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RESEARCH ARTICLE

EFFECT OF GULLY EROSION ON LIVELIHOODS IN SUSWA CATCHMENT, NAROK COUNTY

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ABSTRACT

This study investigated the effect of gully erosion on livelihoods in Suswa catchment, Narok County. Data was collected in 4 villages (Eluai, Olepolos, Olesharo and Enkiloriti) using a questionnaire on the effect of the gully on livelihoods (movement, infrastructure, livestock and farming practices). The effect of gully erosion on activities within the four villages was determined using Chi square test. Results showed that the effect of gully erosion on house activities differed significantly between the villages. This could be due to the fact that houses near to the gully where the most affected by runoff. The effect of gully erosion on farming, livestock, level of income, water availability, firewood collection, building materials, health and mosquito breeding did not differ significantly between the villages. This is because the effect on the mentioned livelihood activities was more or less the same in the 4 villages. According to community members the level of damage to farming, livestock, house activities, water pan and road/footpath was severe. Community members were also aware of the risk of erosion and its effects on their livelihoods. The low use of soil conservation measures in the Suswa catchment could have contributed to negative effects on livelihood activities. Community recommendations for the rehabilitation of the gully included the use of soil and water extension services, soil and conservation measures, training, the use of indigenous knowledge and reduction of livestock numbers and financial support.

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INTRODUCTION

A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base (Tang *et al* 2013). Sustainable livelihoods thus encompass the protection and assurance of the means of livelihood for people and society. In addition, a sustainable livelihood avoids depleting stocks of natural resources to a level which results in a permanent decline in the rate at which the natural resource base yields useful products or services for livelihoods (Forsyth, 2007). Sustainable livelihoods define environmental risk and resources. Therefore working with communities to define risks may build sustainable livelihoods. Sustainable livelihood approaches therefore seek to gain an understanding of resource access, use, and allocation and on the way in which individuals and households can transform resources into livelihoods (Thomsen *et al.*, 2001). Therefore the ways in which livelihood strategies relate to natural resource potentials at the community level are important in explaining environmental change. Discussions on sustainable livelihood approaches have been on the pre-existing notions of environmental risk, rather than being a way to specify this risk using the perspectives of vulnerable people. Sustainable livelihood approaches have now been used as ways to build institutions around poor people's perceptions of resources and vulnerability. This approach is therefore a response to environmental stress. Soil erosion is one of the causes of risks to individual households. Responses to soil problems ensure that erosion is not as damaging as it might be. According to Oumer *et al.,* (2013) investing in soil management provides opportunities for diversification of livelihood options that minimize resource degradation. Households not investing in sustainable soil management practices are less likely to diversify their livelihoods, are trapped in poverty and have fewer opportunities. Consequently, these households are forced to pursue very risky and resource-degrading livelihood activities which include overexploitation of resources and overgrazing to sustain their livelihoods. Sustainable livelihood approaches emphasize reduced vulnerabilities to soil erosion in order to influence future livelihood strategies. According to Valentine *et al.,* (2008) as

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the pace of social change accelerates, large tracts of forest may be converted to agricultural land with potentially critical environmental implications that include a higher frequency of floods, droughts leading to crop failure and soils become subjected to misuse and unsustainable farming practices, resulting in degradation. As the land resource base becomes less productive, food security is compromised and competition for dwindling resources increases. Thus a downward spiral is created. This trend is both avoidable and reversible in many circumstances. Communities can seek innovations to stabilize or improve the resource base, or to compensate for their welfare effects by depending less on the degrading resource. The enhancement in social–ecological systems can ameliorate and mitigate the impacts of hazardous processes significantly. Social–ecological systems can enable livelihoods to be more sustainable in the face of change (Gardner *et al.,* 2007). A household's experience of an environmental shock or change and how they cope with the event, may result in a dramatic change in livelihood activities with potentially negative welfare outcomes or may provide opportunities for learning and welfare improvement (Eakin *et* al., 2012). Livelihood responses to stress can therefore affect ecological and social functions including erosion control. This study investigated the effect of gully erosion on livelihoods in Suswa catchment, Narok County, Kenya.

