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On-Site Cost of Gully Erosion and Benefit-Cost of Rehabilitation vs. Establishment of Conservation Measures in the Kilimanjaro Region, Tanzania

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Abstract
This study provides empirical justification for prevention of on-site costs of gully erosion so as to raise political and public awareness of the impacts of land degradation and significance of sustainable land management from an economic perspective in the Kilimanjaro Region. In the context of this paper, the on-site cost of gully erosion is about TZS 82.61 million ha^{-1} and TZS 82.22 million ha^{-1} respectively assuming maize, a staple in the Kilimanjaro Region and sunflower, a commercial crop are grown. From an economic perspective, it is more viable to establish soil-erosion control structures than gully rehabilitation. The average benefit-cost ratios for the latter are almost three times as much as for the former if maize is grown, but two times more in the case of sunflower. These results support the old adage that says "prevention is better than cure". This information is of particular significance because some decision-makers and land-users have inadequate knowledge of the need for preventing soil loss from an economic viewpoint. They contend that the durability of rehabilitation interventions outweighs the short-term gains of investing in soil-erosion control structures. Considering that land in the region is being degraded by soil erosion, while the rest is vulnerable because of physical factors and anthropogenic activities, it would be prudent of decision-makers especially to support sustainable land management initiatives that aim at controlling soil loss instead of rehabilitation after vast amounts of land are rendered unproductive due to soil loss.
Keywords: on-site cost, empirical evidence, rehabilitation, conservation measures, crops

1. Introduction

This study provides empirical justification for prevention of on-site costs of gully erosion so as to raise political and public awareness of the impacts of land degradation and significance of sustainable land management from an economic perspective in the Kilimanjaro Region. Empirical justification in terms of financial costs informs decision-making on the part of land users and decision-makers whether to implement soil-erosion control measures or fund costly rehabilitation works. Such an economic perspective is almost non-existent from East Africa, Tanzania specifically. Instead, studies have emphasized on soil erosion-crop productivity relationships (Kaihura *et al*., 1997, Lal and Singh, 1998, and Lal *et al*., 2003). The absence of empirical justification may explain why some decision-makers and land-users, apparently with inadequate knowledge in sustainable land management, contend that the durability of rehabilitation interventions outweighs the short-term gains of investing in soil-erosion control structures.This study fills that gap.

Although some investigators in the United States of America (Pimentel *et al.,* 1995, Uri 2000, Yuan *et al.,* 2002, and Zhou *et al.*, 2009) and Ethiopia (Yitbarek, *et al.,* 20012) have estimated the on-site costs of erosion and conducted analyses of the benefit-cost of soil conservation measures, there are considerable differences between American and African environments. Even within Africa, the environmental conditions in the north-eastern, where Ethiopia is located, are different from those in the East. Consequently, it is difficult to apply the American or Ethiopian economic values to local conditions because cost of materials and labour used in either rehabilitation of gullies or installation of conservation measures, and discount rates applied in such analyses may not be the same. As such, the results may not be applicable to Tanzania.

The Kilimanjaro ecosystem provides a range of services including water catchment, soil formation, nutrient cycling, and primary production. The mountain supports a tourism industry, hosting close to 10,000 tourists annually (United Nations Development Programme ((UNDP), 2010). However, the ecosystem is experiencing extensive degradation and deforestation, which is driven by a set of complex interrelated physical and anthropogenic factors, such as gradient, soil erodibility, rainfall erosivity, poor land-management practices, unsustainable harvesting of natural resources, etc. Some patches of the forests and agricultural lands have almost crossed "thresholds of irreversibility" in the course of ecosystem degradation, making "passive" restoration to a presumed pre-disturbance condition impossible (Aranson *et al*., 1993). Examples include completely deforested patches and numerous enormous soil-erosion gullies (refer to examples in the Methods section).

