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ENHANCING RURAL LIVELIHOODS THROUGH SUSTAINABLE LAND AND WATER MANAGEMENT IN NORTHWEST ETHIOPIA

ABSTRACT. Rural livelihoods (RLs) in highland Ethiopia is critically threatened by increasing degradation of land and water resources (LWRs) and lack of sufficient livelihood assets. In response, farmers adapted diverse indigenous land and water management (LWM) technologies and livelihood strategies. This paper describes farmers' methods of soil erosion identification and the practices of managing LWRs to enhance RLs. It presents the results of studies focusing on assessment of soil erosion indicators, farmers' in-built sustainable land and water management practices (LWMPs) and RLs in Dangila *woreda* (district) in the northwestern highlands of Ethiopia. Data were gathered from May 2010 to October 2013 through participatory transect walks, field observation, formal and informal discussions with farmers, examination of office documents and from a survey of 201 rural households. Descriptive statistics and the livelihood strategy diversification index (LSDI) were used to analyze the data. Results indicated that farmers employ around 13 indicators to identify soil erosion on their farmlands. Over 79% of the farmers indicated the occurrence of soil erosion on their farm fields and some 59% reported the trend was increasing for twenty years, 1991–2011. More than 174 km soil-bunds and greater than 4 km stone-bunds were constructed on farmlands and on grazing fields through farmer participatory watershed development campaigns. Some 34 gullies were stabilized using check-dams and vegetative measures. Almost 72% of the households applied cattle manure on about of their 75 ha lands to improve soil fertility. A total of 44 diversion canals and 34 water committees were established to facilitate the irrigation practice of 33% rural households. Over 20% farmers obtained results ranging from moderate to excellent by combining manure with chemical fertilizers in the same field. Nevertheless, introduced methods such as improved seeds and fertilizers were commented for unaffordable prices and short-range services. Farmers utilized over eight livelihood strategies but the mixed crop-livestock farming was their main source of income. Sharecropping contracts were the ways of stabilizing the land demands of the studied households. It is concluded that integrated use of technologies (i.e. structural & vegetative plus indigenous & introduced measures) and participatory research & planning should be promoted to improve farmers' LWMPs and livelihoods. Increased effort should be made by concerned agencies to help farmers own assets (e.g. farm land) and diversify their livelihoods strategies. Special focus should be also given to farmers' inbuilt LWMPs and livelihood strategies.

KEY WORDS: Rural livelihoods; farmers' methods; sustainable land management; Ethiopia.

INTRODUCTION

The livelihood of rural people in the developing countries of sub-Saharan Africa (SSA) strongly relies on farming and exploitation of natural resources. But, farming in these countries is greatly confronted with resource degradation and unsustainable resource use. Resource degradation and pervasive poverty deprive the rural people in these countries from holding essential livelihood assets. The condition hampers the ability of farmers to produce food supplies; weakened their capacity to cope-up risks and exacerbate their vulnerability to shocks [Shiferaw *et al*., 2009]. It also diminishes the capacity of farmers to invest on sustainable natural resource management (SNRM) and uphold sustainable rural livelihoods (SRLs). The appalling impacts of land degradation in these countries are in general reflected through the loss of the inherent potential of LWRs in the form of soil fertility depletion and declining agricultural potential [Shiferaw *et al*., 2009; Schmidt and Tadesse, 2012]. For instance, in Ethiopia a total of 1,493 million tonnes of soil is lost annually at the rate of 12 t ha^{-1} yr^{-1} on average [EPA, 2012]. Around 17% of the agricultural gross domestic product (agricultural GDP) of the country is estimated to be lost each year due to physical and biological soil degradation [Amede *et al*. 2007]. According to Zeleke [2005], nearly 81 billion m^3 water hauling soil nutrients moves out of the country, and some 700,000 tonnes of grain crops are lost each year by burning dung.

Restoring and sustaining the natural resource base of agriculture has thus become imperative to SRLs in developing countries like Ethiopia. Understanding choices, needs and priorities of the rural households happens to be essential to design sustainable land and water management (SLWM) interventions [Shiferaw *et al*., 2009]. Hence, linking SNRM with SRLs has received significant focus in recent decades.

SLWM involves the activity of 'enhancing' and 'preserving' the productive potential of LWRs and grants enhanced options for continuous resource use and agricultural development. It is essentially linked to the application of soil and water conservation (SWC) technologies that match ecological, social and economic needs [Dumansky, 1997]. Livelihoods on the other hand refer to people and their resources, capacities and activities of making a living [Chambers and Conway, 1991]. The sustainability of making a living is determined by the presence or absence of assets. Livelihood assets enable rural people to own property [Barrett *et al*., 2001], enjoy meaningful life, and develop a sense of worth (respect and dignity) and to cope up with shocks and challenges [Nepali and Pyakuryal, 2011]. Farmers' access to basic assets such as farm land, water, forest, fodder and fuel are core indicators of SRLs and enable them to carryout SNRM practices. Diversity of choices, livelihood assets and strategies fix households' capabilities to cope-up with shocks and stresses, shape their investment and resource use efforts and to use new LWM technologies [Adato and Meinzen-Dick; 2002; Shiferaw *et al*., 2009]. But, LWRs can be easily exhausted if misused, disrupted and abused by improper practices. Hence, the sustainability of rural households can be threatened directly or indirectly [Chambers and Conway, 1991; Scoones, 1998] by their asset endowment levels. When farmers lack sufficient assets and institutions, they lose the base to invest on sustainable LWMPs [Shiferaw *et al*., 2009].

In Ethiopia, livelihood resources are endangered by the degradation of LWRs, population growth, rising social demands, and lack of equity and access and strong institutions [Anley *et al*., 2007]. The complex inter-linkages among poverty, population pressure, institutional failure and environmental degradation cause shrinkage of land holdings that led to farm fragmentation, landlessness and expansion of farming to steeper and marginal lands [Anley *et al*., 2007]. Due to increased population pressure and continual land degradation, the size of agricultural land (i.e. the basic livelihood asset) is continuously shortened [Teklu and Lemi, 2004]. Hence, farmers entirely abandoned the traditional practice of using natural fallow to restore soil fertility [Zeleke *et al.*, 2006]. Average per capita crop land for instance declined from 1.96 ha in 1957 to 0.53 ha in 2000 in the Baressa watershed, central highlands of Ethiopia [Amsalu, 2006]. Adenew and Abdi [2005] also note that the average landholding per household and per capita landholding in the Amhara Region measures only 1.1 and 0.24 ha, respectively.