MATERIALS AND METHODS

Research Site

The study was conducted in Suswa in Narok County (Fig 1) which lies between latitudes 0^0 50' and 2^0 05' South; and longitudes 35^0 58' and 36^0 0' East and covers an area of 15,087.8 km^2 (NEMA, 2009). Narok county has five agro-climatic zones namely humid, sub-humid, semi-humid to arid and semi-arid (NEMA, 2009).

Two-thirds of the county is classified as semi-arid. The agro-ecological zones found in the sub-county include: Tropical Alpine (TA), Upper Highland zones (UH) Lower Highland zones (LH) and upper-midland zones (UM). According to NEMA (2009) the county has a population of about 460,793, with only about 11% residing in the urban areas.

The population in the county ranges from 12 to 119 persons per km^2 (NEMA 2009).The county has diversified topography which ranges from a plateau with altitudes ranging from 1000 m-2350 m.a.s.l at the southern parts to mountainous landscape which is about 3098 m.a.s.l at the highest peak of Mau escarpment in the North (NEMA, 2009).According to NEMA (2009), the sub-county experiences bi-modal pattern of rainfall with long rains (mid March-June) and short rains (September-November). Rainfall distribution is uneven with high potential areas receiving the highest amount of rainfall ranging from 1200 mm-1800 mm p.a while the lower drier areas classified as semi-arid receiving 500 mm or less p.a. (NEMA, 2009). The county serves an important ecological and economic role and supports wildlife, tourism, livestock, farming activities and human settlements (NEMA, 2009). The main soil types in the county include Andosols, Luvisols, Phaeozems, Vertisols and Acrisols. Areas with deep and well-drained soils include hilly and mountainous areas of Mau escarpment, Ngorengore, Shatuka, Suswa and Loita hills (NEMA, 2009).

Methodology

Purposive sampling was used to select the 4 villages affected by gully erosion. Data was collected using a questionnaire on family size, level of education, income, livestock keeping practices, farming practices, land management practices, causes of the gully and the effect of the gully on livelihoods (mainly movement, infrastructure, livestock and farming practices) and recommendations given.

