Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 20 Issue 4 Version 1.0 Year 2020
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Demonstrative Study of the Effectiveness of Low Cost Gully Rehabilitation Measures: The Case of Bonk District SNNPR, Ethiopia

By Wudnesh Naba, Birhanu Wolde & Abiy Gebremichael

Abstract- Gully erosion is the major environmental problem threatening the huge areas of agricultural land in Southern Ethiopia, particularly the Gamo Gofa zone of Bonke district. The present study is aimed at evaluating and demonstrating low- cost gully treatment methods for gully rehabilitation in Bonke district SNNPR, Ethiopia. Three treatments namely, Brushwood check dam+ trench+ head apron, brushwood with stone check dam+ trench+ head apron, and Stone check dam+ trench+ head apron) established in 6 gullies. Building the check-dams, Jatropha, elephant grass, and banana were planted. Data such as sediment deposition and biomass production were collected to investigate their effectiveness in reducing soil erosion and biomass production. Also, the costs for establishing the rehabilitation measures were collected. The Considerable differences among the tested trials in reducing soil erosion and biomass production was not observed. However, the rehabilitation measures maintained the restoration of grass and shrub species as well as the improvement of soil fertility. It is detected that the cost of establishing brushwood check damis considerably low compared to the other tested methods.

Keywords: check-dam, grasses biomass, gully rehabilitation, low cost.

GJSFR-D Classification: FOR Code: 300999

DEMONSTRATIVESTUDYOFTHEEFFECTIVENESSOFLOWCOSTGULLYREHABILITATIONMEASURESTHECASEOFBONKDISTRICTSNNPRETHIOPIA

Strictly as per the compliance and regulations of:

Demonstrative Study of the Effectiveness of Low Cost Gully Rehabilitation Measures: The Case of Bonke District SNNPR, Ethiopia

Wudnesh Naba [α], Birhanu Wolde [σ] & Abiy Gebremichael [ρ]

Abstract- Gully erosion is the major environmental problem threatening the huge areas of agricultural land in Southern Ethiopia, particularly the Gamo Gofa zone of Bonke district. The present study is aimed at evaluating and demonstrating low- cost gully treatment methods for gully rehabilitation in Bonke district SNNPR, Ethiopia. Three treatments namely, Brushwood check dam+ trench+ head apron, brushwood with stone check dam+ trench+ head apron, and Stone check dam+ trench+ head apron) established in 6 gullies. Building the check-dams, Jatropha, elephant grass, and banana were planted. Data such as sediment deposition and biomass production were collected to investigate their effectiveness in reducing soil erosion and biomass production. Also, the costs for establishing the rehabilitation measures were collected. The Considerable differences among the tested trials in reducing soil erosion and biomass production was not observed. However, the rehabilitation measures maintained the restoration of grass and shrub species as well as the improvement of soil fertility. It is detected that the cost of establishing brushwood check damis considerably low compared to the other tested methods. Given there are no considerable differences in rehabilitating gullies among the tested methods, Brushwood check-dam could be preferred by farmers. The results support that adopting the tested gully rehabilitation measures and implementing them larger scales could running the rehabilitation of gullies and change them to productive land.

Keywords: check-dam, grasses biomass, gully rehabilitation, low cost.

I. Introduction

Gully erosion constitutes to be an environmental and social problem in many parts of Ethiopia (FAO, 2003).Soil erosion caused by Overgrazing and low vegetation cover is the main drivers for the creation of gullies (Abate, 2011). Because of the creation of small (<3m deep and drainage area of<20ha) to Medium (up to 3m and drainage area 20-60ha), large areas of agricultural lands are lost or have become unsuitable for cultivation (Mehretie and Woldeamlak, 2012).

