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Kassa TEKA*[1,3], Tigist Araya GESSESSE[1], Yemane WELDAY[1], Aregawi BIRHANE[2], Anton VAN ROMPAEY[3]

CAN DEGRADED COMMUNAL HILLSIDE ALLOCATION TO LANDLESS YOUTH IMPROVE WOODY VEGETATION RECOVERY? A STUDY IN THE DRYLANDS OF ETHIOPIA

SUMMARY

Field survey, focus group discussions and key informants' interview were conducted to collect data on the effects of degraded hillsides allocation to landless youth groups. Data on vegetation recovery, and status of physical soil and water conservation structures were collected from 3 allocated and 3 adjacently non-allocated hillsides. Our findings indicated that hillside allocation improved the length of physical soil and water conservation structures by 58% (from 1310 meters ha^{-1} on communal hillsides to 2067 meters ha^{-1} on allocated hillsides). Hillside allocation to landless youth also improved tree survival rate, number of woody species and species diversity by 25%, 14% and up-to 62%, respectively. It can be concluded that allocation of communal hillsides to landless youth resulted in improved land management and vegetation cover on top of their economic benefits. This implies that the strategy can be taken as a potential option to overcome the challenges of land degradation.

Keywords: improved land management; regeneration; species diversity; soil and water conservation; tree survival rate; youth group

INTRODUCTION

Globally, about 10 to 20% of the dry lands are already degraded, and about 12 million ha is degrading each year (Yirdaw *et al*., 2017). The natural vegetation in communal lands was highly degraded for fuel wood, timber and grazing

[1]Kassa Teka (corresponding author: kassateka2012@gmail.com; https://orcid.org/0000-0003-2708-6812), Tigist Araya Gessesse, Yemane Welday, Department of Land Resources Management and Environmental Protection, College of Dryland Agriculture and Natural Resources, Mekelle University, Mekelle, Tigray, ETHIOPIA,

[2]Aregawi Birhane, Kilte-Awulaelo, Office of Agriculture and Rural Development, Wukro, Tigray, ETHIOPIA,

[3]Anton Van Rompaey, Kassa Teka, Department of Earth and Environmental Sciences, KU Leuven, Leuven, BELGIUM

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(Gebremedhin *et al*., 2001), which in turn led to loss of biodiversity (Oniki *et al*., 2020). For example, more than 80% of the energy used in developing countries such as Tigray, northern Ethiopia, comes from biomass (Gebremichael and Waters-Bayer, 2007; Shahzad *et al*., 2023). Forest destruction mostly occurred on steep communal hillsides due to the existence of freely available natural resources (Gebremedhin *et al.*, 2003; Berhe and Hoag, 2014).

Several alternative solutions such as hillside afforestation, conservation, privatization, state ownership, imposition and enforcement of use rules and regulations have been implemented in Tigray since the beginning of the1990s to achieve better vegetation cover and contribute to improved livelihoods of local communities (Gebremedhin *et al*., 2001; Gebremedhin *et al*., 2003; Alefew, 2016; Meaza *et al*., 2016; Shimelse *et al*., 2017). In 1997, allocation of degraded and unproductive communal hillsides to individuals has been initiated and used as a policy framework by the government and local communities in Tigray to solve land degradation and the economic problems of landless youth (Gebremedhin *et al*., 2001; Haile *et al*., 2006; Meaza *et al.,* 2016; Shimelse *et al*., 2017). For example, in Atsbi-Womberta district, where this study took place, 34,456 ha of communal hillsides were allocated to 47 youth groups/cooperatives (Gebregergs and Abraha, 2013).

Nevertheless, scaling up of these interventions is challenged by scarcity of well-organized and documented research results that indicate the contributions of allocated hillsides to vegetation recovery as well as performance of implemented soil and water conservation measures. To our knowledge, only limited studies such as Meaza *et al*. (2016), and Gebregergs and Abraha (2013) were conducted on related issues. The 1st study focused on the contributions of land allocation to degraded hillsides' re-vegetation; while the 2nd study dealt with the contributions of land allocation to the livelihood of landless farmers. However, the results of these studies cannot be fully adapted to the entire region for at least four major reasons: i) the studied locations were limited to the mid-land agro-ecology (1500-2300 m above sea level), while the region is characterized by the highland (>2300 m above sea level), mid-land (1500-2300 m above sea level), and lowland (<1500 m above sea level) agro-ecologies; ii) they were old, written based on data collected before 2013, which cannot easily fit to the recent development; iii) impact on other indicators such as the performance of the implemented soil and water conservation structures were not adequately evaluated; iv) they focused on degraded hillsides allocated to landless individual farming households, while many hillsides are also allocated to youth groups/cooperatives.

