture and soil conservation, land saving, increases production and productivity of both land and livestock), construction of the soil bund, spacing, height etc. Farmers appreciate the technology and decide to practice it and some of them who are outside of established FRG's already started to practice it. Farmers appreciate the technology in terms of land saving, animal feed provision and decided to implement it in a **large scale** on their own farm land. Mini filed day was organized and local community; DAs, Management officials and woreda's experts were also participated and share the experience.

Generally, this training encompasses the following objective;

Create awareness about:

❖ The importance of integrated maize-forage production, and soil and water conservation practices on the same land.

Combining of crop production with soil and water conservation structure, animal forage like legumes variety that replenish soil nutrient, and elephant grass that can be used for both soil conservation and animal feed are the most effective way of land management.

Integrated and well-designed soil and water conservation measures.

Sustainable land management,(cut and carry grazing system, conservation of soil ,soil nutrient and water etc.

Supply of animal feed from small land (using soil and water conservation structures), especially for farmers subjected to land shortage.

Construction of the soil bund and it's design (spacing, height etc.) especially in case of peak rainfall and flooding.

Importance of the technology in improving soil physical and chemical property, specially soil physical property like water holding capacity, improve soil aggregation, /structure and nutrient replenishment and result in improved production for food insecurity mitigation. Accordingly, effect of the intervention on productivity of the crops (grain yield of maize, and biomass yields of maize and the legumes) and productivity of livestock (milk yield) was measured. Quantitative and qualitative data on farmers' perception and other socio-economic factors (income, labour distribution among family members, gender issue, and input availability) affecting adoption of the IFM was collected. Moreover, environmental effects of the intervention like soil erosion, soil nutrient, and soil moisture was evaluated. Farmers, DAs and experts was also trained on IFM approaches. Moreover, training and demonstration was conducted on management of feed produced and livestock feeding.

Table 10. The established FRG and training given in 2016

No	**AGP-II Woreda**	**kebele**	**Number of FRG**	**member of FREGs**			**Type and number of tech. demonstrated**	**plot size per variety(for crop and forage)**	**Mini filed visit participants**	
				Men	**Women**	**total**			**M**	**F**
1	Sofi	Kile	2(four trial farmer	32	13	45	1	20m*10m	30	19
2	wahile	Dujuba	1(three trial farmer)	11	9	20			18	10
3	**Total**		**2**	**43**	**22**	**65**	**1**	**200m^2**	**77**	

Table 11: Type of profession and number of participants during the training at two districts 2017 and 2018

		Kile		Wahil	Adada1		
No.	Participants	Male	Female	Male	male	female	Total
1	Farmers	45	20	**40**	72	**20**	**217**
2	Das	9	**1**	5	6	5	26
3	District experts	4	1	3	4	1	13
4	Journalist	1	0	0	1		2
	Total	**59**	**22**	**48**	**83**	**26**	**258**

Source: Own computation 2016, 2017/18.

Table 12: Ranks of the varieties based on farmers' selection criteria.

Types of technology	Farmers rank	Reasons
Integrated physical and biological swc	1st	Good bund width that is suitable for forage production over the bund, water holding capacity, land saving Good bund height for protection of run of destruction. Improve soil depth.
Soil bund farmers practice	2nd	Poor water holding capacity, shallow soil depth, un appropriate design.

Table 13: Pair-wise ranking matrix result to rank improved swc measures.

Code no.	Parameter of selection	width	height	Soil depth	Water holding capacity			Bulb skin color	Seed set
1	Bund width		2	3	1	1	6	1	1
2	Bund height			3	2	2	2	2	2
3	Land saving				3	3	3	3	3
4	Water holding capacity					5	5	4	4
5	Erosion control capacity						5	5	5
6	Maize yeild							6	6
7	Total fresh biomass harvested								7
8									

Conclusion

Integrated physical and biological soil and water conservation measure is one of climate smart agriculture that alleviate land degradation and enhance soil fertility. Not only conserve soil and moisture but also integrated soil and water conservation measures can address the problem of land shortage, especially for the country that its population grow radically. Leguminous forage crop especially like pigeon pea, is very important to replenish soil nutrient and componset nutrient completion with crop.

Recommendation

Farmers practice integrated physical and biological soil and water conservation measures to cop up the climate change problem specially those farmers who live in arid area. Research extension should go for pre-scaling up and scaling up of the technology to reach for pastoral society specially. Office of agriculture and natural resource create awareness further about integrated soil and water conservation for both arable and degraded land.

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