Yield/Biomass Measurements, Soil Sampling/Testing and Cropping Pattern Research on Target Weredas of GIZ-ASRP in Afar Regional State, Ethiopia

A Progressive Report Implemented in Wet/Summer Season

(September-October, 2023)

Submitted to

Lowland Soil Rehabilitation Project (LSRP)

Addis Ababa/Ethiopia

March, 2024

Table of Contents

1. Introduction

GIZ LSRP project in collaboration with the Afar regional government and different partners has implemented Strengthening Drought Resilience in Pastoral and Agro-Pastoral Communities of Afar and Somali Regional States, Ethiopia. It has constructed water spreading weirs in various woredas of Afar region, namely Chifra; Ewa; Awra; Gullina and Yallo.As a result, various development practitioners as well as the Woreda PADO have been cultivating promising food and fodder crops under the constructed area of the WSWs. It has been reported as a promising trend that WSWs contribute to soil water distribution and soil fertility gradients, effectively capture sediments coming from the highlands along with the flood, enrich the flat plains, improve the natural vegetation of the valleys and availability of fodder for livestock, start crop and forage production and productivity (GIZ, 2017).

Therefore, the regional government has considered WSWs as one of the intervention options to be scaled up in the Afar region. The implementation of water spreading weirs as a rehabilitation technique for degraded dry valleys will be further evaluated based on environmental and socio-economic indicators.

Therefore, APARI in collaboration with GIZ LSRP project has designed a contract agreement to monitor/measure the water spreading weir sites based on a scientific approach and compare the results with control sites that didn't have constructed weirs. This in turn will help to properly understand the merits of constructed water spreading weirs on improving biomass and yield as well assoil carbon sequestration. Thus, this report is the second-year rainy season progress report on the measurement of yield/biomass of food and fodder crops, soil testing & analysis, to know the content of bulk density and organic carbon stocks, and cropping pattern in target woredas of Afar Regional State, Ethiopia the period September-January, 2023/24.

2. General objective of the study:

To conduct field measurement on the impact of WSWs regarding production and productivity of food and fodder crops as well as soil carbon sequestration in the rehabilitated dry valleys where soil erosion control measures and flood-based agriculture activities are implemented in the target woredas namely Chifra; Ewa; Awra; Gullina and Yallo for the wet season 2023/24.

1.2. Specific Objectives

- To conduct actual field survey and measure parameters related toyield/biomass, cropping pattern and soil sampling/testing from the selected sampling sites in wet seasons

- To investigate carbon stocks across the constructed weirs and along soil depths in Chifra; Ewa; Awra; Gullina and Yallodistricts.

3. Methodology/Approaches

3.1. Description of the project area

The fieldwork was conducted in the target districts of Chifra, Ewa, Awra, Gullina and Yallo during the rainy season of 2023. The situation in all the districts was severe drought and in most of theWSWs cascades, there was no vegetation cover shown.In some areas farmers tried crop cultivation, especially Chifra and Yallodistricts, but we couldn't find well established crop fields.

In most of the target districts, similar situations occurred and pastoralists and agro-pastoralists said that there was no adequate rain in the summer/karema season of 2023,and even in the sugum season, 2023 (March & April). There were only small amounts of rain at the end of April (with month of Ramadan). Therefore, we don't have enough data for crop yield/biomass and crop pattern assessment in the rainy season, 2023.

3.2. Study Procedures and Measurement Techniques

3.2.1. Organized Multidisciplinary Working Team

As usual, a multidisciplinary working team was organized, with members and their respective responsibilities in the field:

1) Mr. Nuru Mohammed……………M.Sc. in Forestry and Climate Change
2) Mr. ZinabuAkele ……………….M.Sc. in Irrigation and Drainage
3) Mr. Seid Beshir ………................BSc in Chemistry

3.2.2. Secondary data information

Before starting the actual field survey/data collection, we had a small discussion with district officials about the current situation in each district for all sites and to the assigned focal person of GIZ at district and kebele level. After that, we carried out field sampling collection in each selected site for each district. We recorded the status and activities that were or were not implemented in the constructed structures in the last six months.