Rural households continuously devise different livelihood strategies and SLWM methods in response to the aforementioned context factors [Shiferaw *et al.*, 2009]. Vigiak *et al.* [2005] indicate that farmers have deeper perceptions on soil erosion than agricultural experts. These authors note that farmers' concepts of soil erosion indicators have closer linkages with scientific methods. Ethiopian farmers also use diverse indigenous LWM systems that have been exercised for centuries. Abera and Belachew [2011] indicate that farmers use their knowledge of soil color, texture and water holding capacity to classify soils in terms of fertility. Erkossa and Ayele [2003] note that farmers identify four soil types: black, red, *Koticha* and sandy soils using color and texture. These authors rank soils based on their area coverage, fertility and response to fertilizer. Tefera and Sterk [2010] also inform that farmers in the Fincha watershed shift livestock shelter from one farm to another to retain soil fertility using manure. Government sources indicate that Ethiopian farmers often implement indigenous and introduced SWC technologies. Such sources remark that the current agricultural system encourages application of both technologies to improve the livelihood of the rural people [EPA, 2012]. In recent decades, the farmers adapt external methods in response to the ongoing resource degradation and food deficiency problems.

Zeleke *et al.* [2006] and Amede, *et al.* [2007] indicated that farmer participatory planning and intervention managed by MERET[1] has been succeeding in degraded hillside restoration and income generation via homestead development projects in few sites of the country. Mekonnen and Tesfahunegn [2011] confirmed that participatory based SWC interventions started since the 1980s with the support of the food-for-work (FFW) program have been succeeding in improving the levels of soil depth, natural vegetation, surface and sub-surface water levels in Tigray, northern Ethiopia. EPA [2012] also noted that watersheds covering 1,958,000 ha approximate areas were covered with multipurpose trees; about 1,708,100 ha lands were treated with area closures; some 2,076,000 ha lands were treated with physical and biological SWC measures, and around 122,430 ha lands were irrigated between 2004/05 and 2009/10 through community participatory watershed development in different parts of Ethiopia. About 6.8 million ha degraded lands were stabilized through watershed based community participation campaigns in 2011/2012 [EPA, 2012]. Nevertheless, the ongoing farmer and government initiated NRM development is little researched and not accurately documented in academic literature.

This paper describes farmers' methods of soil erosion identification and the practices of managing LWRs to enhance rural livelihoods. The study was conducted in four rural *kebele* administrations (RKAs, lower levels of local government in rural Ethiopia) in the northwestern highlands of Ethiopia.

METHODS AND MATERIALS

The study area

The study was conducted in four RKAs named Abadira, Badani, Dubi and Gayta in Dangila *woreda* in the northwestern highlands of Ethiopia (Fig. 1). The total land size of the study RKAs measures about 114.90 km^2. They form part of the northwestern highlands of Ethiopia where their elevations vary from 1,800 m asl in the southern plains of Badani to over 2,300 m asl in Abadira and Gayta. The micro-relief

[1] Managing Environmental Resources to Enable Transition to more Sustainable Livelihoods.

in the study RKAs is broken by small streams and wider gullies that often fill with rainwater during *kiremt* (the rainy season). Around 46 streams flow in the area of which 74% are used for irrigation. Based on records at Dangila town, the mean annual temperature in the study areas is about 17 °C and the annual rainfall is 1578 mm. About 93% of the total rainfall occurs between May and October with peaks in June, July and August. These three months account for 62% of the total annual rainfall [see Belay and Bewket, 2013a, 2013b & 2013c].

Based on color, the local farmers identify four soil groups: red color (*Forefor*), black color (*Mezega*), grey-brown (*Bunama*) and dark brown (*Abolse*) as dominating the areas. The red soils (which belong to the Nitosols group) commonly occur on hilly and sloping parts in about half of the study areas. They have a clay-loam texture and are most intensively cultivated, but also most seriously eroded. The black soils (Vertisols group) are more prevalent in Abadira, Badani and Dubi and often cover low-lying landscapes. The grey-brown soils (Luvisols group) frequently occupy the pediments in all areas. The dark-brown (Cambisols group) mainly occur in forested and previously settled areas and village compounds of the study areas, but widely observed in the northwestern margins of Abadira. Croton (*Croton macrostachyus*), Vernonia (*Vernonia amygdalina*), Acacia (*Acacia lahai*), Eucalyptus (*Eucalyptus camaldulensis*), Cordia (*Cordia africana*), Albizia (*Albizia gummifera*), Terminalia (*Terminalia brownie*) and Justicia (*Justicia schimperiana*) form the dominant vegetation types [Belay and Bewket, 2013a, 2013b & 2013c].

About 22,883 people inhabited the four RKAs in 3,343 households. Crop-livestock mixed subsistence farming is the basic source of livelihood of the people. Maize (*Zea mays*) in Badani and Dubi and *tef* (*Eragrostis tef*) in Gayta and Abadira are the leading crops in area coverage and quantity of output. Finger millet (*Eleusine coracana*), potato (*Solanum tuberosum*), oil seeds and pulses are among the crops grown in the RKAs. Vegetables and fruits are important crops cultivated using traditional irrigation around the homesteads in Dubi and Gayta [Belay and Bewket, 2013a, 2013b & 2013c].

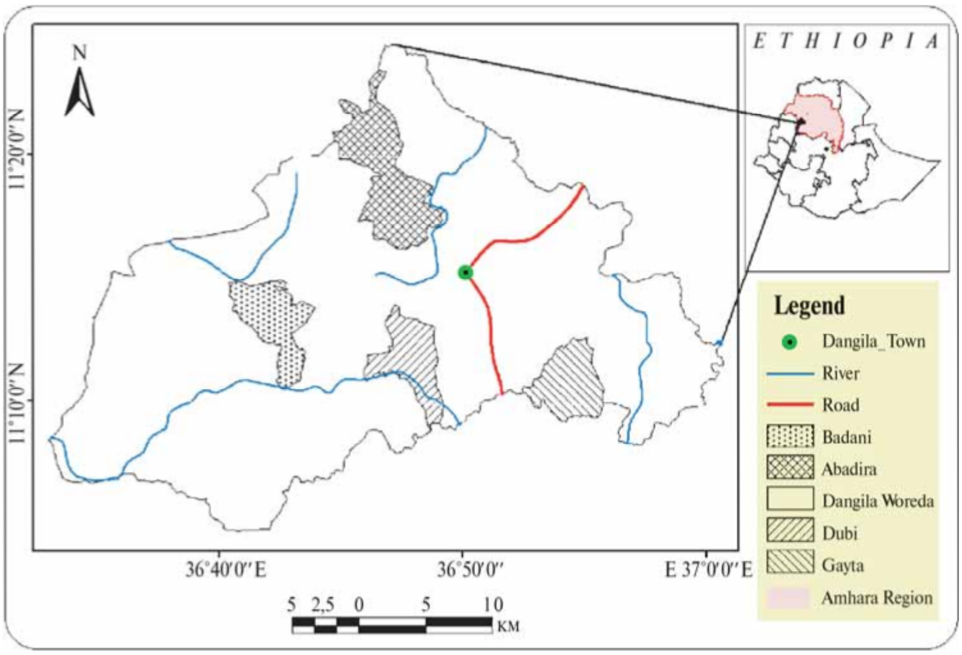

Fig. 1. Location map of the study area [Belay and Bewket, 2012a]