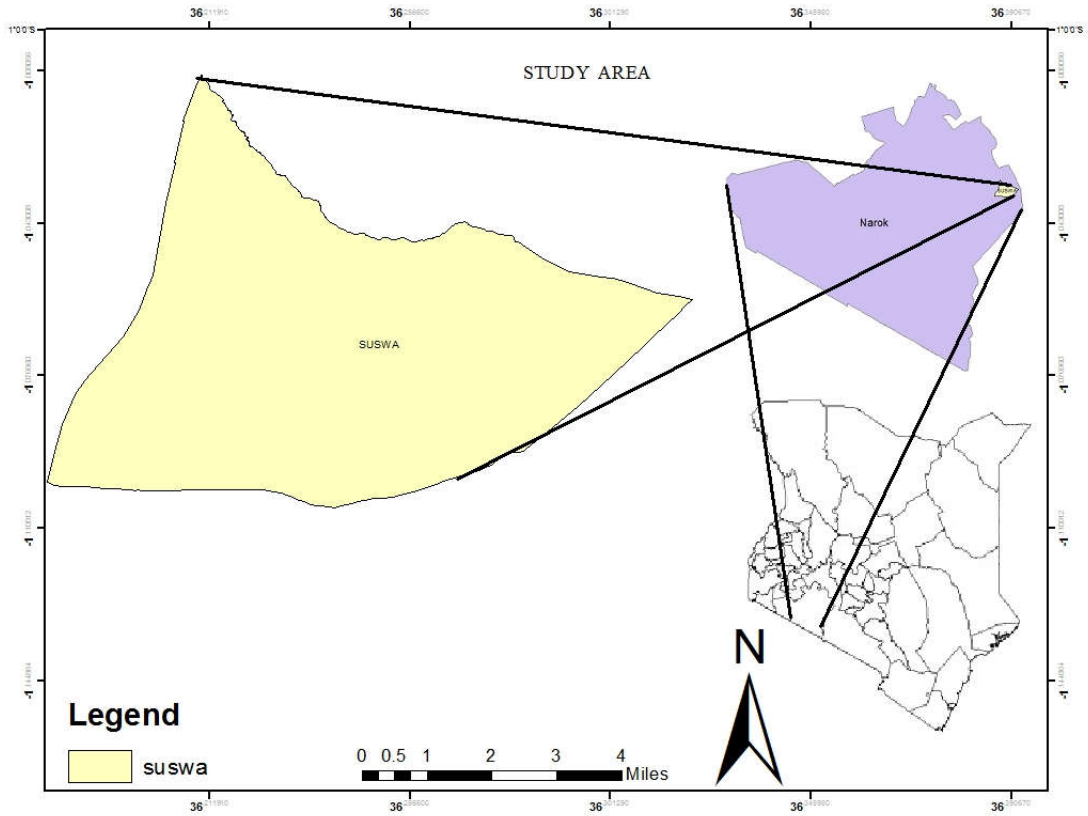

Fig. 1. Map showing Suswa, Narok County

A minimum of 30 households (Ruxton, 2006) were selected randomly from each of the 4 villages. According to NEMA (2009).The county has a population of about 460,793, with only about 11% residing in the urban areas. Pilot testing of the questionnaire was done randomly on 10 respondents and the questionnaire rewritten before final administration. Enumerators were selected based on previous experience in fieldwork and level of education (secondary education and above). Key informant interviews were conducted on the Chief, Village Elders, Ministry of Agriculture, and Non-governmental organizations. Land use practices (types of crops grown and livestock kept), level of income, level of education, size of farms, soil conservation measures and impacts of the gully on livelihoods (movement, infrastructure, livestock and farming practices) were tested using SPSS. Chi-square goodness of fit was used to determine if there were significant effects on livelihoods.

RESULTS AND DISCUSSION

The effect of gully erosion on livelihoods is shown in Figure 2. In Olesharo village, gully erosion had the greatest effect on livestock activities (92%), income levels (90%), followed by water availability (water pan-88%), farming activities (80%) and movement (74%).

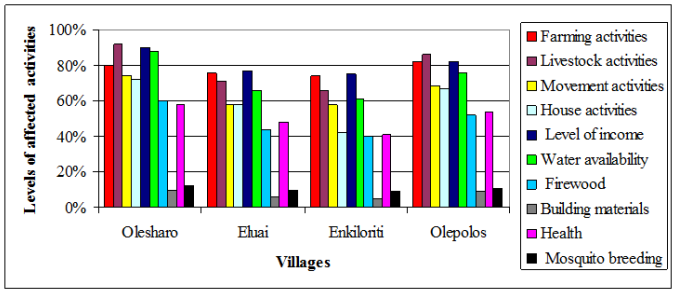

Figure 2. Percentage of the effect of gully erosion on livelihoods in Suswa catchment

In Eluai village, gully erosion had the greatest effect on level of income (77%), farming activities (76%) followed by livestock activities (71%), water availability (water pan-58%), Movement and house activities (58%). In Enkiloriti village, gully erosion had the greatest effect on level of income (75%), farming activities (74%), followed by livestock activities (66%), water availability (water pan-61%) and movement (58%). In Olepolos village, gully erosion had the greatest effect on livestock (86%), farming activities and level of income (82%), followed by water availability (water pan-76%), movement (68%) and house activities (67%). Majority of community members in the 4 villages earned less than Ksh. 10,000 per year. Respondents interviewed were aware of the effect of gully erosion on their livelihoods. Renschler *et al.,* (2002) showed similar results to this study in that erosion lead to yield reduction and sediment removal operations which affected farming activities. Lestrelin *et al.,* (2007) in Laos observed that erosion resulted in decreasing yields and land lost to gullies. Kusimi *et al.,* (2011) in Ghana showed that soil erosion results in socio-economic problems such as overgrazing, fuel wood fetching, land clearance for farming, food insecurity, low levels of income and drought. Therefore there was an increase in erosion without subsequent increase in agriculture productivity. In a Participatory Geographic Information Systems (PGIS) study in the area (by this author) it was observed that between 1985 and 2011 (26 years), there was an overall increase in built up area and bareland and decrease in shrubland and grassland in the 4 villages (Olepolos, Enkiloriti, Eluai and Olesharo). Therefore respondents felt that the effect on their livelihoods was due to gully erosion and the mentioned land use and land cover changes. The effect of gully erosion on house activities (Table 1) differed significantly between the villages ($P < 0.05$). This could be due to the fact that houses near to the gully were the most affected by runoff. The effect of gully erosion on farming, livestock, level of income, water availability, firewood collection, building materials, health and mosquito breeding did not differ significantly between the villages. This is because the effect on the mentioned livelihood activities was minimal in the four villages.