As usual, we considered and used sampling methods to cluster the WSWs & check dams into two groups based on the year of construction.

Group one: Weirs constructed between 2014-2017

Group two: Weirs constructed between 2018-2022.

For additional clustering methods of Water Spread Weirs, we used to base them on types of management practices such as cultivation and non-cultivation, fenced and free-open, and control (outside-WSWs and Check Dams).

3.2.3. Biomass Measurement of Maize Crop

3.2.3.1. Biomass Estimation through Crop Cutting Method

The crop cutting method was used to estimate the yield and biomass of food crops. A randomly selected plot technique was employed in the specified crop field, and the produce was harvested following standard procedures outlined in the proposal. During field observations, we recorded the status of each measured structure and the ground types of crops (maize, broadcasted planted). We only took samples from one WSW (Taaboy) Kebele for biomass estimation from WSW2 P1.

A transect of 50 meters was laid down and a total of nine sampling plots of 1m2 were marked along the transect(s). The representative transect was selected along the treated/control area, including the best, medium, and bad areas in terms of results. The selection of the areas depended on the availability of crops along the WSWs. The GPS coordinates of each sample and control site (if available) were recorded using the **Onstruc** application.

After defining the transects, we placed a 50m tape for each transect and measured the crop performance and coverage on a 1m band along with the tape. We took a total of nine samples from three classes for replications in each transect, based on weak, medium, and strong crop performance. The maize crops were harvested and then compressed for bagging using plastic to reduce dehydration. The biomass was weighed, labelled, and coded with information such as kebele, site, transect, crop type, and harvested date before being transported to our laboratory. During transportation, we measured and calculated the weight of the biomass in ton per hectare.

3.2.1.2. Biomass (forage & fodder) measurement techniques

In regards to sampling forage and fodder biomass in the WSWs, a rapid field appraisal was conducted in Chifra district. No types of improved forage and fodder sowing were found in any of the districts. However, landrace Sudan grass and indigenous grass were found in a fenced area at Taaboy sites. The area was then clustered into fenced areas with indigenous grass and open indigenous grass species.

Grass Biomass measuring techniques:

Sampling plots were randomly selected from each class using a 1x1m frame quadrant.

- All grass and herbs within the quadrant were collected and their fresh weight recorded.
- The collected samples were labelled, taken to the laboratory, and oven-dried at 70°C.
- The dried samples were weighed to calculate the dry matter/biomass yield.

3.2.4. Soil sampling/testing

Before laying out the field for soil sampling, we conducted a field observation of the study areas. We selected sampling sites clustered around constructed weirs based on their age (either 4 years old or over 4 years old) and two types of rehabilitation practices: flood-based farming practices and rehabilitation without intervention of the constructed weirs. For the purpose of comparison, soil samples were collected from natural gullies without water spreading weirs for control.

3.2.5. Second wet seasons soil sampling

Second wet season

During the field trip, we collected field samples for soil sampling in all districts of the selected WSWs. Composite soil samples were collected at two soil depths (0-15 cm and 15-30 cm) along a transect line or grid, depending on the size of the command area, following standard procedures. We recorded the coordination point of each sample site using the Onstruc application.

For each composite soil sample, five soil samples were taken within a 15m radius from a point. Each sample contained a minimum of 1kg of soil and an equal volume of each sample from a given transect line was pooled and mixed together according to their depths. Finally, the composite samples were divided into five equal parts, of which one was randomly chosen and stored in labelled plastic bags. These bags were sealed and transported to our soil laboratory for further analysis. Bulk density was determined for each soil depth of the soil profile using a core sampler with a known volume of 100cm3.

3.2*6*. Soil analysis in the laboratory for major parameters

Soil samples were taken from all sampling plots using a standard core sampler. Metal core samplers with plastic coating were then used to measure the bulk density. The core sampler had a volume of 100cm3 for bulk density measurement. The soil samples were dried in an oven at 105°C for 24 hours and then weighed for bulk density analysis.