Data and Methods

The data used in this study were gathered from May 2010 to October 2013. The background data was gathered from unpublished reports and archives available at the study RKAs and the district agriculture office. Participatory transect walks, field observations, structured questionnaire surveys and formal and informal discussions were used to generate the primary data. During the survey, farmers' groups (FGs) were organized in the RKAs to work together with the lead researcher in field measurements, observations and transect walks. DAs working at RKA levels in natural resource, crop, livestock and irrigation development were involved in the discussions, transect walks and field observations. The primary data from FG discussions, field observation and transect walks were gathered from the four RKAs (Abadira, Badani, Dubi and Gayta). The structured questionnaire survey data were generated from 201 households selected using proportional systematic random sampling techniques from only three RKAs (Badani, Dubi and Gayta) for the purpose of another study and used in this paper. Data from published sources were also used to enrich the data gathered from different sources.

A livelihood strategy diversification index (LSDI) was computed to assess the degree of income diversity of livelihood activities. According to Wang *et al*. [2010], LSDI increases with increasing in the number of income generating activities and when the income share of the activities grow to be steadily normal; but decreases with a decrease in the number of activities and approaches zero when the coping strategy is one. Conversely, specialization increases with decreasing in the number of activities and when the income share of one or a few activities get larger than other activities. The LSDI for this study was thus computed using the formula used in Wang *et al*. [2010]: LSDI = 1 – H, where H is the Hirschman-Herfindahl index [kurosaki, 2003; Woerheide and Persson, 2008]:

$$H = \sum_{k=1}^{n} S_k^2;$$

$$LSDI = 1 - \sum_{k=1}^{n} S_K^2,$$

Where LSDI is livelihood strategy diversification index; S_K is the income share of the k activity in decimal units; k is the livelihood activity and n is the number of livelihood activities. The qualitative information obtained from formal and informal discussions was used to verify the quantitative information. The Statistical Package for Social Scientists (SPSS Version 15) and Microsoft Excel were used to manage and analyze the data.

RESULTS AND DISCUSSION

Land degradation identification and controlling practices by farmers

Like elsewhere in the world, farmers in northwest Ethiopia encounter problems of soil erosion. Over 79% of the farmers approached indicated the occurrence of soil erosion on their farm fields and some 59% reported the trend was increasing for twenty years 1991–2011 (Table 1). A field measurement study (Table 2) discovered the removal of some 82,692 tonnes of soil from 26 gullies and an average erosion rate of 16 t ha^{-1} yr^{-1} from 31 farms in two RKAs. Gully expansion has caused the loss of 4.66 ha cropped areas and an estimated ETB 2,631 crop yields. The severity of the erosion problem was rated moderate by 32%, severe by 24%, low by 20%, very low by 13% and very severe by 7% of the participant farmers (Table 1). Similar perceptions of considering soil erosion as severe and increasing trend were reported by the majority of the famers in the Digil watershed, northwestern Ethiopia [see Bewket, 2007].

During the questionnaire survey and in FG discussions, farmers were asked to specify what indicators they use to identify the prevalence of soil erosion on their farm fields and what methods they employ to manage

Table 1. Farmers' perceptions on soil erosion

Farmers' responses	% of reporters (n = 201)
Appearance of soil erosion on your farm plot	79.1
Trend of erosion on your farm in the past 20 years:	
increasing	58.7
no change	21.4
decreasing	16.4
no response	3.5
Severity of erosion on your farm in the past 20 years:	
very low	12.9
low	20.4
medium	32.3
severe	23.9
very severe	7
no response	3.5

Table 2. Soil erosion, land and crop damages and SWC measures in two RKAs (2010/2011)

Type of erosion damages & SWC measures	Size recorded for each
Erosion measured from tree root exposures (t ha^{-1} yr^{-1})	16
Erosion measured from gullies (tonnes)	82,692
Crop land damaged by gullies (ha)	4.66
Crop lost due to land damage (ETB)	2,631
Farms stabilized with soil terraces	32
Farms stabilized with stone-bunds	19
Farms stabilized with grass strips	39
Farms stabilized with ditches/water ways	52
Farms stabilized with cutoff drains	42
Gullies stabilized with catchment terraces	31
Gullies stabilized with check dams	19
Gullies stabilized with Sesbania	19
Gullies stabilized with Arundinaria	15
Gullies stabilized with Ipomoea	54
N° of farms assessed	31
N° of gullies assessed	26

Source: Adapted from Belay and Bewket [2012a & 2012b].

their land resources. Based on this, they mentioned various methods most of which are summarized in Tables 2. Checking the occurrence of water ways (gullies and rills), observing soil conditions (changes in soil colour and depth), looking the steepness of the land slope, evaluation of crop conditions (crop growth, seedling removal and yield changes), inspecting exposure of plant roots, and accumulation of sediments along lower farm margins were the major methods farmers use to check the occurrence of soil erosion on their farm fields. Most of these land degradation indicators conform to data reported in Vigiak *et al*. [2005] in Tanzania, Okoba and Sterk [2006] in Kenya and to methods used in Stocking and Murnaghan [2001].

Checking the occurrence of gullies and rills to identify the prevalence of soil erosion on farmlands was reported by about 63% and 41% of the farmers, respectively (Table 3). The use of gully to identify soil erosion by most farmers may be due to that gullies are easily and rapidly perceived than rills because of their large morphology and the direct damage of crops by gullies. Farmers continuously examine the occurrence of gullies and rills during their farming operations to check the prevalence of soil erosion on their farmlands. When they detect the appearance of these features, they perceive the occurrence of soil erosion on their farmlands and immediately take actions to reverse the problem. Constructing barriers from stones, soils, grasses and leaves across the channels or obliterating the waterways are among the immediate actions they apply. These structures are often performed during farming operations, very simple to apply and do not demand much labour and high cost. They are, therefore, implemented in a very short period of time and they are sustainable. For instance, check dams and catchment terraces were structures applied on the 19 and 31% of the assessed gullies, respectively. Plantation of sesbania (*Sesbania sesban*), Arundinaria *(Arundinaria donax*) and Ipomoea *(Ipomoea carnea)* were also measures adopted on 19, 15 and 54% of the assessed gullies, correspondingly (Table 2).

