"It is our environment": Farmers' response to degraded hillsides in the northern highlands of Ethiopia

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Abstract

Land degradation is a generic challenge of our time that decreases agricultural productivity. As a response, land rehabilitation measures have been undertaken in northern Ethiopia. However, some of the rehabilitation measures were not means for ends. Hence, the study focused on how farmers responded to degraded hillsides in eastern Tigray. Interview, focus group discussions and transect walks were employed to generate the required data from103 farmers. χ^2 *-test was run to investigate the perceived impact of land degradation; land use changes; extension service delivery; land ownership and investment across study villages. Farmers revealed that land degradation is a driver for crop yield reduction* ($\chi^2=5.23$, $df=3, P<0.002$)*. The study also showed that farmers' perception on wasteland allocation for tree planting was homogeneous across the study villages* ($\chi^2=9.89, df=3, P<0.00$)*. A bylaw was developed on guarding system; rehabilitation measures and production system for effective management of hillside plantation. In conclusion, indigenous knowledge practices go in line with the corridor of the Growth and Transformational Plan designed for sustainable development. Therefore, integration of the existing farmers' knowledge into scientific knowledge is essential to improve natural resource management while ensuring food security in the northern highlands of Ethiopia.*

Keywords: Land degradation – Landless farmers – Tree planting – Indigenous knowledge – Bylaw

Introduction

Land degradation remains an important global problem for the 21st century (Gisladottir & Stocking 2005). Its dynamic process depends on bio-physical, socio-economic and institutional factors with strong negative effects on food security and quality of life for 70% of the dry lands in tropics (Nyssen et al. 2009a). For its pervasive synergy with climate change and biodiversity loss (Feoli et al. 2002), land degradation captured attention of world scholars since

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the last eight decades. Consequently, Millennium Development Goals (MDGs) and National Action Plan to fulfill the ratification of United Nations Convection to Combat Desertification have designed. Poverty reduction by mobilizing natural resources into development agenda in sustainable way is target of MDGs to mitigate land degradation (Nwonwu 2008).

Solid studies indicate that the problem of land degradation is serious and extensive in northern highlands of Ethiopia (Descheemaeker et al. 2006; Hurni et al. 2005). Northern part of the country (40%) hosts 90% of the human population and 70% of livestock (Nyssen et al. 2009b). The excess land demand resulted pushing cultivation onto steep slopes and forest pockets (Mitiku et al. 2006). Likewise, land policy has been guided by the ideology of state control (Menale et al. 2010). The ideology challenges sustainable utilization of environmental resources (Hagos & Holden 2006). Consequently, natural resources base suffered from soil erosion; nutrient depletion, and soil compaction (Girmay 2009) and thereby accelerated ecological degradation (Betru et al. 2005). Since Axum civilization (600 AD), agriculture sector failed to feed the growing population in Tigray (Yohannes & Waters-Bayer 2007). To this effect, about 80% of the households were classified as food insecure and 58% of the households were living in absolute poverty. This indicates land degradation is equally cause and effect of poverty for marginal people in drylands (UNEP 2008).

Rehabilitation strategies have embarked to address problems of land degradation since the last two decades in northern highlands of Ethiopia. Establishment of Area exclosure (Emiru 2006); woodlots (Jagger et al. 2005); agroforestry (Kindeya 2004); land certification (Menale et al. 2010) and integrated watershed management (Mitiku et al. 2006) have been practiced to curb land degradation. Unlike Asefa et al. (2003), the continuous conversion of commons to area exclosure was planned primarily for regeneration of degraded forests and gave less emphasis for benefits (Betru et al. 2005) and thereby caused lack of livestock feeds and fuel wood for local farmers. Attributed by ignoring local participation in the projects (Durand & Lazos 2008), achievement was partial and sense of responsibility on the rehabilitation measures was limited. Moreover, population pressure and shrinkage of cultivable plots triggered landlessness (Hooton & Hagos 2007).

Emanated from increasing land degradation, landlessness and poverty, local farmers were at the forefront to respond land degradation. Based on their own initiative, farmers recommended to respective village councils to allocate the degraded hillsides to landless and nearly-landless farmers for tree planting. After pilot project, the initiative was integrated into regional land policy as new tool of land management in 1997 (Kindeya 2004) and since then degraded hillside has been allocated for tree planting parallele with establishement of area exclosure. However, farmers' practices to manage the allocated degraded hillsides in the process were hardly documented. Therefore, the study was aimed at assessing farmers' perception and response to degraded hillsides in eastern Tigray. Targeting the beneficiaries of hillside plantation, the research questions include: How did farmers perceive land degradation and consequent landuse changes? How did farmers manage the degraded landscapes?

