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Impacts of Community Based Watershed Management on Land Use/Cover Change at Elemo Micro-Watershed, Southern Ethiopia

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Abstract Implementation of watershed at small scale level, through community participation would enhance biodiversity, increase soil fertility, reduce soil loss and also contribute to climate change mitigation. In view of this, this paper assesses the impact of community based watershed management on land use/cover change at Elemo micro watershed. Comparison of land use/ cover before and after the implementation of watershed development program was made using satellite images of four periods to shed light on the role of community based watershed management at micro-level. Cognizant of the prevailing land degradation and the consequent livelihood challenges, the local government in collaboration with the local people had introduced watershed management in the area in 2005. Following the intervention, large areas which were degraded and left bare had been covered with bush/shrub, agroforestry and grassland. Before the intervention (in 2005), the proportion of bush/shrub and agroforestry was 171 ha and 34 ha respectively. This was later increased to 617 ha and 152ha respectively following the measures taken. The result also showed that the implemented community based watershed management intervention resulted in restoration of biodiversity and improvement in soil fertility. A key factor to this success was active participation of the local community through their social organization and cultural practices such as *Urane*. The findings of this study reveal that CBWSM at small scale plays an essential role in improving land use planning, reducing poverty and creating sustainable livelihoods in Ethiopia.

Keywords: *community based watershed management, land use/land cover, micro watershed, agroforestry, Ethiopia*

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1. Introduction

Land use/cover change (hereafter LUCC) is increasingly recognized as an important driver of environmental change in all spatial and temporal scales [1]. It has been occurring at rapid rate, involving the conversion of forest land to agricultural land, range land, grassland, woodland to bare land and vice versa [2]. The changes can either take the form of uni-directional or multi directional. Rapid conversion from forest and woodland to agricultural land in the sub-Saharan African countries, driven by both proximate and underlying forces is an indication of uni-directional changes [2]. The multi-directional changes imply the conversion and modification from woodland and grassland to farmland and then due to fallowing or ex-closure regeneration of grassland and woodland [3]

The change can either bring positive or negative impacts depending on what drives the changes. Apparently, the change is driven by either anthropogenic factors, biophysical, socio-economic, institutional or political factors, which can be categorized as proximate and underlying causes [4]. Human activities that promote conversion of forest land to agricultural and urban may result in negative impacts; while human activities which promote conversion of degraded land to forest land or agroforestry may result in improvement of land cover [2].

Improvement in land cover can be achieved through implementation of different natural resource management approaches among which community based watershed management (hereafter CBWM) is the principal one. Managing natural resources at household level by engaging the local people from the initial phase ensures its effectiveness and sustainability. Thus, in order to successfully restore productivity over degraded land, it is very important to make sure that farmers are willing to invest their labour and limited financial resources on management of natural resource [5].

Different approaches of watershed management exist, ranging from local to global scale, top-down to bottom up, sectoral to integrated [6] Top down approach focus on technical and physical works alone and hence would not lead to the desired environmental objectives. It is more or less a fixed or rigid technology solution, which in most cases failed to bring desired results and, in some cases, may have led to increased environmental degradation [7,8]. The ineffectiveness of most of watershed projects is attributed to top-down approach, which disregard local knowledge, socio-economic condition and available resources [9,10,11]. Local knowledge, experience and practice based watershed management is thus becoming the choice of most practitioners, development agents and government officials.

In developing countries such as Ethiopia, natural resource management through mobilization of rural community, living in a small watershed, sharing similar culture and social organization would bring desired changes than working on large and complex watershed involving different groups of community. Apparently, small holder farmers in Sub-Sahara African countries lack human and financial capacity to invest on land management. Thus, in contexts where majority of the rural community depend on subsistence livelihood, resource management at micro watershed scale would be more effective than at meso and macro scale. This goes with the notion of ‘small is beautiful’, a philosophy of [12], although his philosophical argument is based on the impacts of large scale economics. In his book entitled ‘Small is beautiful; a study of economics as if people mattered’ [12] explained how gigantic modern economic system, its use of resources impacts human well-being. He argued that people-centred economics are more effective because that would, in his view, enable environmental and human sustainability. Watershed management activities conducted at micro level is more effective in terms of mobilizing the local people and engage them in the activities in a sustainable manner [13].