Soil erosion has three types of costs, i.e., energy, on-site, and off-site (Pimentel, *et al*., 1995). Energy costs are incurred on the use of fossil energy-based fertilizers, pesticides, and irrigation to provide high yields (Kendall and Pimentel, 1994). On-site costs are expended to replace lost nutrients (Pimentel *et al.,* 1995, Yitbarek, *et al.,* 20012). Regarding off-site effects costs, dislodged soil particles are transported into water bodies where the suspended sediments have a negative effect on the feeding and breeding behaviour of fish. They cause turbidity thereby limiting the penetration of light, which is essential for primary production (Bootsma and Hecky, 1999). Additionally, sediments seal holes where most of the rock-dwelling cichlids breed (Reinthal, 1993; Munthali, 1997). With gully erosion, the most important effect is the massive loss of soil which prevents the land from being used for cultivation (Yitbarek, *et al.,* 20012).Gullies, therefore, require interventions to promote a favourable environment for the establishment of plants, which increase soil protection, and enable sediment deposition to occur (Anon. 2003).

In response to the land degradation, the Government of Tanzania, with technical and financial support from the Global Environment Facility (GEF) and United Nations Development Programme (UNDP), is implementing a 4-year project aimed at promoting sustainable land management in the highlands of Kilimanjaro Region. Activities include rehabilitation of gullies and establishment of soil-conservation measures. Gully rehabilitation involves use of physical and biological measures. Physical structures such as check dams of wire gabion boxes, and gunny sacks filled with sand are employed. In one rare case, rocks and concrete were used to avoid theft of wire gabion boxes. Biological methods involve planting of bamboo and vetiver to stabilize gully floors. The intention of these interventions is to slow water flow and cause sediment deposition, which may subsequently allow natural colonization by vegetation. Soil-conservation measures used include bench terraces, cut-off drains, contour open channel terrace, and contour ridge terraces.

To provide the necessary justification, this study addresses two questions, i.e., what is the monetary loss to a farmer when a gully develops? How viable is gully rehabilitation compared to installation of soil-conservation measures?

2. Description of Study Area

The Kilimanjaro Region (13,209 km^2) is located in the north-eastern part of Tanzania, lying between 2^0 25' and 4^0 15' S, and 36^0 25' 30'' and 38^0 10' 45'' East (Fig.1). It is administratively divided into 6 district councils, namely Siha, Mwanga, Rombo, Hai, Moshi, and Same, in addition to the Municipal Council of Moshi.