Observing soil conditions (depth and colour changes) is another method employed to check the presence of soil erosion on farm fields. Soil colour change is used by over 44% of the farmers. Sometimes farmers detect the prevalence of soil erosion when they get a hard rock while digging or ploughing their land. In this condition, they perceive that their soil depth is getting shallower because of the removal of the top soil by erosion and they concluded that there occurred severe erosion on their farmland. This method was also repeatedly used by about 63% of the participant farmers (Table 3). In such conditions, farmers often construct cutoff drains on the upper part of the farm to minimize further top soil removal.

Farmers can detect the prevalence of soil erosion by simply visualizing the land slope. If their land is located on a steep surface, they perceive the occurrence of soil erosion and prepare to take measures of protection. The usual performed measures include contour farming, cutoff drains, and construction of barriers such as stone and soil-bunds and grass strips (live-fences). During the field work, cutoff drains, soil terraces, grass strips and stone-bunds were observed on about of 42, 32, 39 and 19% of the farms surveyed, respectively (Table 2). Land slope was perceived as an indicator of soil erosion by about 67% of the farmers interviewed (Table 3).

When farmers observe more stone litters and exposed rocks and if it is strange for them, they suspect that the top soil has moved away by erosion and prepare to take actions to reverse the situation. Few farmers (18–22%) use this method. Tree root exposures are also most commonly used indicators by farmers as they are frequently occurring on farm fields. Inspecting the exposure of plant roots to identify soil erosion is used by about 43% of the farmers. Deposition of sediments on lower farm margins, along fences and stone barriers are also used by some 33% of the farmers to check the occurrence of soil erosion on farmlands and elsewhere in the environment. Fast moving muddy water is an indication of soil erosion for at least 26% of the total participants (Table 3).

Following-up the trend of crop growth, seed removal and yield changes, is another method

Table 3. Farmers' methods of land degradation identification

Method	Indicators: Local name	Indicators: English name	% of reporters (n = 201)
Observing and checking:			
Occurrence of gullies	*Borebor*	Gully	62.7
Appearance of rills	*Boy*	Water way	40.8
The change in soil depth	*Yeafer tilket*	Soil depth	62.7
Soil colour change	*Yeafer kelem*	Soil color	44.8
Crop growth condition	*Sebil*	Crop	69.2
Crop seedling removal	*Yezer mekelat*	Seed removal	54.7
Reduction of crop yields	*Mirt*	Yield	73.6
Tree root exposure	*Yezaf sir*	Tree root	42.8
Steepness of land slope	*Tedafat*	Slope	66.7
Sedimentation at farm bottoms	*Delel*	Sediment	33.3
Surface stoniness	*Yedingay kimichit*	Stone litter	18.4
Rock exposure	*Nitaf dingay*	Rocky outcrop	22.4
Water color change	*Chickama woha*	Muddy water	25.9

used by farmers to examine the occurrence of soil erosion on farmlands. When farmers see stunted crop growth, they understand that there is deficiency of plant food caused by soil erosion and take measures to restore the lost nutrients by adding either chemical fertilizers or animal manure. For instance, Table 4 indicates that about 71% of the farmers applied manure on 221 plots (74.79 ha lands) in the year 2010/2011. However, the use of manure as a natural soil fertilizer has become endangered by its demand for fuel and by the shortage of livestock feed resources [see Belay and Bewket, 2013a].

Farmers also directly perceive the existence of soil erosion when crop seedlings are removed by water. This is an evident sign of soil erosion particularly on steep-lands. Poor crop growth and plant seedling removal by water were reported by about 69% and 55% of the farmers, correspondingly (Table 3). Comparing the trend of successive crop yields on the same land is another proxy indicator used by farmers to understand the presence of soil erosion on their farms. They usually compare the amount of yield obtained in the second year with that received during the first year, and they conclude that there is erosion if the amount of yield has decreased. This proxy indicator was used by over 73% of the farmers because farmers directly associate soil erosion with yield reduction i.e., with the loss of benefits. This is an essential indicator that initiates farmers to take conservation measures to reverse the situation. In such occasions, farmers usually use crop rotation, intercropping and improved seeds in addition to application of manure and chemical fertilizers. Crop rotation and inter-cropping were apparently applied by greater than 92 and 75% of the farmers, respectively (Table 4). During the field work, it was observed that cereal crops like *tef*, maize, millet and barely were planted in rotation with leguminous crops such as oil seeds, pulses and *gibto (Lupins termis)*.

Most of the land degradation indicators are almost similar to the report indicated Vigiak *et al*. [2005] in Tanzania and Okoba and Sterk [2006] in Kenya. Okoba and sterk [2006] indicated that indigenous soil erosion indicators are well in agreement with the broad scientific knowledge. The indigenous methods reported by the participant farmers were based on their perceived experiences, and these are not far from the already accepted scientific methodology. Farmers observe and apply the methods during their farming operations. Hence, they do not take much time to perceive and easily reverse using simple measures. As the farmers detect and reverse observed erosion signs by themselves, there is no need of intervention and convincing what methods to choose and how to apply the preferred methods. They take an action by themselves immediately when they see the danger. Okoba and sterk [2006] indicate that such current erosion signs are easily obliterated and reversed. Efforts have thus to be done by the concerned agencies to enhance these inbuilt farmer practices.

Introduced methods such as chemical fertilizer and improved seeds are applied

Table 4. Soil fertility retention and SWC measures reported by farmers in three RKAs (Badani, Dubi and Gayta) for year 2010/2011

SWC practices	Size performed	N° of plots treated	Size treated (ha)	Reporters (%)
Manure	–	221	74.79	71
Crop rotation	–	–	–	92.5
Inter-cropping	–	–	–	75
Chemical fertilizer (kg)	34,308.5	467	188.5	76.1
Improved seed (kg)	1658.5	184	72.9	70.65
Live fences (N° of trees)	16,283	121	39.3	40

to increase yield for short-term benefits and they are appraised for their immediate advantage and higher productivity. Some 467 plots measuring over 188 ha were treated with 34,308.5 kg fertilizers (Urea and DAP/ Di-Ammonium Phosphate) on over 76% of the farmers' fields in 2010/2011 (Table 4). In FG discussions, farmers were complaining and blaming on use of fertilizer on the ground of high cost and on only one time use. Most farmers complain chemical fertilizer is too expensive to afford. Tefera and Sterk [2010] reported that 41–50% of the farmers in the Fincha'a watershed, western Ethiopia, add chemical fertilizer and collect better yields, but they complain on the higher costs. This finding is thus in line with the result reported in Tefera and Sterk [2010]. A significant number of farmers complained that the use of chemical fertilizer exhausts the long-term fertility of land. They explained that a land planted using fertilizer in the first harvest will never give good yield without fertilizer use in the next harvest. During FG discussions, more than half of the participants commented that urea creates a hard crust on their farms. Similar complaints were also reported in Beyene *et al.* [2006] in Tigray, northern Ethiopia.

