Supplement of SOIL, 10, 637–654, 2024
https://doi.org/10.5194/soil-10-637-2024-supplement

Supplement of

Gully rehabilitation in southern Ethiopia – value and impacts for farmers

Wolde Mekuria et al.

Correspondence to: Wolde Mekuria (w.bori@cgiar.org)

S1. Survey questions

(a) Survey Questions used in Table 5

Do you think there is land degradation problem in your community?	1: Yes 0: No
If Yes: What is the most important form of land degradation?	1: Soil erosion on farm land , 2: Soil erosion on communal grazing , 3: land Gully erosion, 4: Depletion of soil quality [SOM and nutrient depletion] , 5: Degradation of vegetation covers , 6: All, 7: Other, _____
Compared to your past experience, how do you see gully formation now?	1: increasing 2: decreasing 3: remain the same
Where are gullies most frequently observed?	1: farm land 2: grazing land 3: communal land 4: other_____
What are the measures taken to control further gully formation? (multiple answers possible)	1 tree planting 2 water shade activities 3 terracing 4 other
Do you participate in watershed activities?	1: YES 0: NO
Do you think watershed activities use to control land degradation?	1: Not useful, 2: Average, 3: useful, 4: Very useful, 5 Extremely useful

(b) *Survey Questions used in Table 6*

	Awareness/Recognition
	Name three interventions or activities which you know are important to reduce land degradation? ***Open-ended question*** coded into following categories , 1 Physical SWC measures -in mountains area, e.g., hillside terrace, 2-Physical SWC measures - farmlands, e.g., bunds), 3 Gully rehabilitation measures (e.g., check-dams), 4-Afforestation/reforestation – tree planting, 5- Biological conservation measures – grass planting and related ones, 6-Water harvesting structures, e.g., micro-basins, small dams, etc.,7 Grazing land management, e.g., control grazing, cur and carry system, etc.
	Knowledge/Recall

	Please look at the following pictures which represent different gully treatments. Consider each treatment in turn and think about how effective you think it is likely to be against ***reducing gully expansion, reducing runoff and soil loss***
	How effective do you think this **[Picture]**. Gully Treatment it is likely to be against ***reducing gully expansion, reducing runoff and soil loss*** ? Likeart scale 1-5 – ineffective (0) to very effective (5)
	Capacity to Act
	If a gully started to appear on your land, and you wanted to apply this treatment **[Picture]**– Do you think
	Likeart scale 1-5 1- You and your family could get the materials and have the capacity to do the work required on your own 2- You would need help getting the materials, but you and your family could do the work required on your own 3- You could get the materials but would also need help from neighbours and friends to do the work 4- You would need help getting the materials and help from neighbours and friends to do the work 5- You would require community mobilization and action to get the materials and do the work
	Picture Code A. Gully head treatment –using stone rip rap/rubble at gully head, B. Reshaping the gully banks at 45^{o} and planting forage grasses, C Making check dams made of relatively small rocks are placed across the gully.D Making check dams constructed using vegetation or logs, E Making small barriers constructed of a series of gabion baskets bound together to form a flexible row in drainage ditches or storm water runoff channel. 
	Attitudes
	Consider the following statements . Answers on Likert Scale (1 Strongly Disagree to – 5 Strongly Agree)-
	I think that gully rehabilitation measures that individuals or small groups can implement without external support are possible and will be effective in addressing gully rehabilitation.
	I think that as an individual or as a group with neighbours or friends, if a gully appeared on my land I could take action to prevent it from becoming worse
	I think there are practices I can use in my day-to-day farming that could reduce gully formation
	I think that we as a community can prevent gullies from becoming worse
	I think that we as a community can restore land that has had gully-formation

	I think that in a small group with neighbors or friends, I can take action to which will be effective in in restoring degraded land..
	I think that we as a community can restore land that has had gully formation.
	Behaviour
	Consider the following statements Likert 1 (**No, not at all - 5 -Yes, regularly**)
	In the last 6 months, I have undertaken work on my own or with neighbours and friends to help restore and prevent gullies on the land which I use
	In my farming, I actively try to decrease gully formation
	In the last 6 months, I have undertaken work as part of the community to help restore and prevent gullies