Similarly, local people centred resource management endeavor carried out at micro watershed level is more effective as compared to top-down approach; as it would strengthen the already in place traditional practices and facilitate mobilization of the local people to engage them in a consistent and coordinated manner. In areas such as Gedeo, where culture based resource management prevails, capitalizing on the already in place community based resource management is vital. On the other hand, focusing on large watersheds limit participation and ownership feelings of communities dilutes efforts and creates problem on sustainability of activities [6].

Empirical evidences have also shown that watershed managements conducted at the micro-watershed level were more successful than the one carried out at macro-watershed scale [13]. Watershed development programs launched in the Northern parts of Ethiopia are among exemplary watershed management programs in the country simply because they were people centered and thus all were accompanied by success stories [14,15,16].

Therefore, this paper is developed from a study conducted on a micro-watershed development program in Gedeo zone in Southern Ethiopia with the aim to assess the impacts of watershed management on land use/cover changes.

2. Materiasl and Methods

2.1. The Settings

Elamo micro watershed is located in Wonago Woreda, Gedeo zone, Southern Nation, Nationality and People (SNNP). The watershed is located between $6^{o}\,24'$ to $6^{o}\,38'$ North latitude and $38^{o}\,14'$ to $38^{o}\,25'$ East longitude. The total area of the watershed is 1551hectares.