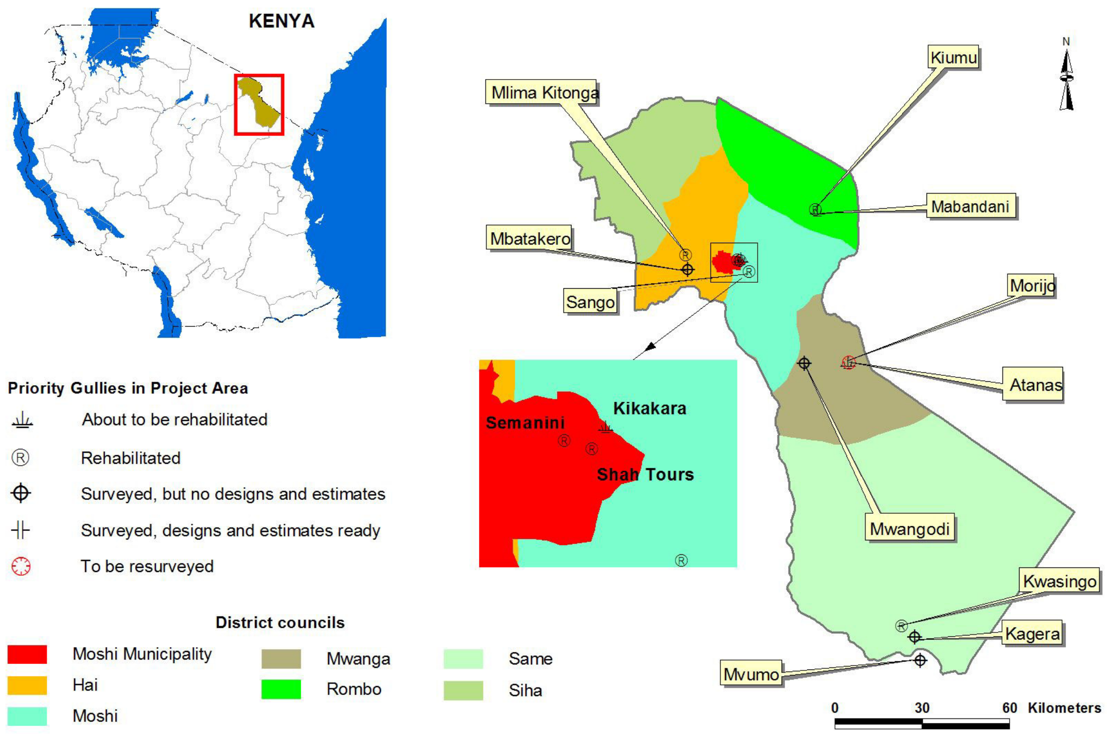

Figure 1: Location of priority gullies for rehabilitation under the project that aims at reducing land degradation in the Kilimanjaro highlands, Tanzania

With regard to land degradation, the region is naturally vulnerable because of its physical factors such as slope (steepness and length), rainfall energy, soil erodibility, and vegetation cover, which are the determinants of soil erosion (Stocking *et al*, 1988, Pimentel *et al*., 1995). The physiography includes the peak of Kilimanjaro Mountain (1,800 to 5,895 meters above sea level (m.a.s.l)), highlands (900 to 1,800 m.a.s.l), and the lowland /plains (below 900 m.a.s.l). This type of relief creates extremely steep slopes, with gradient as high as 25% (Anon., undated).

In terms of rainfall, the region has a bimodal rainfall regime, i.e., a major season in March-May and a minor one in November-December (United Republic of Tanzania (URT), 2014a). There are also two dry seasons, a major one in January-February and a minor one in July–August, with the driest months occurring between November and January (Rowshani *et al*., 2011). The mean annual rainfall varies from 500 mm in the lowlands to over 2,000 mm in the mountainous areas (URT, 2014a). When converted to rainfall energy, which causes raindrop splashes that dislodge soil particles and transportation of sediments, this amount of rainfall translates to 9423-37692 joules (j)/m^2 using the relationship between annual precipitation and energy (E), which is described by the formula $E=18.846\ P$, where P is the annual rainfall (Paris, 1990). Considering that energy values that are less than 15,000 j m^{-2} are highly erosive (Elwell and Stocking, 1982), it is inferred that the lowlands of the Kilimanjaro Region are highly vulnerable to soil erosion. In fact Makundi (2009) illustrated that soil degradation in the whole region ranges from moderate to severe, especially in the lower lands and Pare highlands.

Although the region is potentially vulnerable to soil erosion by water on account of physical factors such as steep topography, and erosive rainfall, human activities, e.g., deforestation and agriculture exacerbate this potential. Land-use arising from the conversion of dry deciduous forest into agricultural land has reduced vegetation cover, which intercept rainfall energy. Kashaga *et al*., (2014) reported substantial changes in land use and cover, e.g., agricultural land was 35.6% in 1995 but in 2014 it had increased to 37.0%. Bare land also increased from 1.0% to 15.6% during the same period. Invariably, forest land declined from 9.8% in 1995 to 9.3%. Cultivation of steep slopes, without appropriate soil-conservation measures, such as terracing, is also common. Additionally, ploughing across the contours is a prominent feature of land preparation in the region because of the orientation of the fields, which tend to be narrow across the slope but long downward. With mechanized ploughing, which is common in the region, yet it is not suitable for small holdings, estimated to be only 0.66 ha per household on the average (URT, 2014a), there is not much room for tractors to turn across the slope without having to trespass into someone else's field. To avoid doing so, ploughing is down the slope.

Soils of the region fall into four major groups, i.e., Humic Nitosols and associated Humic Andosols, Chromic Cambisols and associated Eutric Cambisols, Orchric Andosols and associated Chromic Cambisols and Vitric Andosols, and Mollic Andosols and associated Eutric Nitosols, according to the Soil Map of World produced by Food and Agriculture Organization/United Nations Education and Scientific Organization (FAO/UNESCO, (1976)). Andosols are highly erodible, while nitosols and cambisols have moderate and high resilience to degradation respectively (FAO, undated).