Soil organic carbon was determined using the Walkley-Black method (Walkley & Black, 1934) and calculated according to Pearson, Brown, and Birdsey (2007) as follows:

Soil organic carbon = % Carbon * ρ_b * depth,

where % Carbon is the carbon concentration (%) determined in the laboratory following the Walkley and Black (1934) method, ρ_b is the soil bulk-density (gm/cm3), and depth refers to the depth of the soil sample (0-15/15-30 cm).

3.2.7. Stastical Analysis and Interpretation

The data obtained from vegetation, yield, biomass, and soils were analyzed using descriptive statistics, including mean, frequency, standard deviation, and percentage. The analysis was performed using the same program for sorting and summarizing.

4. Result

4.1 Biomass measurement

For the assessment of grain and biomass/straw yield, we only have data from Teaboyi kebele in Chifra district, where maize is the only food crop grown during the summer season. The area covered by maize cultivation is limited to a small hectare of land. Meanwhile, in Sheqayiboru kebele, agro-pastoralists attempted to sow not only maize but also sorghum in August, but the crops failed to grow due to the lack of rainfall during the season. Additionally, agro-pastoralists reported a lack of government support for seed inputs, similar to last year. As a result, many individuals had been unable to cultivate their fields, despite their interest in growing food crops.

Regarding grain and biomass/straw yield of food crops, it was difficult to estimate due to a small number of agro-pastoralists cultivating only maize. Therefore, judging the yield performance of maize based on the data from Teaboyi village of Chifra district does not reflect the real data due to the minimal and lower sample size. We calculated the grain and biomass/straw yield of maize and maize crops cultivated in Chifra district.

WSW1 (P1) produced 0.76 ton/ha, while WSW2 (P2) produced 0.58 ton/ha. These sites recorded the lowest maize biomass/straw yields compared to last year. It is important to note that this data was collected from only two agro-pastoralists and may not be representative of the entire Chifra district. The low performance of maize crop biomass can be attributed to severe drought conditions during the last summer season.
As we visited the targeted sites, we didn't get any control plots, the reason might be similar due to absence of adequate rainfall and flood in the site, let alone to get a control plot outside the weirs as they couldn't even cultivate crops on the constructed weirs.

Table 1: Biomass/straw yield (ton/ha) of food crops in Teaboyi villages of Chifra in wet season, 2023

Variety	Village	WSW's	Biomass/straw yield
Maize	Teaboyi	WSW1 (P_1)	0.76ton/ha
		WSW2 (P_1)	0.58 ton/ha

Table 2: Total Indigenous Forage Biomass on WSWs structures in wet season of 2023/24

kebele	WSWs	Fresh wgt per (gm/M2)	Dry wgt (gm/M2)	Measurement material wgt (gm)	Dry Biomass per plot (gm/m2)	Dry Biomass (kg/ha)	Dry Biomass (ton/ha)
Teaboyi	WSW1P_1	1100	790	125.5	184.5	1845	1.85
	WSW1P_2	1450	1015	185	250	2500	2.5

Table 3: Biomass production comparisons of both food & forage crops on WSWs structures in wet season of 2022 and 2023

Wereda	Village	WSWs code	Crop types	Biomass/Straw yield in 2023	Biomass/Straw yield in 2022	Difference
Chifra	Teaboyi	WSW1P_1	Maize	0.76 ton/ha	0.85ton/ha	-0.09
		WSW1P_2		0.58 ton/ha	-	
		WSW1P_1	Forage	1.85 ton/ha	2.84 ton/ha	-0.99
		WSW1P_2		2.5 ton/ha	3.55 ton/ha	-1.05

4.2 Forage Crop Biomass production

4.2.1. Improved Forage & Fodder Crops Biomass

Regarding the biomass yield performance of improved forage and fodder crops, we were unable to find any areas in the constructed weirs where such crops were cultivated.

4.2.2 Dry matter/biomass yield of indigenous grasses

In terms of dry matter and biomass yield of indigenous grasses, the results indicate a maximum of 2500 kg/ha and 1845 kg/ha at Teaboyi (WSW-P2) and Teaboyi (WSW-P1), respectively.