Gully expansion was observed to be high in Southern Ethiopia, and mainly caused by the uilding of poorly designed roads. For example, Belayneh *et al.* (2014) showed that 20 new gullies had been created down the slope of the Hadero Tunto Durgi construction. Their development is found to be associated mainly with culverts by and roadside ditches. This study further elaborated that the rate of soil loss due to the formation gullies was estimated at 12.86$tha^{-1}y^{-1}$, and the total damaged area estimated at 1.6ha in 6 years' time span. studies (e.g., Alemu and Awdenegest, 2014) conducted in the southern region demonstrated that the long term gully erosion rate at watershed level is about 2.12$tha^{-1}y^{-1}$, with the total surface area covered by gullies ranged from 0.7 to 2ha, and estimated total volume of soil loss was varied between 8,700m3 and 36,000m^3. The most critical aspect of gully erosion control is the stabilization of gully beds. Technically it is possible to stabilize the gully head before the gully bed has achieved its stability, but only if it is possible to predict with some degree of certainty the ultimate profile, i.e., elevation of the gully bed. There is usually more than one option to threaten gully erosion. A better understanding of these gully erosion processes will result in more effective erosion control at less cost (Nissen *et al.,* 2004).The major issue is finding the treatment option that best suits the local environment and the affected land. Though there have been numerous attempts to control gully erosion in the region, the problem is still persistent (Alemu and Awdenegest, 2014). The reason was that little had been discussed about ways to prevent their onset or the use of community-based low-technology to prevent its development. Therefore, the reason for this is the cost of gabions to protect the gullies, lack of awareness regarding the degree of gully expansion by the community to rehabilitate marginal lands. Therefore, the use of low-cost materials for gully rehabilitation is essential to prevent the enlargement of gully erosion. Accordingly, the objective of the study was to demonstrate the effectiveness of different gully treatment methods for gully rehabilitation.

II. Materials and Methods

a) Description of the Study Area

The study was carried out in Bonkeworeda, Southern Ethiopia (Figure. 1). Bonke is one of the 15 woredasin Gamo Gofa Zone and lies between 5°55′N

Author α σ: Arba Minch Agricultural Research Centre, SARI.
e-mails: wudnesh2017@gmail.com, birhanuwolde2016@ gmail.com
Author ρ: Bonga Agricultural Research Centre, SARI, P.O.BOX 101.
e-mail: gebremichaelaby@gmail.com

latitude and 37°15′E longitude with an altitude ranges from 600 to4200 masl. The land area of the Woreda is estimated to be 85,940 km^{2}andbordered on the south by the Dherashe and Alleworeda, on the west by the Weito River which separates it from Kemba, on the northwest by Deramalo, on the north by Dita, and on the eastby Arba Minch Zuriaworeda. The agro-ecology of the woreda is classified in to three zones: Dega (covers 46% of the land area), Woina Dega (30%), and Kola (24%). The mean annual average rainfall and temperature of the woreda are 1400 mm and 13.05ºC, respectively (Guyo, 2016). The estimated human population of the woreda was about 205, 73of, which 102,458 males and 103,281 are females (BoFED, 2015).The soil type of the study woreda is Vertiso land Acrisols. Acrisols is the dominant soil type in the area which covers (84%). The land use pattern is dominated by agricultural land. The woreda Altitude ranges of 709-3467m.a.s.l (Meter above sea level) (FAO, 2012).