Level of damage within Suswa Catchment

Amsalu *et al.,* (2006) in Ethiopia observed that farmers perceived soil problems as moderate, severe and mild. This shows that farmers understand erosion problems which influence their soil conservation decisions. In Olesharo village 86%, 12% and 2% of the respondents interviewed (Table 2) felt that the level of damage to farming activities (maize, beans, wheat) was severe, moderate and mild respectively. In Eluai village, 78%, 14% and 8% of the respondents felt that the level of crop damage (maize, beans, watermelon, tomatoes, potatoes, onions, kales and carrots) was severe, moderate and mild respectively due to gully erosion. In Enkiloriti village, 76%, 14% and 10% of the respondents interviewed felt that the level of damage to farming activities (maize, beans, watermelon, tomatoes, potatoes, onions, kales and carrots) was severe, moderate and mild respectively. In Olepolos village, 82%, 14% and 4% of the respondents felt that the level of damage (maize, beans, wheat) was severe, moderate and mild respectively. The level of damage to farming activities in the villages could be due to runoff from the gully which uproots the crops. Community members therefore experienced losses in crop production. Majority of community members in the 4 villages owned farms of about 30 acres. Amsalu *et al.,* (2006) in Ethiopia showed that soil erosion was constraining crop production. Hella *et al*., (2003) in Tanzania observed that there was an increase of erosion without subsequent increase in agriculture productivity.

Boardman *et al.,* (2009) in the UK reported that soil erosion on agricultural land is a growing problem and constitutes a threat to soil quality and to the ability of soils to provide environmental services. Gicheru *et al.,* (2012) in Narok, observed that increased soil erosion reduced nutrient availability to crops and pasture. Zegeye *et al.,* (2010) in Ethiopia indicated that farmers perceived soil erosion as a problem constraining crop production.The level of damage to livestock activities in Olesharo village was 90% (severe), 9% (moderate) and1% (mild), Eluai 78% (severe), 17% (moderate) and 5% (mild), Enkiloriti 76% (severe), 16% (moderate) and 8% (mild) and in Olepolos 82% (severe), 15% (moderate) and 3% (mild). The level of damage to livestock activities and health in the villages was due to livestock falling inside the gully, dust getting into the eyes of livestock and livestock getting colds. Runoff from the gully could also have affected pasture with grass being uprooted by runoff. Majority of community members in the 4 villages in total, kept less than 50 cows, goats, sheep and chicken each. Mekuria *et al.,* (2009) in Ethiopia observed that erosion contributed to poor health of livestock due to lack of pasture grass to feed on, loss of grazing

Table 1. Effect of the gully on activities within the four villages

	Farming activities	Livestock activities	Movement activities	House activities	Level of income	Water availability	Firewood	Building materials	Health	Mosquito breeding
X^2	0.513	5.567	2.899	8.715	1.654	5.866	4.816	20.213	3.279	19.091
df	3	3	3	3	3	3	3	3	3	3
p value.	0.916	0.135	0.407	0.033	0.647	0.118	0.186	0.000	0.351	0.000
Significance	Not significant	Not significant	Not significant	significant	Not significant	Not significant	Not significant	significant	Not significant	significant