Hence, this study aimed at establishing up-to-date information on the contribution of landless youth groups' managed hillsides to woody vegetation recovery and performance of soil and water conservation structures in the highland agro-ecology.

MATERIAL AND METHODS

Study site

The study was carried-out in Atsbi-Womberta district, in the highlands of Tigray (elevation > 2300 m above sea level), northern Ethiopia (Figure 1). The total area of the district is about 147,096 ha, of which 34,456 ha communal hillsides are allocated to 47 youth groups/cooperatives. The district is geographically located between 13°33'0" - 14°6'0''N and 39°39'0'' - 39°54'0''E. The study was, specifically, piloted in three communal hillsides namely 'Tikul-emni at Ruba-felleg village, Enda-anahb at Dibab-akorean village and Adefa at Hayellom village'. The 1st site, Tikul-emni, was allocated to a formal youth group/cooperative (composed of 7 male and 10 female members) called "SEGENAT" in 2016. The 2nd site, Enda-anahb, was allocated to a formal youth group/cooperative (composed of 31 male and 17 female members) known as "SEGISELAM" in 2011. The 3rd site, Adefa, was allocated to an informal youth group (composed of 60 male and 20 female members) in 2000.

Based on the 2019 population projection, the district has a total population of 133,813 or 20,089 households. The climate ranges from cool to warm with an average temperature and rainfall of 18°C and 667.8 mm, respectively. The agro-ecology of the district is classified in to highland/Degua (75% of the total area) and midland/Weina-Degua (25% of the total area) (ILRI, 2004). However, all of the studied sites are found in the highland/Degua agro-ecology, which is related to the high population size in such agro-ecologies that requires puting every possible piece of land in to food and energy production (Gete *et al.* 2006; Gashaw *et al*., 2014). The farming system in the area is also characterized as mixed farming in which livestock rearing (such as cattle, shoat, poultry and bee keeping) and crop production (such as *Hordeum vulgare*/barley, *Triticum aestivum*/wheat, *Vicia faba*/Faba bean and *Eragoristic tef*/Tef) are integral components (ILRI, 2004).

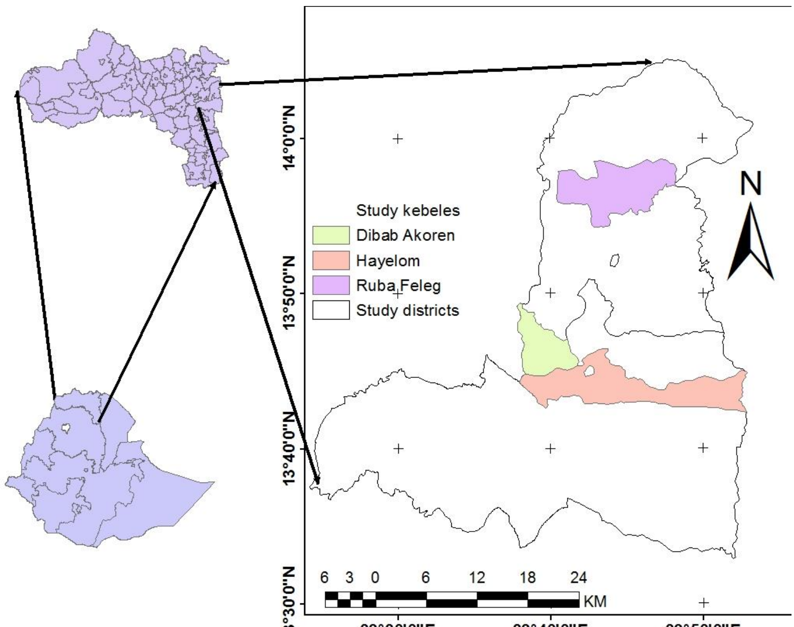

Figure 1. Location of the specific sites in Tigray, Ethiopia

Study method

Data were collected from a total of 74 plots in three allocated and three adjacent communal hillsides (Table 1). The assumption is that both hillsides had similar conditions before land allocation. Field survey (observation and measurement), focus group discussions and key informants' interview were the major primary data collection methods employed. Field survey, with the aim of assessing woody species recovery and existing soil and water conservation measures, was conducted in three parallel transect lines in each study site. Sample plots were laid along each transect at a distance of 100 meters between lines and 40 meters between plots as suggested in Abiyu *et al*. (2011) and Kuma and Shibru (2015).