3. Methods

3.1 Cost of gully erosion

Although there are three types of costs of erosion, this paper only considers on-site ones because the others sound nebulous when raising political and public awareness. In this case, we considered on-costs as the net income foregone as result of the land occupied by a gully being uncultivable, and the expenses cost of gully rehabilitation. We did not include the cost of nutrients in the soil accumulated in the gully as done by Yitbarek *et al*., (2012) because such soil is a mixture of what moves from upstream and adjacent land. As such, the accumulated soil may have different properties from what existed prior to gully formation. Also, we did not use the cost of nutrients from the adjacent land as proxy because almost all the gullies, except one are over 20 years old, implying that the soils on the adjacent lands have been disturbed during that period. Therefore, it is unlikely that the properties are the same as the pre-disturbance period.

To determine the net income, we calculated the area of each one of the six out of the fourteen gullies on which topographic and corridor surveys had been conducted by surveyors engaged by the project. These gullies were selected as a priority for rehabilitation by Ward Development Committees because of their size (Table 1), and threat they posed to property, especially houses and cultivated land. For this study, they were selected because they have complete data; five of them have been rehabilitated, while works are about to begin on the sixth one (Fig. 1). The topographic and corridor surveys were conducted to determine the layout and elevations of the gully so as to facilitate designing of interventions. Appropriate parameters (Table 1) needed to estimate the area of a gully and amount of soil lost were taken. We used the methods of Stocking and Murnaghan (2000), as follows:

i) the average cross-sectional area (in m^2) of the gully, using the formula ½ (average width 1+average width 2)/2 multiply by depth (m);
ii) the volume (m^3) of soil lost (in m^3) from the gully by multiplying the cross-sectional area with the length of gully (m);
iii) the volume lost per m^2 equivalent within the catchment (contributing) area, i.e. volume of soil lost,

divided by the catchment area of the gully; and

iv) the volume of soil lost in t ha^{-1} over the whole catchment area, i.e., soil loss per m^2 multiplied by bulk density (tonnes m^{-3}). In the case of Kilimanjaro, the bulk density is 1.3 (Maro, 2009); and

v) soil loss per year (t ha^{-1} yr^{-1}), i.e., volume of soil lost divided by the age of the gully

Table 1: Measurements of priority gullies for rehabilitation under the project that aims at reducing land degradation in the Kilimanjaro highlands, Tanzania

Measurement	Administrative Council and Name of Gully						Total
	Same	Moshi Municipal		Hai	Moshi		
	Kwasingo	Semanini	Shah Tours	Mlima Kitonga	Kikarara	Sango	
Area of gully (ha)	20.4	8.6	18.5	0.1	1.3	0.7	49.5
Mean tw (m)	19.6	5.2	5.5	2.4	8.0	2.9	43.5
Mean bw (m)	12.6	1.8	2.0	1.7	5.2	4.7	28.1
Mean depth (m)	4.0	2.3	3.0	0.9	3.4	1.9	15.5
Mean length (m)	1,539.1	736.0	1,083.3	244.0	1,600.0	2,400.0	7,602.4
Soil loss (t ha^{-1})	6,320.6	452.6	432.5	182.2	1,016.0	650.4	9,054.3
Age of gully (yrs)	20.0	20.0	25.0	5.0	25.0	25.0	120.1
Soil loss (t ha^{-1} yr^{-1})	316.0	22.6	17.3	36.4	40.5	26.0	458.9