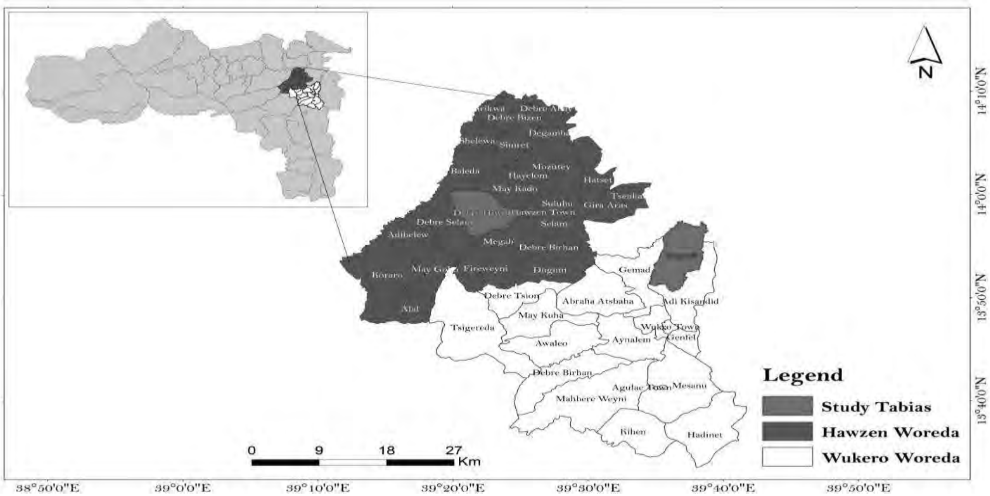

Fig.1: Map of the study areas (the boundaries are tentative)

Materials and method

Study area

The study areas, Ḥawzén and Negash, are located in eastern Tigray, northern highlands of Ethiopia (Fig. 1). Ḥawzén is located between 13° 58' 39" N and 39° 25' 45" E with an average altitude of 210m covering a total area of 8576.64 km^2. With a total area of 58.66 km^2, Negash is situated 13° 52' 42"N and 39° 35' 52"E and has an average elevation of 2025m. The topographic feature of the study areas is flat (40%), sloppy (15%) and hillside (45%). The soil type of Ḥawzén (Cambisols) and Negash (Fluvisol) is composed of sandy loam and clay loam textures (Efrem 2008). Rainfall of the study sites is variable as it is influenced by Inter-Tropical Convergence Zone (Feoli et al. 2002). Ḥawzén district has an average temperature of 21^{0}c with annual evapotraspiration of 152mm and mean rainfall of 519mm. According to the traditional agro-climatic classification, the study area consist of *Degu'a* (>2300m), *Hawusi Degu'a* (1500-2300m) and *Qolla* (500-1500m) elevations representing 9.5%, 68.5% and 22% coverage respectively (BoNAR 2009).The dominant stable crops are finger millet (*Eluesinecoracana* L.), wheat (*Triticumaestivum* L.), maize (*Zea mays* L.) and barley (*Hardeumvulgare* L.). Wastelands inḤawzén shares 41,197.25ha (49.04%) of other land uses and contributing 77.73% of wasteland in Tigray. The study sites were characterized by limited cultivable land and farming on steep slopes (Tesfay 2008). Moreover, eastern Tigray is known for its livestock population. Free grazing; crop residues and cutting grass from margin of mountains are main source of feed for livestock (Efrem 2008).

Data collection and analysis

Smallholder farmers who had considerable hillside plantation were target of this study. List of the households was obtained from Farmers Training Center (FTC). Representative districts including Ḥawzén (Ahrag (70%) & Dongar (65%)) and Wuqro (Addi-Qeshi (75%) & Qal-Habile (80%)) forming 103 sample households were selected randomly. Questionnaires were tested for 20 households in Addi-Qeshi village to ensure if the research protocol was healthy (Bryman 2008). The pre-tested-interview was employed to capture socio-economic condition of the respondents. Farmers’ perception on indicators of land degradation; land use changes; tenure system; delivery of extension services and management strategies were also interviewed. Focus group discussions were also held in seven compartments having six participants in each group to generate information on extension service delivery and sense of land ownership. Age, gender and education level of the respondents were considered during group formulation (Sattler & Nagel 2010). More importantly, older beneficiaries were considered as their cumulative indigenous knowledge on the landscape changes is better (Oba et al. 2008). Ultimately, transect walks along the managed and disturbed hillsides were complemented to observe farmers’ activities at FTC; intensity of erosion (sheet, rill and gully) and management system.