Table 1. Sample plot size and their distribution (Source: Field survey, 2020).

Study site	Allocated hillsides		Non-allocated hillsides		Total	
	Ha	Plots	Ha	Plots	Ha	Plots
Tikul-emni	2.68	7	2.68	7	5.36	14
Enda-anahb	6.37	13	6.37	13	12.74	26
Adefa	9.18	17	9.18	17	18.36	34
Total	18.23	37	18.23	37	36.46	74

Each sample plot had a square shape (20 m × 20 m) and three nested compartments of different sizes as proposed in Yami *et al*. (2006) and Kuma and Shibru (2015). The woody vegetation recovery status of both land uses was determined through measurement of species composition, density, diversity, and tree survival rate following recommendations in Mengist *et al*. (2005) and Tewolde-Berhan *et al.* (2016). On the 1st compartment (20 m × 20 m plot size), three tasks were accomplished: i) the length, type and quality of the existing physical soil and water conservation structures were recorded as suggested in Walie and Fisseha (2016); ii) species composition, diversity, density and tree survival of planted and naturally grown woody species having ≥ 10 cm diameter at breadth height (dbh), and greater than two-meters in height were recorded as proposed in Yami *et al.* (2006); iii) for species having less than one-meter height, only their number was recorded as put forward in Birhane *et al.* (2006). On the 2nd compartment (5 m × 5 m plot size), both planted and naturally grown sapling trees with 2<dbh≤10 cm were counted and recorded as suggested in Tewolde-Berhan *et al.* (2016); shrubs with ≥ 2 cm diameter at 30 cm stem height above the soil surface was measured and counted as proposed in Mengist *et al*. (2005) and Yami *et al.* (2006). On the 3rd compartment (2 m × 2 m plot size), the number of naturally regenerated woody species having less than one-meter height was counted as recommended in Mengist *et al*. (2005) and Tewolde-Berhan *et al.* (2016); their survival rate was estimated following equation 1. Woody vegetation status in each site was described in terms of species diversity, species evenness and Simpson's diversity index (Kent, 2011).

$$Survival\ rate\ (\%) = \frac{Number\ of\ seedling\ living}{Total\ number\ of\ seedlings\ planted} \times 100 \quad \text{(Eq.1)}$$

To obtain more reliable information, the field survey data were supported by focus group discussions (FGDs). Therefore, a total of three FGDs each composed of twelve respondents (six from user and six from non-user group) were conducted. Finally, quantitative data obtained through field survey were analyzed by using SPSS. Descriptive statistics such as mean, percentage and frequency were used to present the qualitative results. Independent t-test was employed to analyze the differences between the two land use types (allocated and communal hillsides) and for each specific objective. The implemented soil and water conservation structures, survival rate, diameter at breast height (dbh), and vegetation density were treated as responsible variables, while land use as a group (Asmare and Gure, 2019).

RESULTS AND DISCUSSION

Impact on quality of the implemented physical SWC measures

Major physical soil and water conservation (SWC) measures implemented in the studied sites were hillside terrace, and hillside terrace+trench (Table 2). The results showed that the length of the implemented physical SWC structures was much better on the allocated hillsides, which was 58% higher as compared to the communal hillsides (from 1310 meters ha^{-1} on communal to 2067 meters ha^{-1} on allocated hillsides). Hence, hillside allocation gave a chance for additional hillside terraces and trenches construction on ten of the 37 plots.

Table 2. Occurrence of physical SWC structures in the study sites (Source: Field survey, 2020).