tw= top width, bw= bed width

We estimated the yield (t ha^{-1}) of maize and sunflower that would have been harvested from the area of land occupied by each gully, assuming it were cultivated using appropriate agronomic practices. We used the current average yields of the crops, i.e., 2.0 t ha^{-1} in the case of maize (FAOStat, 2013), a staple and 1.1 t ha^{-1} for sunflower (HEM Trust Fund, 2010), a cash crop. We used the price of TZS 500.00[1] kg^{-1}of maize to calculate the gross income. This is the highest price that the National Food Reserve Agency (NFRA) pays for maize. The NFRA's mission is to guarantee national food security by procuring and reserving strategic food stocks in an efficient and cost-effective manner (NFRA, 2009). We also used the highest price (TZS 485.00 kg^{-1}) of sunflower that farmers can fetch from processors who manufacture cooking oil in the region. To estimate the net income of each crop, we subtracted the variable costs of its production (labour, seed, fertilizer) from the estimated gross income, using values (TZS 256,000.00 kg^{-1} and TZS 450,000.00 kg^{-1} of maize and sunflower respectively) obtained from the District Agriculture, Irrigation, and Cooperatives Office in Same. To determine the total on-site costs of erosion per hectare, we added actual or estimated expenses of rehabilitating a gully, to the amount of net income from each crop, and averaged them for the region because of variability in expenditure incurred by each district depending on the materials and type of labour used, i.e., communal or hired.

3.2 Cost Benefit Analysis of gully rehabilitation vs. establishment of soil-conservation measures

We used the Cost-Best Analysis method to compare Net Present Values (NPV) and Benefit-Cost Ratio (BCR) of rehabilitation of gullies with those for establishment of soil-conservation practices assuming the same crops were grown on the land occupied by the gullies, we conducted a cost-benefit analysis. The NPV tests whether or not the sum of discounted gains exceeds the sum of discounted losses. If it exceeds, a project can be said to represent an efficient shift in resource allocation (Hanley and Barbier, 2009). With regard to BCR, where the sum of the benefits of the investment exceed the costs, it is considered a general economic argument to support the action taken (Puget Sound Regional Council, 2009).

We used the costs of rehabilitation and installation of soil-erosion control measures and regular maintenance of these structures to determine the NPVs and BCRs. Investment costs were taken at year 0, when the structures were established, while maintenance expenses, which are 15% of the capital, were discounted for 15 years, which is considered to be the average lifespan of soil-conservation measures (Atampugre, 2014). Based on these values, we incrementally discounted the annual maintenance costs of the soil-control measures from 0.1% one year after establishment of the structures to 1.8% in the fifteenth year because maintenance expenses are generally lower during the early years than toward the end of the lifespan of the structures. For purposes of uniformity, we applied the same lifespan and percentage of the annual maintenance costs to gully rehabilitation. While the cost for rehabilitating the gullies varied between districts, the same did not apply when establishing soil-erosion control measures.

For the same period, we discounted the benefit, i.e., the net income per hectare of maize and sunflower. We assumed that the price maize would increase annually by 20% based on the trend between 2007 and 2014 (World Bank Group, 2014; Economic and Social Research Foundation, 2015). On the other hand, the price of edible oils did not change much. We used a 5.5% discount rate (real interest rate), which we obtained by subtracting the average inflation rate (7.1%) from long-term interest rate of a bond of 12.6% (Trading Economics, 2015). Following Hanley and Barbier (2009) we calculated the NPV using the formula

[1] US$1.00 was equivalent to TZS 1800.00 in February 2015

$$NPV = \sum_{t=0}^{15} B_t * (1+r)^{-t} - \sum_{t=0}^{15} C_t * (1+r)^{-t}$$ where

NPV = net present value

B_t = accrued benefit in a specified year

C_t = accrued cost in a specified year

r = real interest rate

Benefit-Cost Ratios were simply calculated by dividing the amount of discounted benefits with discounted costs. Considering that the cost of gully rehabilitation varied from one district to another, we calculated the average NPVs for the region and used them to calculate the BCR. As for installation of soil-erosion control measures, we used the cost from only one of the districts because it did not vary. In this case, the average NPVs, they were positive for maize (TZS 18,449,972.26 ha^{-1}), and TZS 5,083,165.93 ha^{-1} for sunflower in the case establishment of soil-conservation measures, but negative for rehabilitation, i.e., TZS 71,019,750.82 and TZS 84,386,557.14 for maize and sunflower respectively.