Table 2. Level of damage within the villages

Village	Olesharo	Eluai	Enkiloriti	Olepolos
Farming Activities				
Severe	86%	78%	76%	82%
Moderate	12%	14%	14%	14%
Mild	2%	8%	10%	4%
Livestock Activities				
Severe	90%	78%	76%	82%
Moderate	9%	17%	16%	15%
Mild	1%	5%	8%	3%
House activities				
Severe	76%	42%	40%	68%
Moderate	20%	50%	53%	17%
Mild	4%	8%	7%	5%
Water pans				
Severe	86%	77%	72%	84%
Moderate	12%	16%	19%	11%
Mild	2%	7%	9%	5%
Roads/footpaths				
Severe	84%	78%	75%	81%
Moderate	12%	13%	15%	13%
Mild	4%	9%	10%	6%

Table 3. Responses (%) on the causes of the gully per each village

Village	Rainfall		Overgrazing		Farming		Deforestation		Roads		Topography		Soil type		Settlement	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Olesharo	99.0%	1.0%	90.0%	10.0%	84.0%	16.0%	92.0%	8.0%	78.0%	22.0%	76.0%	24.0%	54.0%	46.0%	28.0%	77%
Eluai	95.0%	5.0%	86.0%	14.0%	77.0%	23.0%	86.0%	14.0%	57.0%	43.0%	58.0%	42.0%	42.0%	58.0%	10.0%	90%
Enkiloriti	94.0%	6.0%	86.0%	14.0%	71.0%	29.0%	82.0%	18.0%	54.0%	46.0%	55.0%	45.0%	40.0%	60.0%	9.0%	91%
Olepolos	97.0%	3.0%	88.0%	12.0%	80.0%	20.0%	89.0%	11.0%	66.0%	34.0%	65.0%	35.0%	51.0%	49.0%	20.0%	80%

land and poor bush regrowth. Ighodaro *et al.,* (2013) in South Africa found that soil erosion resulted in a negative effect on animal health, shortage of grazing land and farmland and poor production of crops. Agricultural land was also being reduced due to erosion activities. Farmers also indicated that soil erosion affected their profitability, product quality, yield and sustainability due to the effects on grazing land, production of crops and on animal health. Amman *et al.,* (2004) in Narok reported that high livestock levels caused degradation, which lead to high livestock mortalities, especially during critical periods of drought. The most severely affected village in terms of damage to house activities was Olesharo (76%), Olepolos (68%), Eluai (42%) and Enkiloriti (40%). Those affected moderately and mildly were Olepolos (17%), Olesharo (20%), Eluai (50%) Enkiloriti (53%) and Olesharo (4%) Enkiloriti (7%), Olepolos (5%) and Eluai (8%) respectively.

According to the communities, the severe damage to house activities (including the store) was due to flooding/runoff from the gully in Suswa catchment. Boardman *et al.,* (2009) in the UK observed that erosion resulted in the flooding of households. According to community members the level of damage to water pans in Olesharo village was severe (Olesharo- 86%, Eluai-77%, Enkiloriti-72%, Olepolos-84%), moderate (Olesharo-12%, Eluai-16%, Enkiloriti-19%, Olepolos-5%) and mild (Olesharo-2%, Eluai-7%, Enkiloriti - 9%, Olepolos-5%). The severe damage to water pans within the villages could be due to siltation of the water pans from the gully in the study area. In Northern Thailand, Forsyth (2007) found that gullies were contributors to sedimentation. Boardman *et al.,* (2009) in the UK also observed erosion resulted in damage to the water reservoir. Gicheru *et al.,* (2012) in Narok observed that runoff polluted the water used for both livestock and human consumption.

erosion resulted in deposition of sediments on roads and damage.