SWC Structure	Tikul-emni		Enda-anahb		Adefa		Total	
	AHS	NAHS	AHS	NAHS	AHS	NAHS	AHS	NAHS
Hs trace m ha^{-1}	16,500	8,500	7,500	20,500	33,000	19,500	57,000	48,500
Hs+trenc m ha^{-1}	0	0	18,000	0	1,500	0	19,500	0
Coverage m ha^{-1}	16,500	8,500	25,500	20,500	34,500	19,500	76,500	48,500
Mean m ha^{-1}	2,357	1,214	1,961	1,576	2,029	1,147	2067	1310
Std.dev	244	447	431	187	514	606	459	593
M.difference	1,143		384		882		123	
T-value	3.22		2.95		4.58		6.14	
p-value	0.015		0.009		0.000		0.000	

AHS=Allocated, NAHS=Non-Allocated

Our findings also indicated that the quality of physical SWC structures on allocated hillsides was more superior to those on the communal hillsides (Table 3). The dimension (height and width) of the implemented SWC structures on allocated hillsides were statistically different (p<0.001) as compared to the communal hillsides. Out of the 37 plots studied on the communal hillsides, physical SWC measures implemented in four plots were totally destructed; while these structures were fully maintained on the allocated ones.

Table 3. SWC structure dimension (width and height) in the study sites (Source: Filed survey, 2020).

Dimension	Tikul-emni		Enda-anahb		Adefa		Total	
	AHS	NAHS	AHS	NAHS	AHS	NAHS	AHS	NAHS
Width								
Mean	0.3	0.27	1.0	0.32	0.32	0.24	0.56	0.28
Std.Dev	0	0.21	0	0.04	0.07	0.14	0.33	0.13
Mean diff	0.04		0.68		0.08		0.28	
T-value	0.367		55.66		2.10		7.32	
p-value	0.73		0.000		0.047		0.000	
Height								
Mean	0.5	0.36	1.18	0.38	0.58	0.30	0.78	0.34
Std.Dev	0.21	0.28	0.06	0.13	0.10	0.17	0.31	0.18
Mean diff	0.14		0.08		0.28		0.44	
T-value	1.34		20.66		5.79		7.32	
p-value	0.205		0.000		0.000		0.000	

AHS=Allocated hillside; NAHS=non-allocated hillside

Impact on vegetation recovery

Tree survival rate

The vegetation regeneration status of woody plants was also evaluated taking tree survival rate as an indicator. Our findings indicated that hillside allocation increased tree survival rate by more than 25% as compared to the communal ones (Table 4).

Table 4. Summary of planted trees and their survival rate (Source: Field survey, 2020)

	Tikul-emni		Enda-anahb		Adefa		Total	
	AHS	NAHS	AHS	NAHS	AHS	NAHS	AHS	NAHS
Planted (N ha^{-1})	2,100	2,010	1,800	1,900	3,900	3,910	7,800	7,820
Counted (N ha^{-1})	1,655	1,000	1,150	820	2,820	1,835	5,616	3,655
Survived (%)	78.8	50.05	64.05	43.2	72.3	46.9	72	46.7
p-value	0.006		0.010		0.009		0.001	

AHS=Allocated hillside; NAHS=Non-allocated hillside

Woody species density

Field survey results indicated a significant difference on the number of woody plant species between the two land use types (Figure 2). Woody species in the order of occurrence on the allocated hillsides were *Acacia seyal* (25.6%) > *Olea africana* (21.3%) > *Dodonea angustifolia* (17%) > *Juniperus procera* (10.9%) > *Rhus vulgaris* (8.1%) > *Acacia etbaica* (9%). Whereas, *Dodonea angustifolia* (18%) > *Calpurnia aurea* (3.3%) > *Carissa edulis* (3.8%) dominated the communal hillsides. Land allocation to youth groups increased the number of trees in a hectare from 25 to 148 trees, a 4.9-fold increase.