S2. Difference-in-difference approach and Multinomial logit

(a) Difference-in-difference approach

The DD approach is one of the most popular non-experimental techniques in impact evaluation. . In a DD model, the relevant comparison is changes in the indicator over time. Thus, the comparison in a DD model is between the trends in the control group from before and after the project versus the trends in the treatment group. The double difference then refers to the difference over time (the first difference) and difference between the control and treatment (the second difference). If the trends are significantly greater for the treatment group (in a statistical sense), this suggests that the intervention had an impact. Thus, the DD estimator combines cross-sectional and over-time variation to correct for differences between groups when treated and controls start from different level. The DD approach can also be estimated using a regression approach provided there is baseline and post-treatment data for treatment and control groups. If there is, the following regression can be estimated:

$$Y_i = \beta_0 + \beta_1 D_i + \beta_2 T + \beta_3 (D_i T) + \varepsilon_i \qquad \text{(S1)}$$

Where

Yi is the outcome variable indicator of interest for respondent) i=1…N

Di is equal to one if the respondent lives in the treatment area and zero otherwise.

T is equal to zero if at baseline and one after treatment;

εi is the error term

With this estimation, the coefficient β1controls for initial differences between control and treatment, β2 controls for general trends over time, and β3 provides the estimate of impact or the average treatment effect. The fundamental assumption of the DD estimator is that the control-group trend is identical to the trend that the treated group would have had in the absence of treatment. While this assumption is not testable, its validity should always be carefully discussed to ensure that the DD properly estimates the impact of the program.

(b) Latent Variables, Measurement Items and Cronbach Alpha

Assume there exists some unobservable latent variable $\boldsymbol{\xi}$ which represent some concept of interest e.g. knowledge of gully treatments. We assume that the answers to the set of k questions (items) used in the survey will provide measurements $\boldsymbol{x_k}$ (via factor loadings $\boldsymbol{\Lambda}$) on this unobservable variable with error, $\boldsymbol{\epsilon}$, i.e.

$$\boldsymbol{x_k} = \boldsymbol{\Lambda}\,\boldsymbol{\xi} + \boldsymbol{\epsilon}\,, \quad \ldots\ldots \text{(S2)}$$

The Cronbach alpha is used to test reliability of whether the set of measurements (items) $\boldsymbol{x_k}$ are capturing the same underlying latent variable. The Cronbach alpha statistic is defined as

$$\alpha = \frac{k\bar{\sigma}_{ij}^2}{\bar{\sigma}_i^2+(k-1)\bar{\sigma}_{ij}^2} \ldots\ldots \text{(S3)}$$

Where $\bar{\sigma}_i^2$ – average variance of each measurement item k , $\bar{\sigma}_{ij}^2$ is the average covariance between the measurement items. The coefficient alpha ranges from 0 to 1, and coefficient alpha of 0.7 or greater is considered to be an acceptable measure of reliability (Taber, 2018).

(c) Multinomial logit

Multinomial logistic regression (MNL) is widely used to model discrete data where there are multiple choices and that these have no natural order (Greene 2012). In this application, the survey answers reflect the individuals perceived capacity to deal with different gully treatments, were aggregated into three categories namely, could do it on own (1) , need neighbors (2) and need community mobilization (3). The MNL models the probability of each choice as a function of whether the respondent is in a treatment area or not (Di =1.0), relative to the base category, where the base category here equals 3 (need community).

$$\pi_{i1} = Pr(Y_i = 1) = \frac{e^{\beta_1 D_i}}{1+e^{\beta_1 D_i}+e^{\beta_2 D_i}} \ldots. \text{(S4)}$$

$$\pi_{i2} = Pr(Y_i = 2) = \frac{e^{\beta_2 D_i}}{1+e^{\beta_1 D_i}+e^{\beta_2 D_i}} \ldots. \text{(S5)}$$

$$\pi_{i3} = Pr(Y_i = 3) = \frac{1}{1+e^{\beta_1 D_i}+e^{\beta_2 D_i}} \ldots. \text{(S6)}$$