The data was managed using MINITAB (version 15.1) software package. Editing, reducing and cleaning of the data were performed to keep logical consistency and legitimacy of the assigned variables. Descriptive statistics was computed on the measured variables. Pearson’s Chi-square (χ^2) test was used to compare categorical responses on the impact of land degradation; critical problem of land degradation; land use changes and application of physical structures between hillsides using $\chi^2 = \sum [(Q_i - E_i)^2 \div E_i]$, where Q_i = observed frequencies and E_i = expected frequencies. *Goodness-of-fit test* on level of extension services; land investment, and land security was also used to analyze perception homogeneity across the villages. Beneficiaries’ suggestion with respect to what to do with the rest of communal land was narrated. What is more, content analysis on sketches produced by the farmers at FTC was carried out.

Results and discussion

Demographic and socio-economic characteristics of the farmers

Age, sex and family size were important variables to understand demographic characteristic of the farmers. Most of the farmers were within the active working group (25 to 44 years) and the mean age was 41.33±10.90 years (Mean ± SE). Of the target population, female-headed households accounted 11.6%. The result reveals that most of the farmers involved at hillside plantation were male-headed households. This indicates that women were singled out from hillside plantation and agreed with the narration "leaving the two thirds women out of development" (Haward & Smith 2006). Family size was indicator of wealth status in the study villages. Households with better family size involved in on-farm; off-farm, and non-farm activities to diversify their income sources. Similarly, Holden et al. (2004) showed that good family size was better-off income.

Despite the fact that education is considered as prevailing human capital affecting the livelihood of the households (Nwonwu 2008), 78 % of the respondents did not get formal education. Age analysis indicated that those who attended formal education were below 35 years old revealing access to education was recent phenomenon in the villages. The respondents (73%) owned mixed livestock species of varied herd sizes. However, some of the respondents owned neither cattle (16%) nor small livestock (12%). Moreover, land is the most decisive factor production system by influencing natural capital, and social and economic development (UNEP 2008). Landholdings was fragmented and located here and there at an average of 3.5 plots. Statistically, 56% of the respondents had land size of 1.75±1.00 *tsimidi* (one *tsimidi* is equal to 0.25ha) and 44% of the respondents were landless.

Farmers' perception on land degradation and the consequent land uses

Farmers recognize a change in the environmental resources during their lifetime. They had traditional knowledge of classifying soil types based on suitability for various crops production per a specific plot of land. Ox-drawn-plow, sticks and finger detection technologies were used to catalog the soil quality of cultivable plots. The perceived impact of land degradation on land productivity was significant (χ^2=5.23, d*f*=3, p<0.002). Farmers from Adi-keshi village were the most supportive that land degradation remained the most important driver of crop yield reduction at plot level due to soil erosion; nutrient depletion and gully formation. Furthermore, non-timber forest products which were an integral part of gap-filling during bad years were challenged by land degradation. Correspondingly, a study undertaken in Ethiopia (Worku 2008) and Kenya (Okoba & De Graaff 2005) indicate that soil erosion is a serious problem that threatens agricultural productivity. Farmers perceived that if consistent joint effort is performed; the trend of land degradation will decline and ecological functions will be restored. The finding confirms that farmers do have home-grown knowledge to predict potential land degradation effects and thereby model environmental management (Fig. 2). The result is analogous with a photographic record over 30 years reporting vegetation cover increased due to enormous environmental initiatives (Nyssen et al. 2007).