4. Results and Discussion

4.1 Cost of gully erosion

The average on-site cost, i.e., expenses incurred on rehabilitation, plus net income foregone from each crop is TZS 82.61 millionha^{-1} and TZS 82.22 million ha^{-1} for maize and sunflower respectively (Tables 2 and 3). Under normal circumstances, cash crops provide higher income than subsistence ones. In the case of Kilimanjaro, however, it is the opposite because there is an influx of sunflower from Singida, a region neighbouring Kilimanjaro (Simon Msoka, Principal Agricultural Officer, Kilimanjaro Region *pers comm.*). This influx results into low prices, hence the lower income from sunflower (Table 3). Besides, the price, sunflower yield is comparatively lower than maize, i.e., 1.1 t ha^{-1} and 2.0 t ha^{-1} respectively.

The cost per hectare is higher for three of the gullies than the rest, i.e., Mlima Kitonga, Kikarara, and Sango (Tables 2 and 3). This is due to material and labour charges. Generally, where the community provided labour, the costs are much lower than where contractors were hired. The exception is Mlima Kitonga where despite provision of labour by the community, the cost is the highest because of the stone and concrete materials used in constructing the check dams.

Table 2: On-site cost (TZS '000,000) of gully erosion if maize was the crop cultivated, Kilimanjaro Region, Tanzania ""

Gully	Area (Ha)	Rehabilitation expenses	Net income /Ha	Total	Cost/Ha
Kwasingo	20.30	74.10	15.90	90.00	4.43
Semanini	8.60	21.20	6.70	27.90	3.24
Shah Tours	18.40	38.50	14.40	53.00	2.88
Mlima Kitonga	0.06	20.0	0.50	20.00	333.33
Kikakara	1.28	104.40	1.00	105.40	82.34
Sango	0.69	47.40	0.50	47.90	69.42
Total	**49.33**	**305.60**	**39.00**	**344.20**	**495.66**
Average	***8.22***	***50.93***	***6.50***	***57.37***	***82.61***

Table 3: On-site cost (TZS '000,000) of gully erosion if sunflower is the crop cultivated, Kilimanjaro Region, Tanzania

Gully	Area (Ha)	Rehabilitation expenses	Net income /Ha	Total	Cost/Ha
Kwasingo	20.30	74.10	6.40	80.50	3.97
Semanini	8.60	21.20	2.70	23.90	2.78
Shah Tours	18.40	38.50	5.80	44.30	2.41
Mlima Kitonga	0.06	20.0	0.02	20.00	333.33
Kikakara	1.28	104.40	0.40	104.80	81.88
Sango	0.69	47.40	0.20	47.60	68.99
Total	**49.33**	**305.60**	**15.52**	**321.10**	**493.35**
Average	***8.22***	***50.93***	***2.59***	***53.52***	***82.22***

4.2 Cost Benefit Analysis of gully rehabilitation vs. installation of soil-conservation measures

Establishment of soil-conservation measures produces positive NPVs ha^{-1} after 15 years, i.e., the average is TZS 18.50 million and TZS 5.08 million for maize and sunflower respectively. Results are not presented in table form because the NPV was the same for all the districts. In contrast, those for rehabilitation are negative, i.e., TZS 71.,01 million ha^{-1} for maize and TZS 84.40 million ha^{-1} in the case of sunflower (Table 4). The ramification is that a farmer will have already recovered the costs of establishing soil-erosion control structures and generated profit in less than 15 years, while it would take longer to recover costs for rehabilitating a gully and realize profit under same crops.

Table 4: Net Present Values (TZS ('000,000)) and Benefit-Cost Ratios of rehabilitating each gully when either maize or sunflower is the crop of choice, Kilimanjaro Region, Tanzania

Name of the gully	NPV/Ha		B-C Ratios	
	Maize	Sunflower	Maize	Sunflower
Kwasingo	15.30	1.90	3.26	1.20
Semanini	16.60	3.20	4.02	1.38
Shah Tours	17.0	3.60	4.34	1.45
Kilima Kitonga	-343.10	-356.50	0.06	0.03
Kikakara	-69.40	-82.80	0.24	0.12
Sango	-62.50	-75.90	0.15	0.15
Total	**-426.10**	**-506.30**	**12.06**	**4.33**
Average	***-71.0***	***-84.40***	***2.01***	***0.72***