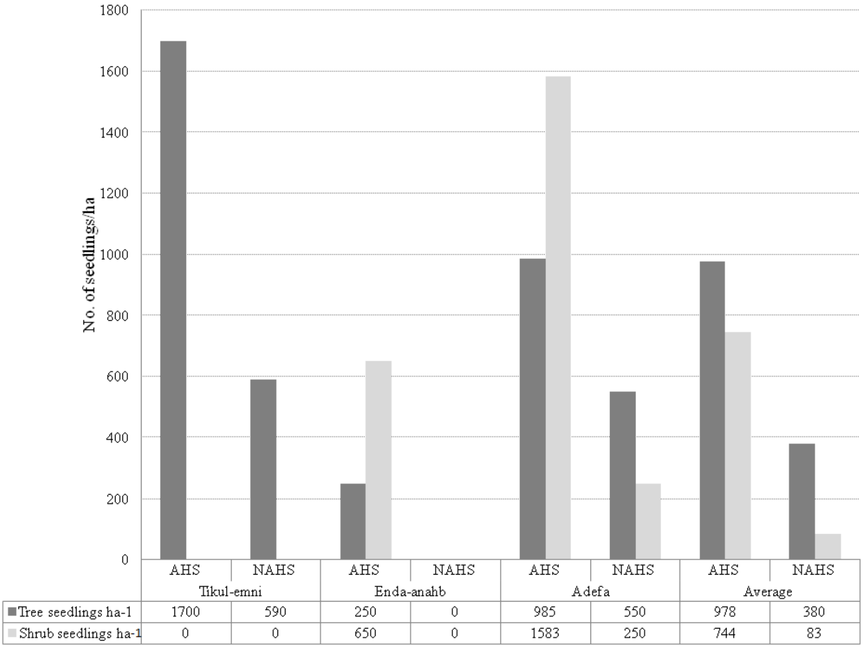

Figure 2. Number of tree and shrub seedlings in a hectare in the study sites

<u>Woody species composition</u>

The experimental results indicated that allocated hillsides had higher species composition than the communal ones (Table 5). Allocated hillsides had 16 woody species representing 12 families; while only 14 species representing 10 families were recorded in the communal hillsides. This implies hillside allocation to landless youth improved woody species and family's composition by 14.3% and 20%, respectively; while species diversity increased by up to 62%.

Table 5. Shannon–Wiener diversity index of species in the study sites (Source: Field survey, 2020)

Species	Tikul-emni		Enda-anahb		Adefa		Total	
	AHS	NAHS	AHS	NAHS	AHS	NAHS	AHS	NAHS
Sh.diversity	1.64	1.10	1.22	0.95	1.78	1.07	2.4	1.48
S. diversity	0.79	0.59	0.68	0.52	0.73	0.59	0.85	0.72
Evenness	0.85	0.69	0.87	0.68	0.68	0.49	0.76	0.56
Abundance	90	164	422	567	541	498	1053	1229

AHS=Allocated hillside; NAHS=non-allocated hillside

<u>Woody species diversity</u>

The Shannon diversity index of woody species indicated that *Eucalyptus globulus, E. camadulensis*, *Euclea schimperi*, *Rumex nervosus* and *Becium grandiflorum* were uniformly distributed all over the sampled plots in the allocated hillsides. However, two of these species (*Calpurnia aurea* and *Carissa edulis*) were absent in the adjacent communal hillsides. *Rumex nervosus* (0.39), *Becium grandiflorum* (0.36) and *Euclea schimperi* (0.35) were more diverse than the other species found in the non-allocated hillsides.

Species evenness

Species equitability (evenness) ranges between 0.33 and 0.75 for non-allocated hillside, while it was 1.0 for the allocated ones. These values indicate that allocated hillsides were more diverse than their adjacent communal hillsides. Similarity assessment results, above 0.58 in most of the studied plots, indicate the species were nearly similar.

Stand basal area, important value index (IVI) and dominancy

Table 6 shows the measurement results of stand basal area, important value index (IVI) and dominancy of both land uses. The survey results indicated higher basal area (3.73 m^2 ha^{-1}) on the allocated than that of communal hillside (0.78 m^2 ha^{-1}). Taking tree basal area as an example, allocated hillsides had higher tree basal area (5 m^2 ha^{-1}) than communal hillsides (0.3 m^2 ha^{-1}). Important value index (IVI) and dominancy values also shown variation between the studied land use types. On the allocated hillsides, *Eucalyptus* species had the highest important value index (IVI); while, *Calpurnia aurea* and *Withania somnifera* had the lowest IVI. Shrubs such as *Euclea schimperi*, *Becium grandiflorum*, and *Rumex nervosus* had the highest IVI in the communal hillsides. The highest IVI indicates that the species is uniformly dispersed with big value of dominancy position.