Improved maize seeds were used by about 71% of the farmers in 2010/2011 cropping year. Some 1658.5 kgs of improved seed were applied on 184 plots covering 73 ha (Table 4). But, they were blamed for their one-time service because the crop obtained using improved seed in the first harvest cannot be used as a seed in the next harvest. This has forced the farmers to search for new seeds from seed trading enterprises and make them dependent on purchased seeds. In FG discussions, it was learned that seed for the next harvest was kept from yield obtained at home or from the surrounding villages and farmers were not involved in search of seed when the sewing season approaches before the expansion of external seed application. But now, farmers spend part of their time in search of seed and other inputs. The seed accessed through such efforts was also observed sometimes to fail to germinate or to grow as expected. This condition has worried farmers of the study areas, particularly in 2010/2011 main cropping season. Farmers reported that maize seed (BH660) accessed from a seed enterprise at Bahir-Dar, northwest Ethiopia, was failed to germinate and to grow well. They were; therefore, subjected to additional cost of money and labor to replace the lost crop in RKAs named Dubi and Gayta. Adato and Meinzen-Dick [2002] reported that improved maize varieties in Mexico were more vulnerable to pests and decaying and farmers in Zimbabwe who had adopted hybrid maize were vulnerable to widespread crop losses and loan defaults due to susceptibility of the new maize to drought and fertilizer burn in the early 1990s. The problem encountered by farmers in the study areas has thus support from other areas worldwide.

A significant number of farmers have reported that introduced seeds caused the loss of indigenous crop varieties from their farms and crop stocks. According to the reports (Table 5), maize varieties locally named *dimishumbi* (red maize), and *zagir/ageriche* (indigenous maize) were on the verge of disappearance. About 55% of the participants indicated that *Zagir* has lost from their farms and from their crop stocks beginning from 2004 and 23% of them reported *dimishumbi* has disappeared from 1998 onwards. The mentioned maize varieties are preferred in the area mainly for their sweet taste and preparation of the local traditional drink named *tella (*local bear*).*

Table 5. Maize crop varieties lost from smallholder farms (% of reporting farmers)

Local name	English name	Reporting farmers (%)	Time (year)
Dimishumbi	Red maize	23	since 1998
Zagir/Ageriche	Indigenous maize	55	since 2004

The above cited evidences indicate that a significant number of farmers used to depend on purchased seed that may sometimes be difficult to access due to shortage or inability

Fig. 2. Farming in Abadira (Oct. 2012).

to afford the required market level costs. In some occasions, the seed shortage may cause failure to cultivate available land and may also lead to food insecurity. The loss of the indigenous maize (*zagir/agerich*) from the stock of 55% farmers meant that the crop would gradually disappear from the area. This eventually could cause the risk of genetic erosion. Heal *et al.* [2004], remarked that a turn down in genetic diversity in agriculture can lead to susceptibility to pathogens, and cause the risk of crop failure and problem of food supplies. Visser [1998] has also indicated the rise of modern breeding industries during the green revolution have caused the shift from many locally adapted varied landraces to fewer high-input demanding external varieties. The focus on only external crop varieties with neglect of indigenous ones may lead to the loss of indigenous genetic resources like what was happened in Greece, India, and other Southeast Asian countries after the 1960s as cited in Visser [1998] and Heal *et al.* [2004].

The continuously growing fertilizer price is also another frequent headache to farmers. Dependence on external input degrades the

Fig. 3. SWC measures adopted by farmers in micro-watersheds (Oct. 2012)

confidence of farmers to use local resources and indigenous methods. Takeuchi and Shaw [2008], for example remarked that the reliance on introduced technology make farmers to be expectant of external resources and methods and erode their self-esteem to assist themselves. Farmers who use only chemical fertilizer and government seed frustrated and worried when the sewing season approaches. Shortage of supply including lack of the necessary money to buy seed and inputs make them much worried and frustrated. Takeuchi and Shaw [2008] thus advice the ideal LWM measure ought to incorporate the 'right mixes' of local and introduced methods.

SLWM measures practiced by farmers in the study RKAs include also contour farming, traditional ditches and unplowed farm strips. Contour farming (Fig. 2) is a commonly used traditional practice exercised by farmers in the study RKAs as elsewhere in Ethiopia. In the study RKAs, farm lands are usually ploughed three to seven times depending on the type of soil, requirement of the specific crop and availability of draught power and labor. Nevertheless, as Bewket [2003] notes repeated farming prepares the soil to further erosion. Nyssen *et al.* [2000] also remarked that traditional contour ploughing practices initiate down-slope soil movement and accumulation of soil in the lower farm margins. Therefore, there is a need to assess the benefits and adverse effects of the traditional practice of repeated ploughing. Traditional ditches are usually applied on newly plowed farms immediately after sewing. They are used to drain-out excess water on water-lodged soils. During the field survey, traditional ditches were recorded on about 52% of the assessed farms (Table 2). Unplowed farm strips were often observed between the boundaries of farms owned by different people. Grass and bushes grow along these strips and trap eroded soil materials.

In recent years, installations of structural SWC measures (Fig. 3) have been going on through community-based campaigns on micro-watersheds. For instance, in 2011/2012 alone, over 152 km soil bunds were constructed on 968 farm plots measuring 758 ha lands in the four RKAs (Table 6). Soil-bunds measuring some 22 kms were also constructed on 6 community grazing fields measuring 219 ha. Stone-bunds measuring 2 km were installed on 20 plots of 10 ha lands and other 2 km stone-bunds were built on three grazing fields measuring 10 ha lands. Over 53 km soil-bunds and 2 km stone-bunds on farmlands and over 11 km soil-bunds and some 2.2 km

Table 6. SWC structures built by farmer campaigns in micro-watersheds in the four RKA (2011/2012)

Structure type	Size covered
Soil-bunds on farm lands	
Size executed (km)	152.3
N° of plots treated	968
Size of plots treated (ha)	757.5
Size stabilized with vegetation (km)	53.5
Length maintained (kms)	144
Soil-bunds on grazing lands	
Size executed (km)	22
N° of fields treated	6
Size of fields treated (ha)	219
Size stabilized with vegetation (km)	11.3
Length maintained (km)	12.5
Stone-bunds on farm lands	
Size executed (km)	1.85
N° of farms treated	20
Size of fields treated (ha)	10
Size stabilized with vegetation (km)	1.85
Length maintained (km)	1.85
Stone-bunds on grazing lands	
Size executed (km)	2.2
N° of fields treated	3
Size of fields treated (ha)	10
Size stabilized with vegetation (km)	2.2
Length maintained (km)	2
N° of Gullies stabilized	
Gullies treated with check dams	22
Gullies stabilized with vegetation	12
Gullies maintained	14

Source: RKA offices in the study areas (Oct. 2012) stone-bunds on grazing fields were stabilized with vegetative measures. Previously installed 144 km soil-bunds and 2 km stone-bunds on farmlands and over 12 km soil-bunds plus 2 km stone-bunds on grazing fields were also maintained in the four RKAs in 2012. In addition, new check-dams were constructed on 22 gullies and old check dams were maintained on another 14 gullies. Gullies stabilized with vegetation were found 12.