Similar to the previous wet season, well-fenced and well-managed indigenous grass species in Teaboyi WSW1 P2 & P1 showed good biomass growth. This result highlights the importance of proper management practices, such as fencing, for the growth of Sudan grass within the WSWs. The importance of construction of structures should not be overemphasized in comparison to other options such as implementing biological measures. Agro-pastoralists require continued support in forage cultivation. It is important to internalize this need.

4.2.3. Biomass production comparisons of both food & forage crops on WSWs in wet season of 2022 and 2023

Based on the data we collected in the wet season of 2023, we have a biomass/straw yield of maize in Teaboyi village with a WSWs code of WSW1 (P1) and WSW2 (P2). The straw biomass in WSW1 (P1) was 0.76ton/ha, and in WSW2 (P2) was 0.58 ton/ha. Compared to the 2022 wet season of straw biomass yield, WSW1 (P1) was 0.85 tons/ha, with a 0.09 tons/ha difference between the two cropping seasons. In the year 2023, due to severe drought and the absence of adequate rainfall during summer and big seasons, crop production dropped. In the previous wet season, 2022, straw biomass yield was relatively good compared to the wet season, 2023. We could not get maize grain yield in the wet season of 2023 because of severe drought in target woredas.

In forage biomass production, 1.85 tons/ha and 2.5 tons/ha were harvested in the wet season 2023 from WSW1 (P1) and WSW2 (P2), respectively. While in the wet season of 2022, the forage biomass production was 2.84 tons/ha in WSW1 (P1) and 3.55 tons/ha in WSW2 (P2).

Compared to the wet season of 2022 forage biomass production, there was declining production in WSW1 (P1) and WSW2 (P2). The decline might have occurred due to drought.

4.3 Soil tested for Bulk Density (BD) and Soil Organic Carbon (SOC)

For wet season

Bulk Density (BD) values are used as indicators of root penetration and soil aeration problems in different soil horizons. Mineral soils typically have a bulk density range of 1.0 to 1.5g cm–3 for fine-textured soils and 1.3 to 1.7g cm–3 for sandy soils. The soil sample results indicate that all samples, except for Geriro-control (15-30) and Golina Control at both depths, fall within the range of fine-textured mineral soils. The implementation of structured measures in degraded rangeland has the potential to improve soil texture and alter water content, as indicated in Appendix 1.

Soil Organic Carbon Stocks

The estimation of an ecosystem's effective carbon sequestration capacity requires a soil organic carbon range calculation, which measures the accumulated difference between primary production inputs and decomposition outputs. Our observations of sample sites indicate that Chifra Taaboyi, Sheqayiboru, Garriro, Ewa-Duba, Awra-lekura and Yallo-Wakreide and Kolina & Gabule kebeles have the highest total soil organic carbon stocks. Additionally, the top layer's SOC significantly decreases with depth. The majority of the topsoil (0-15 cm) contained the highest amount of soil organic carbon (SOC), followed by the soil from a deeper depth of (15-30 cm) (see Appendix 1).

In some sites like Tibbiadora in gulina, the control sites produced similar or slightly greater results than the the WSWs structures. This can be attributed to differences in vegetation cover and management. Overall, during the second wet season, SOC results indicate a declining trend across districts from Chifra to Yalo district.

5. Problems encountered

- There are insufficient farming practices in the catchment area of many of the measured WSWs, DSMs, and Check Dams structures. This prevented us from obtaining an ideal representative sample for grain yield and cropping patterns.
- Additionally, the water tank reportedly crashed and dropped due to high wind speeds, requiring long-term maintenance.

- Furthermore, there was a lack of water source in Semera town for a month, which caused a delay in our soil analysis in the laboratory.

6. Possible measured we had taken

- We attempted to search all constructed weirs to obtain representative samples.
- We repeatedly maintained our soil laboratory water tanker to ensure its functionality.
- We also explored other options, such as bringing tap water using a truck.