With for example, the relative probability of a respondent answering that they would be able to undertake the gully treatment (y = 1) relative to the base outcome (community support needed) is

$$\frac{Pr(Y_i=1)}{Pr(Y_i=3)} = e^{\beta_1 D_i} \ldots.\text{(S7)}$$

While the discrete marginal effect defined e.g. for $Pr(Y_i = 1)$, as

$$\sum_i \big(Pr(Y_i = 1|D_i = 1) - Pr(Y_i = 1|D_i = 0)\big) \ldots. \text{(S8)}$$

Table S1. Benefits of gully rehabilitation measures in the perspective of local communities

Factors	Women Group						Men Group					
	GHT	GRP	LRC	VLC	GC	F-Category	GHT	GRP	LRC	VLC	GC	F-Category
Enables additional income						Economic	✓	✓	✓	✓	✓	Economic
Uses locally available materials	✓	✓		✓		Economic						Economic
Facilitates movement of people and livestock		✓	✓	✓	✓	Social	✓	✓	✓	✓	✓	Social
Creates opportunities for fattening		✓			✓	Economic		✓				Economic
Increases access to food and food diversity in HHs						Social	✓	✓	✓	✓		Social
Conserves water/increase access			✓		✓	Environmental						Environmental
Improves the scene of the environment						Environmental		✓				Environmental
Improves agricultural production	✓	✓		✓	✓	Economic	✓					Economic
Increases land productivity	✓	✓	✓	✓	✓	Economic	✓	✓			✓	Economic
Increases access to productive land			✓			Economic						Economic
Improves soil fertility	✓	✓		✓	✓	Environmental				✓		Environmental
Increases availability of livestock feed	✓	✓	✓		✓	Economic	✓	✓	✓	✓	✓	Economic
Rehabilitates degraded lands						Environmental			✓			Environmental
Increases livestock products		✓				Economic		✓				Economic
Improves soil moisture content		✓			✓	Environmental	✓	✓	✓	✓	✓	Environmental
Reduces damage caused by flood						Social	✓	✓	✓		✓	Social
Regulates micro-climate						Environmental					✓	Environmental
Easy to construct and takes less labor						Economic	✓			✓		Economic
Lasts for longer time						Economic			✓			Economic
Serves as a learning site						Social		✓	✓	✓		Social
Prevents farmland loss	✓	✓	✓	✓	✓	Economic						Economic
Reduces soil erosion	✓	✓	✓		✓	Environmental	✓	✓	✓	✓	✓	Environmental
Reduced run off	✓	✓	✓	✓	✓	Environmental						Environmental

***Note**: GHT refers to gully head treatment, GRP – gully reshaping and planting, LRC – loose rock check-dam, GLC – Vegetation log check-dam, GC – gabion check-dam and F-category – factor category.*

Table S2. Costs of gully rehabilitation measures in the perspective of local communities

Factors	Women Group						Men Group					
	GHT	GRP	LRC	VLC	GC	F-Category	GHT	GRP	LRC	VLC	GC	F-Category
Takes more productive lands	✓					Economic		✓				Economic
Construction takes time			✓		✓	Social						Social
Requires energy and labor	✓	✓	✓	✓	✓	Economic	✓	✓	✓		✓	Economic
Needs to be done in large scale						Economic	✓	✓		✓		Economic
Causes accidents to people and livestock		✓	✓	✓	✓	Social			✓		✓	Social
Requires collaboration among farmers						Social					✓	Social
Does not last long	✓		✓	✓		Economic				✓		Economic
Costly	✓	✓	✓		✓	Economic					✓	Economic
Less effective in reducing runoff/erosion				✓		Environmental				✓		Environmental
Could cause conflict among farmers		✓			✓	Social						Social
Lack of locally available materials	✓	✓	✓	✓	✓	Economic	✓	✓	✓	✓	✓	Economic
Requires integration with biological measures						Environmental			✓		✓	Environmental
Requires skilled labor & technical support			✓		✓	Social		✓	✓		✓	Social
Requires maintenance and protection from theft of stones						Economic			✓			Economic
Requires farm implements	✓	✓	✓		✓	Economic		✓	✓		✓	Economic
Shortage of seedlings						Economic		✓				Economic
The wood and materials like nails are exposed to theft				✓		Social						Social