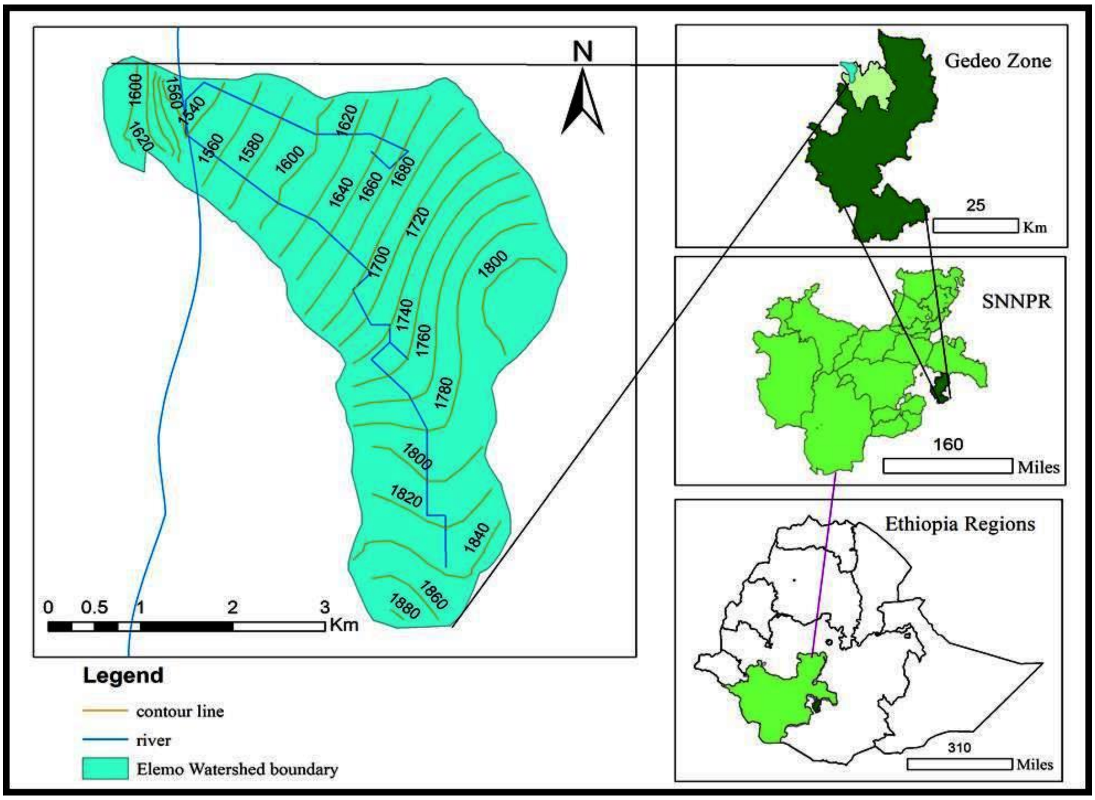

Figure 1. Location map of the study area

The watershed is characterized by rugged topography. The slope of the watershed ranges from 0 to 60%. The topography is oriented from SE and SW to NW, controlling the flow of the river (See Figure 1). Altitude of the watershed ranges from 1640 ma.s.l to 2020 m a.s.l..

The main rainfall is received during summer season from August to October comprises about 58.98% and the second one, which accounts for 29.52% comes during Spring season (March to June).The mean maximum temperature for different months falls between 25^0c and 30^0c. The mean minimum and maximum temperature of the watershed are 10.1°C and 31.2°C respectively.

Cereals crops such as maize, teff and sweet potato are dominantly grown in the lower parts of the watershed, while agroforestry land use is dominant in the upper and middle parts of watershed [13,17].

The watershed is one among the watersheds in the zone seriously affected by soil erosion. Significant parts of the watershed have been devoid of natural vegetation. Before the intervention (in 2005), bare land and rock outcrops abound in the area. However, following the intervention made, considerable changes have been observed in the watershed. Some parts of the watershed were under area ex-closure and were kept from any contact while other parts have been treated with different soil management and conservation activities [18].

According to a report obtained from the woreda agricultural office, the intervention was started in 2005. In the first phase (2005-2009) of the intervention period significant parts of the watershed were under treatment and this effort continued in the second phase (2010-2014).

In both phases, CBWSM project has been implemented by mobilizing the local community based on the principle of participatory watershed management with the support of Productive Safety Net program (PSNP). The purpose of the intervention was to adopt participatory watershed management as a technological intervention averting the land degradation and improving rural livelihood through restoration of degraded land. The components of the intervention include: area exclosure, physical and biological soil and water conservation on communal and farmers' land, mobilizing the community to participate on watershed development, improving women's participation on watershed development, giving support to poor family through PSNP and Household asset building program [18].

2.2. Methods

The study employed time series spatial and non-spatial data to examine changes in land use/cover before and after the implementation of CBWSM in the study area. Cloud free Landsat satellite images of four periods (1987, 1995, 2011 and 2015) downloaded from USGS were used to map and detect the changes and thereby examine the impacts of watershed management. Prior to classification, all images were geometrically and radiometrically corrected in ERDAS IMAGINE 2013 environment. Supervised classification method was employed to classify the images using the decision rule of maximum likelihood classifier algorithm. A visual interpretation of the LUC types was also used based on an evaluation of image characteristics.

Ancillary data such as contour, slope, and drainage maps were generated from 30 by 30 meters SRTM (Shuttle radar Topographic mission). Other important data such demographic and socio-economic characteristics were also employed to assess the relationship between the observed changes and the activities being conducted in relation to watershed development.

In order to examine the drivers and perception of farmers on the contribution of watershed management, we have chosen a total 76 interviewees and discussants through snowball and purposive sampling. The interviews and discussions conducted with selected informants helped us to generate data related to land use/cover change history, drivers for the change, major watershed activities, status of the watershed and land management, and pattern of LUC change before and after intervention of CBWSM.

Five major land use types were identified in the watershed, namely agroforestry, shrub/bush land, grassland, agricultural land and bare land. The general description of the land use/cover is given below on Table 1.

Beside the conventional monitoring and mapping of LUCC, an attempt was made to quantitatively analyze the spatio-temporal dynamics of LUCC patterns using three quantitative indices to analyze the extent, rate and magnitude of change. Change Intensity Index (Ti), Rate of Change (Ai) and Dynamic Index (Di) are the three indices used for analysis. The critical analysis of these indices provides a basis to explain the nature of temporal dynamics of LUCC as an Index of land degradation and to indicate the impact of watershed management intervention on land use/cover change before and after intervention [19].