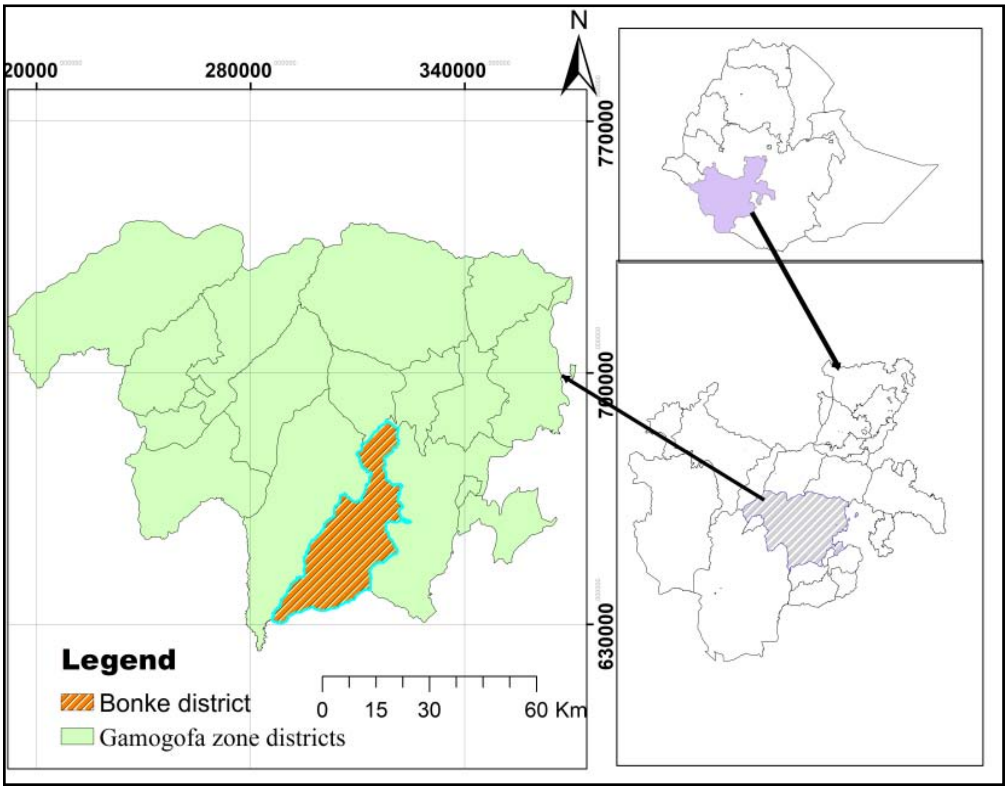


Figure 1: Map of the study area

b) Site selection, experimental design and data collection

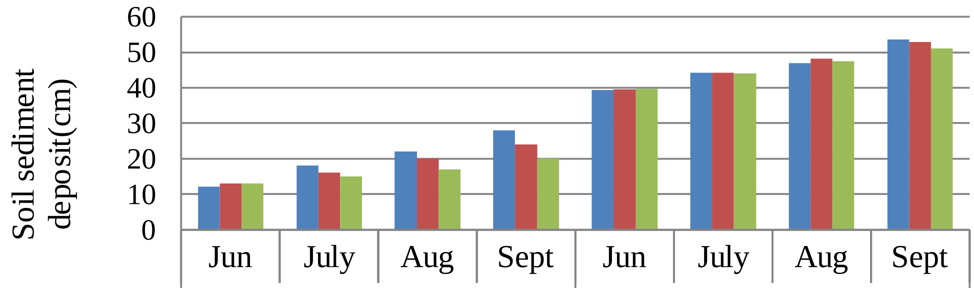
A reconnaissance survey was conducted to get a better understanding of the district and select a specific study site. Following the reconnaissance survey, six gullies that have similar dimensions (2-3m depth and 1-3m width) near the head gully was preferred for evaluation. Three treatments (Brushwood check dam+ trench+ head apron, brushwood with stone check dam+ trench+ head apron, and Stone check dam+ trench+ head apron) each were applied on any other two gullies as a replicate. The dimension of trenches in the ravine was 50cm deep and 1m widespread that is extended to 0.5m on both sides of the channel. The spacing (S) of check-dam was determined by dividing the height (H) of check-dam to channel gradient in decimal number and multiplying by a correction factor of 1.2. The check-dams have the height of 1.3m, top width 0.52m, and base width of 2.5m while the base width of drop structure and head apron is 2m.

Graduated ranging poles at the edges and centre of the gully were installed at different positions of check dams to monitor the soil deposit from each treatment. The biomass data of newly emerged vegetation was collected using a quadrant of 50cmx50cm plot to identify the rehabilitation potential of the gully area. Data on soil deposit was collected during the rainfall season for two years. To monitor the gully rehabilitation status, progressive pictures were used. At the end of the evaluation, economic analysis was made between the interventions to compare their cost of rehabilitation. The cost estimation was done using lab or cost of construction, transportation cost for required materials and maintenance. To speed up gully rehabilitation, vegetative stabilizers like Jatropha plant, Elephant grass, and Banana fruit were planted at the side of the structures.

III. Results and Discussion

a) Soil sediment deposit

The cumulative soil deposit on gully rehabilitation treatments was determined for the two consecutive years (2016 &2017) in rainy seasons (Figure 2). Figure 2 shows increasing trends of soil deposition from the onset to the end of the rainy season. This indicates that gully erosion can be treated using locally available materials within a short period. This will be effective if the gully rehabilitation is done before to its expansion to the more uncontrollable stage. This experiment was done on smaller gullies having the depth of 2-3m at active head parts. In the first year, the maximum and the minimum cumulative sediment deposition was observed on brush wood check-dams (280mm) and stone check-dams (200mm), respectively. Similarly, in the second year, the maximum and the minimum cumulative sediment deposition was found on brush wood check-dams (535mm) and stone check-dams (510mm), respectively.