References

- Amede et al,. (2019). Facilitating negotiated funder and partner: transformation from pastoralto sustainable agro-pastoral systems through flood-based land restoration in drought-proneregions of Afar, Ethiopia (under review).
- Elisabeth van den Akker, Wolf Berdel, Jemal Nur Murele.2015. Reversing NaturalDegradation into Resilience: The Afar Case. Conference on International Research on FoodSecurity, Natural Resource Management and Rural Development organised by the Humboldt-Universität zu Berlin and the Leibniz Centre for Agricultural Landscape Research (ZALF),Tropenta, Berlin, Germany September 16-18.
- GIZ .2017. Strengthening Drought Resilience in Afar and Somali Regions of Ethiopia.Available at: https://www.giz.de/en/worldwide/81128.html
- Tsegaye, D., Moe, S.R., Vedeld, P. and Aynekulu, E. (2010) Land-Use/Cover Dynamics inNorthern Afar Rangelands, Ethiopia. Agriculture, Ecosystems & Environment, 139, 174-180. http://dx.doi.org/10.1016/j.agee.2010.07.017
- Walkley, A., & Black, I. A. (1934). An examination of the degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science, 37(1), 29–38.

7. Photo Gallery

Forage crops biomass collection in GIZ Target woredas

Food cropsbiomass/straw yield collection in GIZ Target woredas

Soil sample collection in GIZ target woredas

Soil samples analysis in APARI soil laboratory

Appendix1: Soil bulk density &soil organic carbon second wet season results laboratory analyses

Kebele- District	Code number	Depth (cm)	Mass of Dry Soil (g)	Volume of core cm^3	Bulk Density (g/cm^3)	Total OC (%) = OOC * 1.334	OM = 1.724* TOC	SOC (t C/ha)
Teaboyi .. Chifra	Ch-T-01	0-15	144	100	1.44	1.366	2.354	29.50
Teaboyi		15-30	124.5	100	1.245	1.182	2.037	22.07
Teaboyi	Ch-T-02	0-15	114	100	1.14	1.090	1.879	18.64
Teaboyi		15-30	112.5	100	1.125	1.087	1.874	18.34
Teaboyi	Ch-T-con	0-15	132.5	100	1.325	0.935	1.612	18.58
Teaboyi		15-30	135	100	1.35	0.918	1.583	18.59
Sheqayiboru..Chifra	Ch-SB-01	0-15	134	100	1.34	1.252	2.159	25.17
Sheqayiboru		15-30	115.5	100	1.155	1.231	2.122	21.32
Sheqayiboru	Ch-SB-02	0-15	133	100	1.33	0.967	1.667	19.29
Sheqayiboru		15-30	130	100	1.3	0.937	1.615	18.26
Sheqayiboru	Ch-SB-03	0-15	141.5	100	1.415	1.087	1.874	23.07
Sheqayiboru		15-30	130	100	1.3	1.065	1.837	20.77
Sheqayiboru	Ch-SB-con	0-15	125	100	1.25	0.872	1.504	16.35
Sheqayiboru		15-30	124	100	1.24	0.802	1.382	14.91
Garriro..Chifra	Ch-G-01	0-15	133	100	1.33	1.424	2.455	28.41
Garriro		15-30	119.5	100	1.195	1.412	2.434	25.30
Garriro	Ch-G-02	0-15	132	100	1.32	1.205	2.077	23.85
Garriro		15-30	142.5	100	1.425	1.174	2.024	25.10
Garriro	Ch-G-con	0-15	144	100	1.44	0.921	1.588	19.90
Garriro		15-30	161.5	100	1.615	0.903	1.556	21.87
Duba..Ewa	E-D-01	0-15	177.5	100	1.775	1.090	1.879	29.02
Duba		15-30	138.5	100	1.385	0.998	1.720	20.73
Duba	E-D-02	0-15	141	100	1.41	1.004	1.731	21.23
Duba		15-30	115.5	100	1.155	0.998	1.720	17.29
Duba	E-D-03	0-15	136.5	100	1.365	0.984	1.696	20.15