The above SWC structures were executed through farmer participatory approaches operated in mass mobilization campaigns (similar to what was happening before the 1990s). The farmers' campaigns were carried out for a period of 20–40 days during the dry months using free farmer labour. Similar SWC measures were reported implemented in central Ethiopia during the Derg time (1975–1990) through farmer campaigns assisted by FFW program [Shiferaw and Holden, 1998]. But, such projects were only partially successful or else ended in failure due to their dependence on forced labour as reported in previous studies [e.g. see. Shiferaw; Holden, 1998; Amsalu, 2006].

Integrated application of technologies

Research evidence recommends the use of integrated measures such as local and new practices, structural and vegetative measures, run-off control and yield enhancing technologies in the fields of sustainable land management (SLM) and agricultural activities [Erkossa and Ayele, 2003]. Many studies remark that neither animal manure nor chemical fertilizer alone will improve soil fertility and most recommend the integrated use of organic and inorganic inputs [Damisa and Igonoh, 2007] such as manure, chemical fertilizer, mulch, intercropping, cereal legume rotation and green manure.

Many farmers in the study RKAs were observed using integrated SWC technologies such as structural and vegetative, indigenous and introduced measures. For instance, farmers used contour farming for longer years accompanied by traditional ditches, farm boundary, cut off drains, stone-bunds, and live-fences to conserve soil and water. They were able to mix indigenous and introduced soil fertility methods on the same plot. About 20% of the farmers integrated manure with compost, Urea and DAP and achieved excellent results. Other combinations also reportedly showed good results (Table 7). Generally, farming households were able to get good results by integrating a number of indigenous methods with introduced ones. Erkossa and Ayele [2003] reported that manure and fertilizer were used together on the same field in western Ethiopia. This supports the current study. According to Osman *et al.* [2000], the use of integrated SLM technologies helps farmers to diversify farming activities, to minimize production risks and to reduce soil erosion hazard. The use of integrated methods such as local and introduced practices, rainfall and irrigation, crop and livestock is thus beneficial.

Table 7. Indigenous and introduced land management technologies integrated by farmers

SWC & soil fertility technologies		**Result**	**% of reporters (n = 201)**
Indi-genous	**Introduced**		
Manure	Urea + DAP + Compost	Excellent	20
Manure	Urea + Lime + Compost	Good	22
Manure	DAP	Good	22

STAKEHOLDER LINKAGES FOR SUSTAINABLE LAND MANAGEMENT

Amsalu [2006] noted that household level LWM decisions tend to be influenced by village, national and regional level authorities. This influence is also reflected in the study areas. Decisions made at federal/regional levels have been influencing household technology adoption decisions. Farmer participation in new technology identification decisions are observed very low (2%). Only 20% of the farmers participate in technology use related trainings at both local and Regional levels. The mean farmer-DA contact regarding LWM issues is observed very low, < one day per annum. Generally, farmer-expert linkages are found getting weaker from RKA to district and regional levels (Table 8).

Table 8. Farmer-expert linkages in SWC activities

Farmers' interactions & participations	Responses in % (n = 201)	
	Yes	No
Contact with RKA officers	85	15
Contacts with DAs	76	24
Contacts with District level experts	18	82
Contacts with Zone level experts	6	94
Contacts with Region level experts	4	96
Participation in training at different levels*	20	80
Participation in new technology selection decisions	2	98
Frequency of contact with DAs (average N° of days yr^{-1})	0.98	–

Source: Adapted from Belay and Bewket [2013c]
*RKA, District, Zone and Region levels

FARMERS' LIVELIHOOD ASSETS AND STRATEGIES

Livelihood assets

A household survey in three RKAs (Tables 9 &10) indicate that age, sex, education, and family size are important human-demographic assets that enable rural households to produce livelihood goods in the study RKAs. Some 15% of the studied households were led by females. The mean age of all farmers interviewed was 39.6 years. The average number of family members was discovered 5.61. The active productive age group in the surveyed population was calculated 48% while the rest 49% were below age 18 and people above age 64 accounted for 3% of the total (Table 9).

Table 9. Household demography (%)

Household heads by age and sex				Total population of sample households by age and sex			
	Sex		Total		Sex		Total
Age	M	F		Age	M	F	
18–35	35	13	32	<18	49	49	49
36–64	57	77	60	18–64	48	49	48
>64	8	10	8	>64	3	2	3
Total	100	100	100	Total	100	100	100

Source: Belay and Bewket [2013a].

Land and livestock are also among the most important resources used by farmers to produce livelihood items (Table 10). Getting professional support from DAs and agricultural experts (Table 8), taking credit from ACSI (Amhara Credit and Savings Institution), using irrigation, charcoal and wood selling, engagement in daily labor and sharecropping (Fig. 4) were among the livelihood strategies used by farmers to improve their livelihood conditions. Intercropping, crop rotation, using improved seeds, adding animal dung and industrial fertilizer were also among the methods used by participant farmers to increase crop yields (Table 4).

Table 10. Mean livelihood assets among the surveyed households in three RKAs

Household assets	Mean values (n = 201)
Age of household heads (years)	39.61
Level of education (years)	1.29
Family size (number)	5.61
Farm size (ha)	1.42
Land/man ratio (ha $person^{-1}$)	0.28
Livestock (TLU)	3.66
Round trip plot distance from home (km)	1.32

Source: Adapted from Belay and Bewket [2013a]

Land is the principal natural asset from which human beings derive their basic livelihood needs such as food, clothing and shelter. Farmland is the basic asset from which farmers in the study RKAs produce food supplies. But its size is diminishing from time to time due

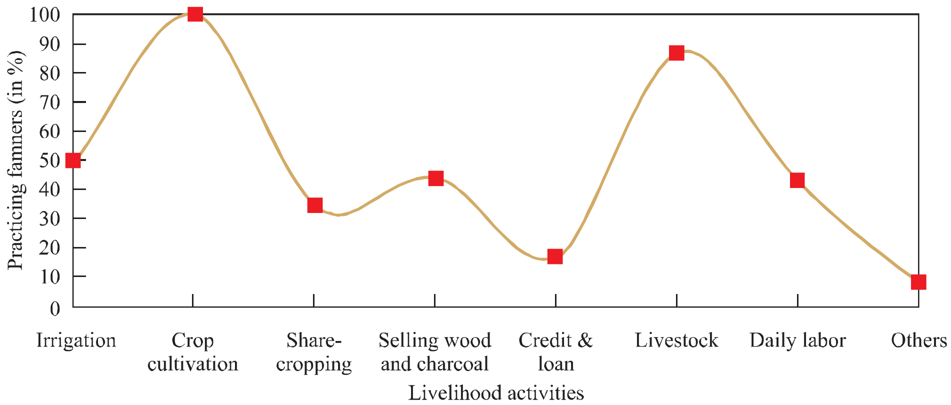

Fig. 4. Farmers' livelihood strategies

to increasing populations. The mean farm size in the study areas was 1.42 ha per household and 0.28 ha per person. The mentioned farm size is also not available for some portion of the households (for about 14%) in the three RKAs [see Belay and Bewket, 2013c] and it is fragmented and faraway from the homesteads wherever it is available, demanding a 1.3 km roundtrip trail distance on average (Table 10). However, walking farther distance from homesteads to work on the farms was found significantly reducing households' sustainable land management technology adoption decisions and practices like manure use as reported in Belay and Bewket [2013a].