	Jun	July	Aug	Sept	Jun	July	Aug	Sept
	Year 1				Year 2			
Brush wood	12	18	22	28	39.3	44.2	46.8	53.5
brush wood + stone	13	16	20	24	39.5	44.2	48.2	52.8
Stone cheakdam	13	15	17	20	39.7	44.0	47.3	51.0

Figure 2: Cumulative soil sediment deposited

b) The trend of low-cost gully rehabilitation method

i. *During construction time*

Figure 3: Gully treatments just after construction

ii. *Gull stabilization progress after six months*

A photographs in the figures below show that the progressive rehabilitation in the period of six months. The trend indicates that use of available materials could be appropriate and effective to rehabilitate small gullies before it expands to large size. Generally, the fast rate of rehabilitation of ravine was found due to the success of selected local material. The picture after six months showed that brushwood produced better progress in soil deposit, and biomass cover of vegetation. It was observed that brushwood stabilized with vegetative materials like Jatropha, elephant grass and banana could control small gullies within a year's. Since gully could not be prevented by these vegetative materials if applied only, integrating it with stones or brushwood would have the promising results to the rehabilitate gully.

Figure 4: Progressive rehabilitation system of gully by different check-dams

This finding was also consistent to study conducted to identify gully rehabilitation methods in Northwestern Ethiopia (Hailu et al., 2015). The author stated that appropriate physical gully erosion control practices coupled with biological measures have resulted in a large decrease of soil loss and stabilized the gully from enlargement, which is a main success to keep a stable and productive ecosystem. Also, the result of using these local materials is effective in controlling gully erosion under depth and width of less than 3m. According to Wolde-Aregay, (1996) check dams have been quite effective in smaller and average size gullies. During small gully reclamation, integrating vegetative materials for productive purposes has been practiced in the Tigray Region Ethiopia, with favorable agronomic results from cultivating banana, elephant grass, and sugarcane on gullied land(SIWI, 2001).It also showed that prioritizing the construction of structures in gully beds and then integrating it with stabilizer plants have multiple advantages like erosion and forages as well as fruits from plants. According to the result of Asefa (2017), grass and shrub species could reduce the probability of gully initiation and could stabilize the banks of gullies.

iii. *Gull stabilization progress after two 2 year*

The Photograph at Figure 5 indicated that vegetative stabilizers are matured and strongly supported the structures. Jatropha played a excessive role at this regard. Planting Jatropha not only maintenance of gully rehabilitation, but also provide multiple uses like fuel (Brittaine and Lutaladio, 2010). Besides to being stabilizer for check-dams in the picture above, banana and elephant grass well performed and can provide additional benefits now and onwards.

Figure 5: Gully stabilized with different check-dams and vegetative materials after two years

The change in rehabilitation resulted in the observation of different plant species in the area (Figure 5 & Table 1). The new grass and shrub specie types of about 18 were observed after two years of rehabilitation. Table 1 below indicates that the rehabilitation of smaller gullies by low- cost method could produce an average biomass yield of 32t/ha within two years period. This can provide additional advantages such as livestock forage, soil fertility improvement, erosion control, and other socio-economic benefits.

Table 1: Biomass production after gully rehabilitation under different measures

Gully treatments	Biomass mass (kg/ha)
Stone check-dams	33855
Stone faced brushwood check-dams	32485
Brushwood check-dams	29915
Average biomass production	32085

From Table 2 below, it was observed that there is a difference in the cost of rehabilitation per cubic meter constructed check-dams. Although there was no significant difference in soil sediment deposition as well as biomass production from the three treatments, the cost of brushwood check-dams is three- fold lower than stone check-dams, and two- fold lower than Stone - faced brushwood check-dams.