Considering the NPVs, it is not surprising that the BCRs follow the same trend, i.e., higher when the preference is to install soil-erosion control measures than to rehabilitate. The ratios are 6.05 and 1.76 for maize and sunflower respectively when soil-conservation measures are installed, but 2.01 and 0.72 when a gully is rehabilitated (Table 4). While there is a general economic argument to support the actions taken in both cases, i.e., rehabilitation and establishment of soil-conservation measures, the latter is more viable than the former. The ratios for the latter are almost three times as much as for the former in the case of maize, but twice in the case of sunflower. Worse still, the benefits of the investment in rehabilitating three of the gullies, e.g., Mlima Kitonga, Kikarara, and Sango do not exceed the costs, thereby emphasizing the superiority of installation of soil-conservation measures over rehabilitation. These results simply confirm the old saying that *prevention is better than cure*. Prevention of gully erosion in the case of Kilimanjaro specifically, but Tanzania in general, is pertinent at the time when land degradation is increasing globally (Hoffman *et al*., undated), compounded by human population growth which are reducing the amount the amount available for agricultural production. According to Haigh (undated), out the total 8,735.0 m. ha of agricultural land globally, a total of 1,965.0 m. ha have been degraded, 1,094 m. ha (56%) of which by water erosion, the rest by wind erosion, soil structural damage, chemical degradation, salinization, and soil pollution. In the case of Tanzania, about 44 million hectares or about half (50%) of the total land area of 94,508,700 ha is affected by land degradation. Highly degraded areas, which is associated with poor farming practices and overgrazing, constitute about 16% of the total land area mostly occurring in semiarid areas (including Kilimanjaro Region) and southern highlands (URT, 2014b). Specifically for the Kilimanjaro Region, the situation is even more worrying considering the increase in the human population from 898,212 in 1978 to 1,640,087 in 2013 (URT, 2013), while the amount of arable land has remained static at 643,300.0 ha. This increase has resulted in a concomitant rise in arable density from 1.4 to 2.55 persons ha^{-1} during the same period, yet soil erosion renders some land useless for cultivation. Arable density a measure of a nation's (a region's in this study) self-sustainability in terms of food (Kalipeni, 1992; Plane and Rogerson, 1994). Considering that an increasing population requires larger amounts of resources to satisfy tangible and intangible needs, most particularly food production (Shaxson 1970), the increase in arable density in Kilimanjaro imposes challenges in terms of food security and ecosystem conservation. Although the arable density for Kilimanjaro is lower than for the nation, i.e., 3.9 persons ha^{-1}, the overall picture that is emerging is that the country, let alone the region, cannot afford to lose more land because of soil erosion.

Considering the magnitude of soil loss because of gully erosion in the region, the project took a rational decision to include gully rehabilitation as one of the activities. However, results of this study present a stronger case for promoting establishment of soil-erosion control measures more than rehabilitation of gullies. Therefore, it would be prudent of decision-makers especially to support initiatives that aim at controlling soil loss instead of rehabilitation after vast amounts of land are rendered unproductive due to soil loss.

Conclusions and Recommendations

This study provides empirical justification for prevention of on-site costs of gully erosion in the Kilimanjaro Region so as to raise political and public awareness of the impacts of land degradation and significance of sustainable land management from an economic perspective. In the context of this paper, it costs about TZS 82.61 million ha^{-1} and TZS 82.22 million ha^{-1} when gully erosion prevents cultivation of maize and sunflower respectively.

With respect to the economic cost and benefit of rehabilitation versus establishment of soil-erosion control measures, the latter is more viable than the former. The average benefit-cost ratios for the latter are almost three times as much as for the former if the crop of choice is maize, but two times more in the case of sunflower. Results support the old adage that says "prevention is better than cure". Considering that land in the region is being degraded by soil erosion, while the rest is vulnerable because of physical factors and anthropogenic activities, it would be prudent of decision-makers especially to support sustainable land management initiatives that aim at controlling soil loss instead of rehabilitation after vast amounts of land are rendered unproductive due to soil loss..

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