Table 6. Stand basal area measurement results (Source: Field survey, 2020)

Species	Tikul-emni		Enda-abahb		Adefa		Total	
	AHS	NAHS	AHS	NAHS	AHS	NAHS	AHS	NAHS
Tree g ha^{-1}	1.37	0	8.29	0	6.60	0.20	5.11	0.33
Sapling g ha^{-1}	2.54	0.61	3.00	0	3.21	1.24	2.69	0.94
Shrub g ha^{-1}	0.98	1.21	1.66	1.40	3.41	5.56	2.58	3.14
Total	2.48	0.57	4.50	0.47	3.27	0.74	3.73	0.78
Mean difference						2.54		2.95
T-value						1.75		1.40
p-value						0.009		0.000

AHS=Allocated hillside; NAHS=non-allocated hillside

DISCUSSSION

Quality of the implemented physical SWC measures

The dominance of hillside terrace and hillside terrace+trench in the study area (Table 2) supports the findings of Asnake and Elias (2017) for the hilly and mountainous areas of Ethiopia. Moreover, Desta *et al.* (2005) stated that the dominant presence of hillside terraces on such mountainous areas was related to its suitability to construct on arid and semi-arid environmental conditions. The superior quality of physical SWC structures on allocated hillsides (Table 3) was related to the continuous and improved construction and maintenance of SWC structures by the youth groups that in turn led to the lower destruction and exploitation status of these and other resources in these hillsides (Mekonnen and Tesfahunegn, 2011).

Vegetation recovery

The highest tree survival rate result, 25% higher than the communal ones, shown in Table 4 corresponds with the findings of Jagger *et al.* (2005) that reported community-managed woodlots had lower tree survival rate (approximately 45%) compared to the household managed woodlots with 65% survival rate, an increase by 20%. Limited sense of ownership of the community in the community managed hillsides was the major reason for the poor tree survival rate. Results from the focal group discussions (FGDs) and key informants interview indicated that majority of the local community assume communal hillsides as the property of the local authority. As a result, farmers throw–out seedlings to the surrounding, plant upside down during plantation campaign, and send livestock to graze/ browse in the dark. These reports are in par with the findings of Meaza *et al*. (2016) that pointed out moisture stress and free-ranging by livestock were the major reasons for the poor tree survival rate in the communal hillsides.

In addition to its positive impact on tree survival rate, land allocation to youth groups resulted to a 4.9-fold increase in the number of trees in a hectare (Figure 2). This implies that land allocation to youth groups results in better vegetation recovery as compared to their corresponding communal hillsides. These results are also in accordance to the findings reported in Gebregergs and Abraha (2013) that revealed an increase of tree density in managed fields by a factor of 4.1 over disturbed hillsides. Mengist *et al.* (2005), Mekuria and Aynekulu (2011) and Manaye *et al.* (2019) also reported a similar result that revealed better regeneration potential in managed fields than adjacent communal fields.

Survey results on species diversity have also shown a 33% increase on allocated land as compared to the communal fields (Table 5), which is in par with the results of Asmare and Gure (2019). However, in most of the studied plots, similar plant species were found. This is in agreement with the findings of Manaye *et al*. (2019) that revealed a high species similarity due to the presence of similar edaphic, climatic condition and altitudinal ranges of the existing land use and vegetation types in the past that in turn leads to re-appearing of similar vegetation types.

The survey results, further, indicated a 378% higher basal area on allocated hillsides than those of communal ones, in which *Eucalyptus* species had the highest important value index (IVI) and dominancy. The highest IVI of *Eucalyptus* species in the allocated hillsides was related to its high preference by the community for multiple uses, economic returns, and resistance to water stress and ecological agents (Saadaoui *et al.,* 2017; Birhanu and Kumsa, 2018; Getnet *et al*., 2022). The dominancy of *Euclea schimperi*, *Becium grandiflorum,* and

Rumex nervosus in the communal hillsides, was also related to their advantage of primary succession and less palatability for browsers (Birhane *et al*., 2007).

CONCLUSIONS

This study assessed the effect of allocated degraded hillsides on woody vegetation recovery and quality of the implemented physical soil and water conservation (SWC) structures by comparing them with adjacent communal hillsides. Survey results showed that the quality and quantity of the implemented SWC measures were much better on the allocated hillsides. Hillside terrace + trench was particularly implemented on the allocated hillsides to boost the growth of planted trees through minimizing soil moisture stress. From the length point of view, the area coverage of SWC was 58% higher on allocated hillsides. Trees survival rate was also 25% higher on allocated hillsides. Moreover, allocated hillsides were better in species composition, diversity and density. Thus, it can be concluded that allocating degraded hillsides to landless youth groups improves woody vegetation recovery, and quality of soil and water conservation structures in addition to their economic benefits.

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