Table 2: Economic analysis of different low- cost gully rehabilitation measures

Treatment	Input cost	Maintenance cost	Total cost
stone check-dams	1342.00	2030.00	3372.00
Stone faced brushwood check-dams	1099.00	1097.00	2196.00
Brushwood check-dams	602.00	580.00	1182.00

Global Journal of Science Frontier Research (D) Volume XX Issue IV Version I Year 2020

IV. Conclusion and Recommendation

The results support that low-cost gully rehabilitation measures tested in this study could be an option to rehabilitate shallow gullies within a year. The tested gully rehabilitation measures also support the rehabilitation of vegetation, which resulted in increased effectiveness of the methods for reducing soil erosion, improving soil fertility, and providing an option for livelihood diversification. As there were not considerable differences in reducing soil erosion among the tested methods, brushwood check-dams could be used by farmers due to its cost advantage.

References Références Referencias

1. Abate, S. 2011. Estimating soil loss rates for soil conservation planning in the BorenaWoreda of South Wollo highlands, Ethiopia. *Sustainable Development in Africa*, 13,87–106
2. Alemu, O. and Awdenegest, M. 2014. Extent of Gully Erosion and Farmer's Perception of Soil Erosion in Alalicha Watershed, Southern Ethiopia. *Journal of Environment and Earth* sci.www.iiste.org. ISSN 2224-3216: ISSN 2225-0948 (Online) Vol.4, No.15
3. Assefa Derebe, 2017. Extent and impact of gully erosion in a watershed in the sub humid Ethiopian highlands. The Ph.D Dissertation, Cornell University, *Unpublished*.
4. Belayneh, L., Bantider, A. and Awdenegest, M. 2014. Road Construction and Gully Development In Hadero Tunto - Durgi Road Project, Southern Ethiopia. *Ethiopian Journal of Environmental Studies & Management*7 Suppl.: 720 –730: ISSN: 1998-0507
5. BoFED (Bureau of Finance and Economic Development). 2015. Annual Statistical Bulletin, BonkeWoreda, Gamo Gofa Zone.
6. Brittaine, R. and Lutaladio, N. 2010.Jatropha: *A Smallholder Bioenergy Crop - The Potential for Pro-Poor Development.* Integrated Crop Management. Vol. 8. FAO, Rome, ISBN 978-92-5-106438-2.
7. FAO, 2003. Data sets, indicators and methods for assessing land degradation in drylands. FAO, internet website: http://www.fao.org/DOCREP/005/Y4609E/y4609e07.htm#TopOfPage,acc.01.5.2017.
8. Food and Agriculture Organization (FAO) (2012). A National Soil Modelof Ethiopia A geo statistical approach to create a national soil map of Ethiopia on the basis of an SRTM 90 DEM and SOTWIS soil data. Master's Thesis. Faculty of Natural Sciences University of Bern, Switzerland P 126.
9. Guyo Demisse A., 2016. Assessment of fattening and marketing system, and effect of concentrate supplementation with locally available feeds on fattening performance of indigenous cattle in Bonke Woreda of Gamo Gofa zone. M.Sc. THESIS. HAWASSA UNIVERSITY COLLEGE OF AGRICULTURE, HAWASSA, ETHIOPIA, Unpublished.
10. Hailu K. A., Belayneh A., Muuz G. and Baye A., 2015. Gully Morphology and Rehabilitation Measures in Different Agroecological Environments of Northwestern Ethiopia. Research Article. Hindawi Publishing Corporation, Applied and Environmental Soil Science, Volume 2015, Article ID 789479, 8 pages http://dx.doi.org/10.1155/2015/789479. Accessed on 24/03/2018.
11. Mehretie, B. and Woldeamlak, B. 2012. Assessment of gully erosion and practices for its control in north-western highlands of Ethiopia, *International Journal of Environmental Studies*, 69:5, 714-728, DOI: 10.1080/00207233.2012.702478.
12. Nyssen, J., Poesena J., Moeyersonsc J., Deckersd, J., Mitiku H. and Lange A. 2004. Human impact on the environment in the Ethiopia and Eritrean highlands-a state of the art Earth-science Reviws 64, 273-320.
13. SIWI, 2001.Water harvesting for upgrading of rain-fed agriculture. Problem analysis and research needs. Report II. Stockholm International Water Institute. Stockholm, Sweden: Stockholm International Water Institute.
14. Wolde-Aregay B. 1996. Twenty Years of Soil Conservation in Ethiopia. A Personal Overview. SIDA/RSCU Technical Report No. 14. Nairobi.