Later we assessed the accuracy of land use/ cover classification map using integration of field observation and historical Google earth imagery. Accuracy assessment result showed that the classification has 87.5% overall total accuracy. Shrub land and agroforestry have high user accuracy (95% and 90% respectively) compared to other land cover classifications. Similarly forest accounts high producer accuracy (95%) followed by shrub land (86%).

Table 1. Description of land use/ cover classes used for analysis

Land cover type	General Description
Agroforestry	Areas covered with perennial crops enset, coffee and remnant of high natural forest forming closed canopy trees which are relatively above 5 m height and cover 0.5 ha according to FAO forest definition.
Bush/Shrub land	Consists of small trees, shrubs, bushes and herbs
Grass land	Areas with 50% grass cover, non-cultivated area, and 50 % herbaceous cover, and bare patches usually used for grazing.
Agricultural land	Areas prepared/ploughed for growing Annual and perennial crops. Major crops grown include cereals (maize, wheat, teff, barley, etc), spices and cash crops (enset, coffee). This category includes areas currently under crop and fallow as well as land under preparation.
Bare land	Areas devoid of vegetation cover, vascular plants, composed of exposed rocks, soil surface

4. Results and Discussion

Elamo micro watershed is one among the watershed in Gedeo zone, in which participatory watershed management was implemented since 2005. The watershed was one among the degraded watersheds in the zone. Cognizant of the level of degradation, the local government in collaboration with the regional government and the local people launched watershed management program in 2005.The watershed management program launched in the area has two phases. The first phase was between 2005 and 2010, while the second phase was between 2011 and 2014.

In order to examine the impacts brought in different phases of the project, we have categorized the study period into two, taking 1987 as a bench mark. The first period (1987-2011) denotes the first phase of watershed development program implemented between 2005 and 2010; while the second phase (2011-2014) represents the period between 2011 and 2015. Different watershed management activities were implemented in both phases of the project through mobilization of the local community. The activities include construction of different soil and water conservation structures such as soil and stone bund, micro basins (eye borrow and half-moon), cut-off drain, trench coupled with tree plantation on the steep slope, and water way. Mulching is widely used by majority of the farmers and its major purpose is enriching soil fertility, conserving soil moisture and improving water holding capacity of the soils.

Major parts of the watershed which were identified as degraded were under ex-closure in both phases of the project. The ex-closed areas were kept out of reach of animals and human beings for more than 8 years. Within the ex-closed areas different conservation structures were constructed and trees were planted. Following the measures taken in the watershed, significant changes were observed. The degraded areas have been covered with grasses, trees and shrubs (see Figure 2, Figure 3 and Figure 4).

Figure 2. Parts of the watershed under physical and biological measures

4.1. LUC Change (1987 - 2011)

Based on the analysis of satellite images of 1987, 1995, and 2011, and 2015 five major LUC types, namely agroforestry, bush/shrub land, grassland, agricultural land and bare land were identified.

As indicated in Table 2, the land occupied by agroforestry in 1987 was only 34 hectares and in 2011 it increased to 207 hectares. This is partly due to a traditional practice known as *urane* – a practice of rotating one's own dwelling with the purpose of rehabilitating degraded land. Through this practice the Gedeo expanded agroforestry land use to degraded parts of the watershed (see Figure 3). Similarly, bush/ shrub land has shown an increment between 1987 and 2011. Area ex-closure, which is accompanied by tree plantation on the degraded parts of the water contributed for the increasing of shrub/bush land.

Figure 3. Urane house constructed on previously degraded land[1]

On the other hand, grassland has shown a declining trend between 1987 and 2011. The discussion held with key informants indicated that during this period substantial parts of the watershed were put under ex-closure, which prohibited the local people from using the grass for grazing and other purposes. Consequently, shrubs and bush trees started to emerge dominating the grassland.