Farmers perceived that area exclosures was a source of conflicts and social complication among farmers due to its crude sharing of benefit streams (grass and dead trees). In this regard, a woman forwarded that "The system of land rehabilitation that excludes local people does not benefit women and old people, rather people with physical capability and good family size are primarily users". In agreement with Acharya (2005), farmers opted that degraded hillsides have to be distributed for tree planting (χ^2=9.89,*df*=3, p<0.00) to address the issues of landlessness and land degradation. The result indicates that rehabilitation strategies should be linked to multiple benefits which diversify livelihood opportunities for the poor. The rehabilitation strategies have to create synergies between targeted technologies, policies and institutions to improve productivity and sustainable resource use (Ostrom 1990).

FTC is built as a center of participatory demonstration and training for farmers in the study area. Development Agents (DAs) provided training for farmers on how and what to plant; how to manage hillside plots and means to integrate beekeeping into treated gullies. Technical advice on technologies and improved agricultural inputs and market information was also given to the communities. The farmers were almost homogeneous on extension services satisfaction across study villages (χ^2=16.92, *df* =9, p<0.72). However, 30% of the respondents claimed that DAs had little contact with most of the farmers and were selective with some influential farmers. The result is consistent with the findings of other researchers from Nigeria (Yila & Thapa 2008) and Uganda (Nyombi et al. 2006) showing extension workers were not a bridge of communication between farmers and research works.

The mean frequency of the study villages in terms of hillside plot ownership was statistically indifferent (χ^2=3.38; p<0.34). There were, however, beneficiaries (29.5%) who did not know whether they own hillside plots and this weak-link perceived by the farmers could bear unwise environmental resources exploitation. In line with this, clear tenure system is the best alternative to respond to land degradation through sustainable utilization of natural resources (Hagos & Holden 2006). Similarly, Hanjra et al. (2009) concluded that pure tenure security has positive effect on farmers' long term investment.

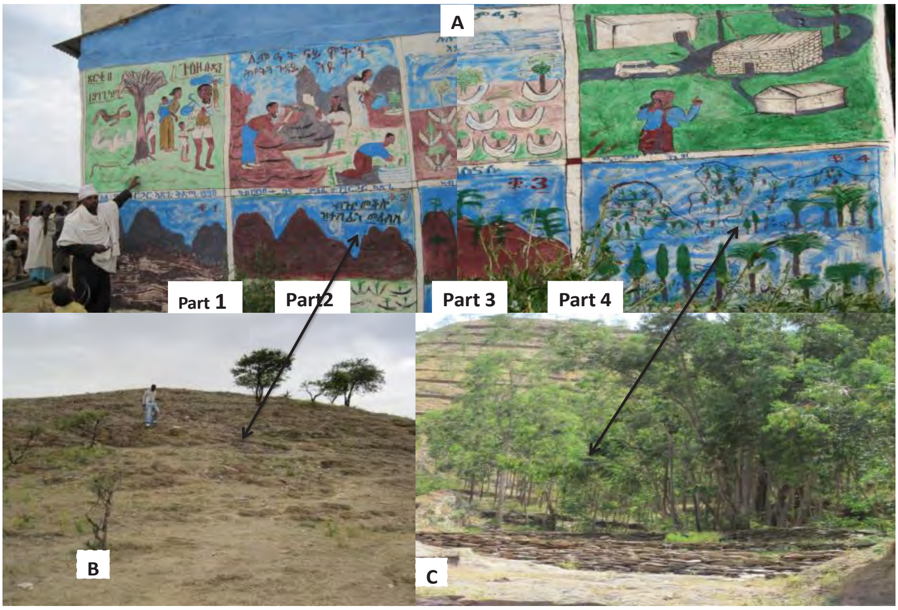

Fig. 2: The status of hillside plantation after 12 years of farmers' scenario (part 4A) in Ḥawzén

Farmers' art and management of degraded hillsides

Farmers interact to exchange information about environmental changes, poverty and the way out. Social networking at FTC appeared to play a significant role in the adoption of introduced technologies. As a response to degraded hillsides and build sustainable communities, the sketch was designed by self-initiated farmers as foreseen strategic plan (Fig. 2A). The sketch describes the chronological interventions to seek solutions to land degradation. It has four parts (Part 1 to 4) under the motto of "Greening the degraded hillsides and reduce landlessness". Part (1) indicates that the degraded hillside is devoid of vegetation and named as *Mingirgar Adgi* (*donkey's field*) to show how the hillside was unproductive. Hillside plots will be distributed to landless farmers if s/he: did not get land in the last re-distribution (1991); had small landholding and can care for the land on his own initiative (Part 2). Farmers will plant woody perennials and half-moon and bunds (Part 3). Eventually, *Mingirgar Adgi* will be covered by ecologically friendly tree species and communities will improve their lives (Fig. 2A).