Duba		15-30	104.5	100	1.045	0.979	1.689	15.35
Duba	E-D-04	0-15	128.5	100	1.285	1.093	1.884	21.06
Duba		15-30	111.5	100	1.115	1.081	1.863	18.07
Duba	E-D-con	0-15	149	100	1.49	0.756	1.303	16.89
Duba		15-30	129	100	1.29	0.728	1.255	14.09
Lekora..Awra	Aw-L-01	0-15	135.5	100	1.355	1.050	1.810	21.34
Lekora		15-30	122.5	100	1.225	0.982	1.694	18.05
Lekora	Aw-L-02	0-15	128.5	100	1.285	1.225	2.111	23.61
Lekora		15-30	129	100	1.29	1.113	1.918	21.53
Lekora	Aw-L-03	0-15	120	100	1.2	1.087	1.874	19.56
Lekora		15-30	116.5	100	1.165	1.019	1.757	17.81
Lekora	Aw-L-con	0-15	126.5	100	1.265	0.937	1.615	17.77
Lekora		15-30	125.5	100	1.255	0.935	1.612	17.60
Tibbiadora..Gulina	Gu-T-01	0-15	145.5	100	1.455	0.935	1.612	20.41
Tibbiadora		15-30	121	100	1.21	0.906	1.562	16.44
Tibbiadora	Gu-T-02	0-15	123	100	1.23	0.998	1.720	18.41
Tibbiadora		15-30	123.5	100	1.235	0.956	1.649	17.72
Tibbiadora	Gu-T-03	0-15	106	100	1.06	0.906	1.562	14.40
Tibbiadora		15-30	111.7	100	1.117	0.881	1.519	14.77
Tibbiadora	Gu-T-04	0-15	125	100	1.25	0.967	1.667	18.13
Tibbiadora		15-30	132	100	1.32	0.906	1.562	17.94
Tibbiadora	Gu-T-05	0-15	125.5	100	1.255	1.153	1.987	21.70
Tibbiadora		15-30	106.5	100	1.065	1.087	1.874	17.36
Tibbiadora	Gu-T-06	0-15	121.5	100	1.215	0.918	1.583	16.73
Tibbiadora		15-30	120	100	1.2	0.918	1.583	16.53
Tibbiadora	Gu-T-con	0-15	163.5	100	1.635	0.786	1.356	19.28
Tibbiadora		15-30	153.5	100	1.535	0.774	1.334	17.82
Wekriede.. yallo	Ya-W-01	0-15	103	100	1.03	1.435	2.473	22.17
Wekriede		15-30	103.5	100	1.035	1.347	2.323	20.92
Wekriede	Ya-W-02		126	100	1.26	1.533	2.642	28.97
Wekriede			143.5	100	1.435	1.237	2.132	26.62

Wekriede	Ya-W-03		123	100	1.23	1.332	2.296	24.57
Wekriede			119	100	1.19	1.274	2.196	22.74
Wekriede	Ya-W-04		110	100	1.1	1.393	2.402	22.99
Wekriede			106	100	1.06	1.734	2.989	27.56
Wekriede	Ya-W-05		109	100	1.09	1.435	2.473	23.46
Wekriede			113	100	1.13	1.427	2.460	24.19
Wekriede	Ya-W-con		122	100	1.22	0.967	1.667	17.70
Wekriede			112	100	1.12	0.952	1.641	15.99
Kulina kee Gabule..Yallo	Ya-KG-01		119.5	100	1.195	1.203	2.074	21.57
Kulina kee Gabule			109.5	100	1.095	1.090	1.879	17.90
Kulina kee Gabule	Ya-KG-02		123	100	1.23	1.249	2.154	23.05
Kulina kee Gabule			113.5	100	1.135	1.206	2.080	20.54
Kulina kee Gabule	Ya-KG-03		101.5	100	1.015	1.007	1.736	15.33
Kulina kee Gabule			129	100	1.29	0.992	1.710	19.19
Kulina kee Gabule	Ya-KG-con		136.5	100	1.365	0.915	1.578	18.74
Kulina kee Gabule			131.5	100	1.315	0.765	1.319	15.09