Between 1995 and 2011, significant parts of the watershed's land have been converted to agroforestry and bush/shrub land (see Table 2). During this period, grassland and bare land has shown a remarkable reduction in size. The proportion of bare land/degraded land was 9.5% in 1987 and it was reduced to 8.9% in 1995 and to 3.9% in 2011.This is principally due to the intervention made through watershed development program between 2005 and 2010. During this period massive works have been conducted in the watershed.

As depicted in Table 2, 39% of grassland was converted to bush/shrub land. The computed LUCC intensity index also indicates that the three land uses have shown a relatively high conversion rate as compared to bush/shrub land and bare land. Grassland area has the highest land use change intensity index (19.6%) followed by agroforestry (11.15%) and agricultural land (8.57%) (see Table 3).

1 This place is one among the rehabilitated areas through a traditional practice known as Urane. It was degraded before it was settled by a Gedeo elder who stayed there for a year.

Table 2. Summary of results land use/cover (1987 – 2011)

Land use/ cover classes	Extent in ha 1987 (U_{ai})	Extent in ha 1995	Extent in ha 2011 (U_{bi})	Change in extent 1987-2011(U_{bi} –U_{bi})	
				Ha	%
Agroforestry	34	167	207	173	508.82
Bush/Shrub land	171	106	456	285	166.66
Grassland	773	748	469	-304	-39.32
Agricultural land	426	391	359	-67	-15.72
Bare land	147	139	60	-87	-59.18
Total study area(B)	1551	1551	1551	$\Sigma U_{bi} - U_{ai} = 782$	

Source: Satellite images of 1987, 1995 and 2011.

Table 3. Summary of Analysis land use/cover index (1987 – 2011)

Land use/ cover	Rate of change (Ai)	Dynamics of change in % (Ki)	LUCC intensity index in %(Ti)
Agroforestry	0.22	21.2	11.15
Shrub land/Bush land	0.11	2.07	5.48
Grassland	0.39	-1.64	-19.6
Agricultural land	0.17	1.30	8.57
Bare land	0.11	-2.46	-5.6

Source: Generated from the Satellite images of 1987, 1995 and 2011.

The discussion held with key informants and visual image interpretation revealed that between 1995 and 2011 large parts of grassland were converted to bush/shrub land following the introduction of ex-closure of the degraded parts. Some of the local people had introduced agroforestry on their farmland while some others used it for cereal crop production. The introduction of agroforestry on land previously used for farming has increased the proportion of agroforestry. However, based on the visual image interpretation, it was noted that, despite reduction in size of grassland, large portion of bare land was converted to grassland because of the management practices (ex-closure) implemented in the area.

Dynamics of land use/ cover index is used to quantify the temporal variation of each land use classes. It allows studying human and physical impacts on land use / covering changes in depth and breadth. It is also used to indicate degradation of biophysical environment [19]. According to the computed land use/ cover dynamics, agroforestry has shown the highest dynamics (21.2%), followed by bare land (2.46%) shrub/bush land (2.07%), grassland (1.64%) and agricultural land (1.30%). The results entail that during the first phase of the study period (1987 – 2011), agroforestry showed a remarkable increase in coverage between 1987and 2011 as compared to the other land use types. In contrary, proportion of bare land from the beginning of the study period declined with 2.46% of change. Socio-economic and cultural factors linked to population growth contributed for the expansion of agroforestry land at the expense of agricultural land, grassland, bush/shrub and even bare land. The Gedeo people have a tradition of converting bare land to agroforestry land through a cultural practice known as *Urane* [2]. This strategic shift of dwelling is driven by shortage of farmland which in turn is the result of high population pressure. Apart from *Urane*, the Gedeo have also a tradition of retaining and planting indigenous trees such as *Dhadhato (Milletia Ferruginea), Walleena (Erytherina abyssinica,)* and others on their farmland. Actually, this tradition of maintaining trees on farmland was not commonly practiced among the non-Gedeo local people inhabiting the lowland region of the watershed. However, the introduction of watershed management, which consists of retaining and planting indigenous trees on farmland, contributed to an increase in tree coverage on farmland. It is through such practice that agroforestry land use has shown a sharp increment while bare land showing a declining trend.