To realize the farmers' scenario (Fig. 2), they developed a *Serit* (bylaw) on guarding system; maintenance of rehabilitation measures, and production system for hillside plantation. The *Serit* was respected for its good attachment with the norm and traditions of the farmers. In agreement with Tadele (2008) and Vatn (2005), local institutions are means to reduce transaction costs, and uncertainties that handicaps for effective utilization of natural resources.

Common forest guards were recruited among farmers to protect from external interventions. Number of forest guards was determined by the size of hillsides and vulnerability to livestock and human encroachment. According to the *Serit*, farmers reported the number of dead seedlings, saplings and trees to the village councils on regular basis. After report if the forest guard did not perform well, a fine was imposed. Consistent with Scoones (2009), formal and informal institutions govern people's behavior by providing adjusted framework of incentives that shape economic, political and social organization.

As part of the *Serit*, maintenance efforts on physical structures were undertaken quite regularly every year to reduce the effect of slope length and slow down run-off. The application of physical structures between the sub-watersheds (χ^2=3.38;*df*=6;P=0.34) were indifferent, though trench (in Dongar and Ahrag) and Fanyujuu (Addi-Qeshi and Qal-Habile) structures were practiced exclusively. Moreover, farmers built *Daget*, which is a kind of local structure, throughout the catchment by leaving unused part of hillside patches. The scale of intervals between the *Dagets* was determined by the land slope: the gentler the slope, the greater distance between *Dagets* was. It was engineered to grow grass; get advantage of water from intercepted runoff, and serve as a boundary among/between plots. The effort resulted in useful addition to groundwater. In line with this, Mitiku et al. (2006) proved that linking indigenous knowledge along with introduced knowledge is important to ensure sustainable land management in the drylands.

Biological measures were sublimated to the structural works where it was found that physical measures alone were not adequate. In this regard, stone terrace was first applied to stabilize the soil in dry season. Tree planting and seeding was then followed in rainy season. Moreover, farmers knew what types of grass/tree species to plant based on the benefits they receive. Silivicultural characteristics of the species; growing rate; ability to coppice and expectation of high economic return were criteria used for tree and grass species preference. Hillside plots were divided into tree and grass production to optimize the benefit streams with articulated calendar of when to plant, and how frequency to harvest depending on their livelihood strategies. Sattler & Nagel (2010), als o reported that farmers were informed about the legislation regarding decision making, monitoring, and implementing different activities of woodlot plantation.

Farmers planted exotic (E.camaldulensis) and indigenous (A.etbaic, D.angustifoli and O.Africa) tree species. Euphorbia and Opuntia species were seeded along steep slopes due to long rooting system that intercept excessive runoff and increases soil organic matter in the upper layer of the soil profiles.

Shallow rooting species, conversely, were seeded on gentle slopes of hillside plots (Elephant grass). Watering, spacing, pruning and weeding the seedlings were part of the *Serit*. Rehabilitated hillsides were a source of improved fodder production; availability and honey production. C*ut-and-carry* conventional system was used to harvest grass species using sickle after seeds are dispersed for the next rainy season. Moreover, farmers dispersed seeds to new hillside plots where the seeds were absent before. In agreement with Aerts et al. (2006), this practice contributed conserving genetic resources. Economic tree were also harvested after maturation and enough substitution. In light of Ticktin's empirical evidence (2004), farmers' knowledge on timing of timber harvesting was varied on socio-economic grounds of the farmers.

Conclusion

This research demonstrated that smallholder farmers were clear about cause-consequence-mitigation loops of land degradation. They preferred that allocation of degraded hillside for tree planting to meet socio-economic demand while restoring the environment. A bylaw was developed as a management tool for effective hillside management. However, the study reveals that farmers claimed that development agents had frequent contact with selective farmers. Therefore, timely delivery of extension services has to be considered as the best institutional arrangement to improve management of hillside plantation. In land scarce areas, set-aside of degraded land for natural regeneration is not a real option to address the issue of land degradation. Therefore, less-favored hillsides should be allocated for household tree planting to assist landless farmers parallel to setting-aside of degraded hillsides for vegetation regeneration. Farmers' efforts for environmental caring need to be supported by policies, incentives and knowledge.

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