Causes of gully erosion in Suswa

In Olesharo village, respondents interviewed felt that the major cause of the Suswa gully (Table 3) was rainfall and deforestation, followed by overgrazing, farming, roads/footpaths, topography, soil type and settlement. In Eluai village, respondents felt that the major cause was rainfall, farming and overgrazing, followed by farming, topography, roads/footpaths, soil type and settlement. In Enkiloriti village, respondents interviewed felt that the major cause of the Suswa gully was rainfall and overgrazing, followed by deforestation, farming, topography, roads, soil type and settlement. In Olepolos village, respondents felt that the major cause was rainfall, overgrazing and deforestation, followed by farming, roads, topography, soil type and settlement. Respondents interviewed were therefore aware of the risk of erosion and its effects on their livelihoods.

In a Participatory Geographic Information Systems (PGIS) study in the area (by this author) it was observed that between 1985 and 2011 (26 years), there was an overall increase in built up area and bareland and decrease in shrubland and grassland in the 4 villages (Olepolos, Enkiloriti, Eluai and Olesharo). Therefore an increase in built up area, bareland and agricultural land and a decrease in grassland are therefore likely drivers of gully erosion which is affecting the area. Respondents felt that rainfall, overgrazing, deforestation, farming, roads, topography, soil type and settlement contributed to gully formation and the effects on their livelihoods. Julien *et al.,* (2011) in Benin found that local perception on the causes of erosion was due to deforestation, settlement, agricultural degradation, and animal

Table 4. Rehabilitation of the Suswa gully within the villages

Village	By training		By advice from soil and water officer		By use of Indigenous knowledge		By reducing livestock numbers		By soil conservation measures		By financial support	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Olesharo	90.0%	10.0%	99.0%	1.0%	91.0%	9.0%	90.0%	10.0%	97.0%	3.0%	96.0%	4.0%
Eluai	88.0%	12.0%	95.0%	5.0%	82.0%	18.0%	82.0%	8.0%	91.0%	9.0%	93.0%	7.0%
Enkiloriti	87.0%	13.0%	94.0%	6.0%	80.0%	10.0%	81.0%	9.0%	90.0%	10.0%	93.0%	7.0%
Olepolos	90.0%	10.0%	97.0%	3.0%	86.0%	14.0%	86.0%	4.0%	95.0%	5.0%	95.0%	5.0%

Udayakumara *et al.,* (2010) in Sri Lanka found that soil erosion resulted in deposition of sediment in the water bodies and lead to deterioration of water quality. Felfoul *et al.,* (2003) in Tunisia indicated that limited rainfall combined with severe soil erosion was jeopardizing the efficiency of water reservoirs. Cantón *et al.,* (2011) in Spain reported that erosion lead to siltation of the water reservoir. Nalule (2010) in Uganda showed that erosion is resulting in silting of water structures. The level of damage to roads/footpaths in Olesharo village ranged from 84% (severe), 12% (moderate) and 4% (mild), Eluai village, 78% (severe), 13% (moderate) and 9% (mild), Enkiloriti village, 75% (severe), 15% (moderate) and 10% (mild), and in Olepolos village, 81% (severe), 13% (moderate) and 6% (mild). The severe damage to roads/footpaths could be due to runoff/flooding from the gully, hence further affecting movement of community members, livestock, vehicles and motorcycles. Boardman *et al.,* (2009) in the UK indicated that erosion had noticeable impacts on roads. Stocking *et al.,* (2000) in the UK observed that footpaths can become gullies, which is the case in the study area. Gobin *et al.,* (2004) found that stamping in the dry season. Okoba *et al* (2006, 2005) in Runyenjes Division observed that farmers identified erosion indicators as rainfall, runoff, steep slopes and soil surface conditions. Local knowledge of on-site erosion indicators could be useful in assessing site-specific erosion risk before planning any conservation measures. Amsalu *et al.,* (2006) in Ethiopia reported that the major causes of soil erosion mentioned by farmers included erosive rains, steep slope, damaged conservation structures, and tillage which makes the soil loose and bare.