4.2. Change in LUCC (2011 - 2015)

Alike the period between 1987 and 2011, significant changes were observed between 2011 and 2015, although the pattern of change is a bit different. In this period, bush/shrub land exhibited remarkable expansion while agricultural land and bare land showed a significant decline. Agroforestry land use has also shown an increasing trend attributed to the continuation of *Urane* and conversion of farmland to agroforestry through retention and planting of indigenous trees. The area under agricultural and bare land had significantly decreased by 45.8% and 90% respectively. Majority of agricultural and bare land were converted to agroforestry and bush/shrub land. The conversion is driven by a strategic shift from mono-cropping to multiple cropping through the introduction of different indigenous tree species on farmlands and abandonment of agricultural land by most farmers due to significant decline in its productivity. Further, the continuation of area ex-closure in the second phase has brought an increase in shrub/bush land coverage.

In this period, large parts of the watershed were kept enclosed, gully banks were rehabilitated, different soil and water conservation structures such as micro-basins, trenches, stone and soil bunds were constructed. According to the report of the Woreda's agricultural office, approximately 55 hectares of land on hillsides and 18 hectares of land on gully floors and banks were under rehabilitation. This has

2 Urane is a strategic temporary shift of one's own dwelling to a degraded area for the purpose of rehabilitation by introducing agroforestry land use system. Only men household move to a new site with his cattle staying in the area until the land gets rehabilitated.

resulted in significant reduction of bare land between 2011 and 2015. The degraded / bare land was covered with grasses as it can be seen from Figure 4. This shows the effectiveness of the implemented participatory watershed management to mitigate environmental problems through improving land use/ cover.

From resource conservation perspective, the shift from mono to multiple and conversion from bare to grassland and from grassland to bush/shrub land has its own contribution in promoting mutual benefits between plant biodiversity, improving water holding capacity of soils, regaining the lost biodiversity and in turn in making contribution to climate change mitigation.

Table 4. Land use/ cover change between 2011 and 2015

Land use/ cover classes	Year					
	2011		2015		Change (2011-2015)	
	Ha	%	Ha	%	Ha	%
Agroforestry	207	13.35	252	9.8	45	21.74
Shrub/Bush land	456	29.40	517	39.78	61	133.77
Grassland	469	30.24	473	30.49	4	0.85
Agricultural land	359	23.15	303	19.55	-56	-15.59
Bare land	60	3.87	6	0.38	-54	90
Total	1551	100	1551	100		

Source: Generated from the Satellite images of 2011 and 2015.

4.3. Land Use/ Changes (1987-2015)

Generally, changes were observed in all land use types in the study period (1987-2015). Among all, substantial changes were observed in agroforestry, bush/shrub land and bare land. Those areas which were completely devoid of natural vegetation were seen covered with trees, shrubs and grasses after the introduction of watershed management (Figure 3).

Bush/shrub land, agroforestry, and grassland exhibited high rate of LUC changes as compared to other LUC types. Bush/shrub land showed the highest LUC change intensity index (28.7%) followed by grassland (19.3%). In terms of dynamics of change, agroforestry (12.39%) and bush/shrub land (9.31%) showed the highest dynamics while the remaining three land use/cover types exhibited the lowest dynamics.

Figure 4. Sloppy areas of the watershed which were put under ex-closure being covered with grasses. This area was bare and covered with rock outcrop prior to the intervention