Livestock are part of the major farming enterprises in the study RKAs like that elsewhere in rural Ethiopia and form the second major activity next to crop farming. They provide farming families with draught power, manure, cash revenue and food items (milk and meat products). Culturally, livestock heads constitute a prestige value and they are indicators of wealth status in the rural areas. Around 87% of the farmers interviewed reported that they have livestock (Fig. 4). The mean household livestock holding (in tropical livestock unit, TLU) was about 3.66 (Table 10). Livestock are essential assets that enable farmers' to enhance sustainable technology adoption decisions and to improve household livelihoods [see Belay and Bewket, 2013a].

Around 17.4% of the studied households were users of rural credit from ACSI and farmers' cooperatives (Fig. 4). Farming households were also receiving professional support from DAs and agricultural experts. However, average annual farmer-expert contacts were < 1 day (Table 8).

Livelihood strategies

Farmers in the study RKAs have various income sources and livelihood strategies to cope-up with challenges. Crop-livestock mixed farming is the major occupation of over 85% of the farmers studied. Crop production is the main source of income for almost over 99% of the farmers (Fig. 4). As shown in Table 11, the mean crop income received by each household in 2010/2011 was ETB 3244. The highest income was derived from maize production and followed by *tef* and potato. The lowest mean income was generated from pulses and oil seeds.

The income earned from farming and livestock rearing is not sufficient to cover all household expenses. Therefore, it is supplemented by income derived from selling wood and charcoal, daily labor, taking credit and loan and other activities (trading, weaving, carpentry, tannery and receiving remittance). These activities correspondingly serve as sources of additional revenue for 44, 43, 17 and 8% of the farmers (Fig. 4). Other

Table 11. Mean crop income of farmers' in three RKAs in 2010/2011

Crop type	Mean income ETB*
Tef	596
Maize	1063
Barely	317
Millet	175
Pulses	4
Oil seeds	57
Fruits	74
Vegetables	216
Potato	590
Sugar-cane	153
Total	3,244

* ETB 16.50 = USD$1 during the time of survey
Source: Field survey (April 2011–October 2012)

livelihood sources mentioned by farmers also include sharecropping and irrigation.

Some 34% households in the study rural communities relied on sharecropped land which provided them with considerable food supplies (Fig. 4). Table 12 indicates that 399 farmers in the four RKAs were sharing-in land from 368 other farmers in 2011/2012. Around 552 plots (121.5 ha lands) were transacted in the process. Some 37 farmers leased-out about 38 plots (11.56 ha lands) costing a total of ETB 141450 to other 36 persons for 25 years. The average cost of the sold farms was ETB 12,236 ha^{-1} or 3,722 $plot^{-1}$. Each household has sold at least one of his/her plots (0.31 ha lands). Over 44% farmers who rented-out their land were women but only one was female among who rented-in land. Most of the farms leased for 25 years were checked planted eucalyptus trees which may lead the soils to be acidic. The bulk of the leased and sharecropped farms were not often treated with proper SWC structures and most of them get exhausted their potential after continuous and repeated tillage with no treatments.

Participation in irrigation in the study areas enabled some farmers to grow diverse crops including vegetables. Table 13 shows that

Table 12. Sharecropping and long-term land leases in the four RKAs (2011/2012)

Information type	Value
No of sharecropped plots (2011/2012)	552
No of farmers who rent-out their land to others (2011/2012)	368
No of farmers who rent-in land from others (2011/2012)	399
Total size of sharecropped plots in 2011/2012 (ha)	121.5
No of farmers who leased out their land for 10–25 years	37
No of farmers who leased-in for 25 years	36
Size of farms leased for 25 years (ha)	11.56
Number of farms for long -term	38
Total land cost ETB	141450
Mean cost ETB per ha	12,236
Mean cost per plot ETB	3,722

Source: RKA offices of the study areas (Oct. 2012)

over 30% of the farmers (22% in Abadira, 4% in Badani, 31% in Dubi and 72% in Gayta) were practicing irrigation in 2010/2011. The proportion of farmers participating in irrigation appears larger in Gayta and lower in Badani. Some 46 streams (9, 8, 14 and 15 in Abadira, Badani, Dubi and Gayta, respectively) were identified during the field work of which 74% (70, 50, 64 and 93 in Abadira, Badani, Dubi and Gayta, correspondingly) were used for irrigation. A total of 44 diversion canals and 34 water committees with mean number of 5 members were observed supporting the irrigation scheme in the study areas. Some 1372 plots were irrigated and around 25 farmers were sharing one diversion canal on average. Irrigation water in the study RKAs was distributed in rotation turns and was managed by an elected water agent named *axu tabla* (the father of water).

Since the past decade, farm land has been shrinking in the study RKAs due to increased population pressure and pressed farmers to grow diverse crops (cereals, vegetables and fruits) and become a "push factor" as what was termed in Barrett *et al.* [2001] for diversification

Table 13. Land use information by RKAs (2010/2011)

Information type	Abadira	Badani	Dubi	Gayta	Sum
No of streams	9	8	14	15	46
No of irrigated streams	7	4	9	14	34
% of irrigated streams	78	50	64	93	74
No of diversion canals	17	4	9	14	44
No of water committees	9	2	9	14	34
No of members in each committee	3	6	4	7	5
Total N° of farm HHs	1350	481	698	814	3343
% of HHs participated in irrigation	22	4	31	72	33
No of HHs participated in irrigation	297	20	218	584	1119
No of irrigated plots	297	20	275	780	1372
No of HHs per diversion canal	17	5	24	42	25

Source: RKA offices of the study areas (February 2011 & Oct. 2012)

of livelihood activities. Farmers with non-or-small sized plots were also forced to search for alternative income generating activities such as daily labor, charcoal production and wood selling. For instance, the LSDI (Fig. 5) indicates that farmers have been able to diversify their livestock and cereal production and off-farm activities in all of the study RKAs. Nevertheless, pulse and oil seed production were not sufficiently diversified and were almost dominated by only one crop. As to Barrett *et al.* [2001], livelihood diversification can be considered as a "self-insurance" to minimize risk factors. In his view, off-farm income is a "pathway" for rural farmers to escape from poverty and hunger. Diversifying livelihood strategies is thus an important issue to be encouraged in the study areas.