Soil conservation measures used in the farm

In Olesharo village, 2% and 1% of respondents interviewed had brushwood in their farms and practiced tree planting activities respectively. In Eluai village, 1% and 1% had brushwood in their farms and practiced tree planting activities respectively. In Enkiloriti village, 1% and 2% of respondents interviewed had brushwood in their farms and practiced tree planting respectively. In Olepolos village, 2 % and 1% of respondents

had brushwood in their farms and practiced tree planting respectively. The low use of soil conservation measures in the Suswa catchment contributed to negative effects on livelihood activities. Fentie *et al,* (2013) in Ethiopia, observed similar results in that decisions to retain conservation structures are related to soil erosion perceptions, yield on farms, attitudes towards new technologies, exposure to new practices, productivity of technology, which could be the case in the study area. Mariara *et al.,* (2010) in Murang'a, Maragua and Narok districts observed that willingness to listen to extension agents affected the willingness to invest in soil conservation measures. Okoba *et al.,* (2005) in Runyenjes Division found that the main constraints to adoption soil conservation measures were lack of money, insufficient labour force, lack of tillage tools and poor knowledge about the benefits of soil conservation measures. Bielders *et al.,* (2003) in Belgium indicated that farmers most affected by erosion are also more likely to take measures. In Olesharo village, respondents interviewed felt that the major focus for the rehabilitation of the Suswa gully (Table 4) should be the use of soil and water extension services (99%), followed by the use of soil conservation measures (97%), financial support (96%), indigenous knowledge (91%), training (91%) and the reduction of livestock numbers (90%). In Eluai village, respondents felt that the focus for the rehabilitation should be the use of soil and water extension services (95%), financial support (93%), followed by the use of soil conservation measures (91%), training (88%), the use of indigenous knowledge (82%) and the reduction of livestock numbers (82%).

In Enkiloriti village, respondents interviewed felt that the major focus of rehabilitation of the Suswa gully should be the use of soil and water extension services (94%), financial support (93%), followed by soil conservation measures (90%), training (87%), reduction of livestock numbers (81%) and the use of indigenous knowledge (80%). In Olepolos village, respondents felt that the major focus should be the use of soil and water extension services (97%), financial support (95%) and soil and conservation measures (95%), followed by training (90%), the use of indigenous knowledge (86%) and reduction of livestock numbers (86%). Respondents interviewed were therefore aware of the major ways/benefits to minimize the negative effects of gully erosion in the Suswa catchment. Oumer *et al.,* (2013) in Ethiopia observed that households perceive soil degradation in a number of ways and will react differently when adopting management practices. Fentie *et al.,* (2013) in Ethiopia found that extension education motivated the use of soil conservation measures. Also providing information on long term impact of soil erosion and project assistance had positive and significant influence on conservation decisions. Barungi *et al.,* (2013) in Uganda reported that access to extension services increases the likelihood of adopting soil erosion control technologies. Alufah *et al.,* (2012) in Ngaciuma Sub-Catchment, Kenya observed that access to information and extension services leads to the adoption of soil conservation technologies.

Conclusion and Recommendations

In this study it was observed that the effect of gully erosion on house activities differed significantly between the four villages - Eluai, Olepolos, Olesharo and Enkiloriti. This could be due to the fact that houses near to the gully where the most affected by runoff. The effect of gully erosion on farming, livestock, level of income, water availability, firewood collection, building materials, health and mosquito breeding did not differ significantly between the villages. This is because the effect on the mentioned livelihood activities was more or less the same in the 4 villages. According to community members the level of damage to farming, livestock, house activities, water pan and road/footpath was severe. Community members were also aware of aware of the risk of erosion and its effects on their livelihoods. The low use of soil conservation measures in the Suswa catchment could have contributed to negative effects on livelihood activities. Community recommendations for the rehabilitation of the gully included the use of soil and water extension services, soil and conservation measures, training, the use of indigenous knowledge and reduction of livestock numbers and financial support. Vulnerable periods for erosion need to be identified by the community in order to minimize threats to their livelihoods. Community members need capacity building particularly in the adoption of soil conservation measures and water pan management in order to minimize the negative effects on their livelihoods. Also the community needs to diversify their activities for a more sustainable livelihood.

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