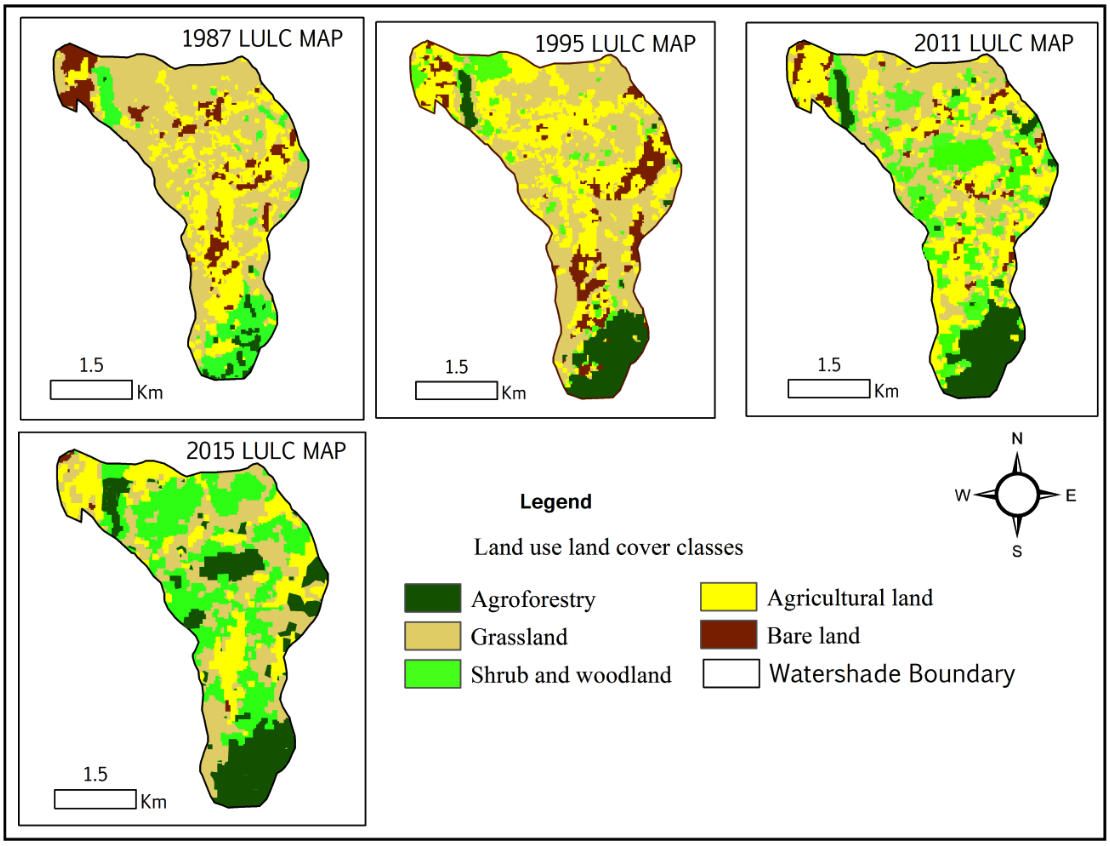

Figure 5. Land use/cover map of the watershed (1987-2015)

Table 5. Change in land use/cover over 28 years period (1987 – 2015)

Land use/cover classes	Extent in ha 1987 (U_{ai})	Extent in ha 1995	Extent in ha 2011	Extent in ha 2015(U_{bi})	Change in extent 1987-2015(U_{bi} -U_{ai})	
					Ha	%
Agroforestry	34	167	207	252	218	641.17
Bush/Shrub land	171	106	456	517	346	202.39
Grassland	773	748	469	473	-300	-38.8
Agricultural land	426	391	359	303	-123	-28.87
Bare land	147	139	60	6	-141	-95.91
Total study area(B)	1551	1551	1551	1551	0	

Source: Generated from the Satellite images of 1987, 1995, 2011 and 2015.

Table 6. Summary of Land use/ cover change Indexes (1987 – 2015)

Land use/ cover	Rate of change (Ai)	Dynamics of change in % (Ki)	Change index in %(Ti)
Agroforestry	0.10	12.39	7.6
Shrub/bush land	0.39	9.31	28.7
Grassland	0.27	-1.38	-19.3
Agricultural land	0.11	-1.03	-7.9
Bare land	0.13	-3.42	-9.09

Source: Generated from satellite images of 1987, 1995, 2011 and 2015.