THE NEED TO BUILD ON LOCAL SUSTAINABLE LAND MANAGEMENT PRACTICES

Generally the low level of success in SLM projects is caused to some extent by attempts to use technologies unsuitable to particular environmental and socioeconomic circumstances of the project sites. It has been proven elsewhere that SLM technologies can only be successfully implemented if it is suitable for the particular conditions of a site. Similarly, research evidence has also shown that a technology which is the development or

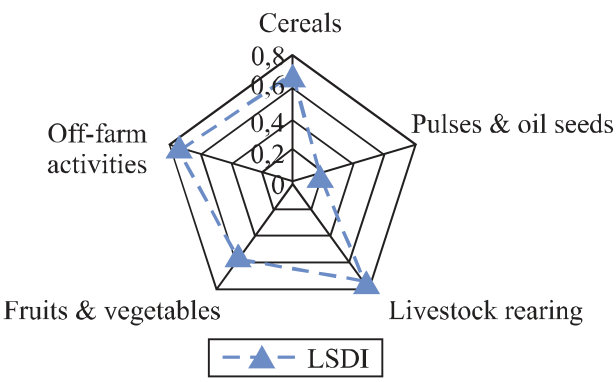

Fig. 5. Livelihood strategy diversification index (LSDI)

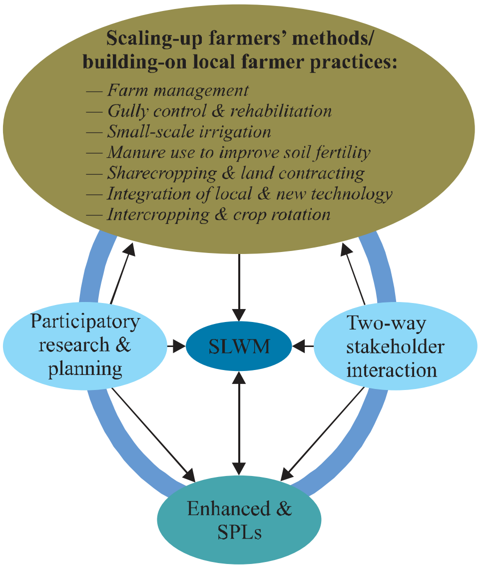

Fig. 6. Framework for enhancing rural livelihoods through SLWM

improvement of an existing practice is usually accepted more readily than something which is completely new, because of the fact that the former are technologies that are built upon local traditional practices and hence local skills and knowledge. In other words, consideration of suitability of technologies to local agro-ecological and socioeconomic circumstances contributes to the success of interventions. This underscores the need for future interventions to pursue participatory planning and farmer-led processes for a systematic integration of indigenous knowledge with modern technical knowledge to arrive at environmentally and socially sensitive technologies and practices encompassing not only watershed rehabilitation goals, but also social benefits in terms of immediate returns to the participating households. SLM practices required to enhance rural livelihoods thus should be emanated from building on local practices, integration of local and conventional technologies, and through promoting two-way stakeholder interaction systems and mapping and documenting land management information (Fig. 6).

Farmer participation must be considered as a key factor in building on local practices. This is because most of the land and water use and management decisions are made by the farmers. It is learned from past literatures that SWC interventions that neglected farmers' involvement in decisions were doomed to failure or offered limited success [Amsalu, 2006]. The previous top-down blanket technology promotion approaches exercised in the area had to give way to more farmer participatory trends that could enable farmers to reach appropriate land use decisions.

In two-way participatory stakeholder linkages both farmers and agricultural experts as well as researchers work in close collaboration, share experiences and grow to be enduring partners [Scherr, 2000]. Land management experts and researchers can enhance technical skills and capacities of farmers and they can learn new local practices, methods and knowledge systems from the farmers. The participatory stakeholder linkage thus must be established on the firm foundation of enhancing technical skills and research capabilities of farmers by involving them in assessment of land and water management constraints, technologies and as decision makers in SLM practices. In such cases, farmers could be made to identify their own needs, priorities and constraints. In the process, they may accept or reject technologies by themselves based on their perceived preferences [Amede *et al.*, 2006]. When they become familiar about technologies, farmers internalize it and make it their own undertaking. Therefore, planners, researchers and extension workers should put farmers at the centre of SLM [Shaxson *et al.*, 1989] to successfully scale-up best practices.

CONCLUSIONS

This paper was intended at assessing farmers' methods of soil erosion identification, SLWMPs, livelihood assets and strategies, in four RKAs in the northwestern highlands of Ethiopia. Participatory transect walks, field observations, examination of office documents and archives, formal and informal discussions with farmers' and FGs and structured household surveys of 201 rural households were the sources of data for the study. Results indicated that famers use around 13 indigenous methods to identify the occurrence of soil erosion on their farmlands. Over 79% of the studied farmers indicated the occurrence of soil erosion on their farmlands and some 59% reported the trend was increasing for twenty years, 1991–2011. More than 174 km soil-bunds and greater than 4 km stone-bunds were built on farmlands and degraded grazing fields through farmer participatory watershed development campaigns. Some 34 degraded gullies were stabilized using check dams and vegetative measures. Around 71% of the households applied cattle manure on about 75 ha lands to enrich soil fertility. A total of 44 diversion canals and 34 water committees were established to facilitate irrigation activities of some 33% households.

Farmers benefited from integrating indigenous and introduced LWM technologies such as structural and vegetative measures, manure and chemical fertilizers. Many farmers get results ranging from moderate to excellent by combining manure with compost and Urea and DAP. However, introduced methods such as improved seed and fertilizer were commented unaffordable and unsustainable. Over eight livelihood strategies were used by people in the study areas. But the mixed crop-livestock farming was the main source of income for the majority of the rural households. Farmers used to grow diverse crop and livestock varieties and perform various off-farm activities to cope-up with livelihood challenges. It is concluded that farmers' inbuilt methods and practices (farm management and gully control, manure use and small-scale irrigation, crop-rotation and intercropping, integration of indigenous and new technologies, sharecropping and land contracts, participatory research and planning and two-way stakeholder interaction) should be encouraged to enhance rural livelihoods and achieve the anticipated green development. Increased effort has to be made by concerned agencies to help farmers own assets essential for household livelihoods and to diversify their livelihood strategies and to use SLWM technologies.

ACKNOWLEDGEMENT

The study was financially supported by the School of Graduate Studies of Addis Ababa University, Ethiopia. ■

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