During the study period (1987-2015), agroforestry and bush/shrub land had shown an increasing trend, while bare land had exhibited a sharp decline. High rate of change was observed in shrub/bush land followed by grassland (Table 6).Those areas under ex-closure were covered with grasses and gradually with bush/shrubs (Figure 3). Bush/shrub land expansion in the flat plain of the watershed is attributed to reforestation of the degraded land through tree plantation, check dams in gullies and trenches dug to intercept and collect runoff.

Apart from the impacts of watershed management program, shortage of farmland in the midland areas necessitated the Gedeo to migrate to the lowland region to expand agroforestry land use. Gedeo is among the densely populated region in the country, with population density reaching 1200 people/km^2 in some kebele. The high population pressure has resulted in shortage of farmland particularly in the mid land region [20], which in turn is a driver for the expansion of agroforestry to the lowland region.

Farmers also confirmed during focus group discussions an increase in vegetation cover following the introduction of watershed management in the area. This was well noted during field survey. Trees planted to stabilize gullies were found along gully courses and sides. Indigenous tree species such as *Milletia ferruginea*, *Albizia*, *Ficus*, *Ficus vasta*, *Cordia Africana*, *Macrostachyus*, and *Podocarpus procera* were found emerging in different parts of the watershed.

In general, the changes observed in land use/cover between 1987 and 2015 indicate effectiveness of the implemented CBWSM. Obviously, the effectiveness of the implemented CBWSM is predominantly the result of unrelenting efforts made by the community. As it has been illustrated by the woreda agricultural experts, active and consistent participation, ownership feeling built, and commitment shown by the local people were a key to the changes brought. Through their social organization and cultural practices such as *babo* [3] and *urane*, the local people have exerted their utmost efforts to rehabilitate the land and have been working towards mitigation of any anticipatable environmental hazards. The Gedeo nurture natural resources in their locality, value trees and strongly believe that they cannot live without land and its resources [20,21,22]. Their everyday life, from cradle to death is attached to tree and its products [22].This is manifested through their everyday activities and different cultural practices conducted by the people. Products of land, mainly tree, enset, coffee have been used in all cultural practices conducted by the local community [20,22]. Thus, the long standing mutual co-existence between human and nature that prevails in the area is a foundation for the Gedeo to willingly participate in the watershed management activities conducted in Elamo micro watershed without subsidy.

Two important points can be singled out from the findings of this research. One is the impacts of the participation of local people on resource management on goodwill basis. It is obvious that resource management that involves the community from the very outset (problem identification) will be effective and sustainable as it builds on the already existing indigenous knowledge based practices and also has the role of building sense of ownership among the community. Thus, the secrete behind effectiveness of the implemented watershed management in the area is participation of the local people, which in turn is associated with the long standing tradition of nurturing natural resources. The second point is related to size of the watershed that needs to be considered when we deal with such degraded areas. In countries like Ethiopia, where there is financial limitation, it is imperative to deal with small and manageable watershed to bring the desired and sustainable changes. This is

3 *Babo* is a traditional land management practices which refers to nurturing newly emerging seedlings. It refers to protecting progeny from destruction (Kura, 2014).

proven by the change seen in Elamo micro watershed. The local people in collaboration with the woreda agricultural office have managed to restore the degraded land and also improved their livelihood.

4.4. Impacts of CBWSM

Although it is difficult to quantify the actual impacts of the watershed development program, by conducting a full-fledged inventory of biodiversity, soil resource and water resources, we have used data obtained from satellite images, FGD, participant observation and interview and secondary documents to examine the perceived impacts of the interventions. Photos taken during the different phases of the project were also used to examine the impacts.

Apparently, proper and effective implementation of CBWSM can result in restoration of degraded land and thereby improvement of human well beings. It can also result in reduced soil erosion rates, increased soil moisture availability, better access to water resources, reduced sedimentation and flooding problems, stabilized gullies, rehabilitated degraded lands and improved ecological balance in general [14]. On the contrary, improper and ineffective implementation of watershed management programs would bring no promising results. Rather it may result in further degradation.

Based on the data obtained from satellite image interpretation, extensive field observation, FGD and interview, we noted that the impacts are quite evident. The quantitative analysis confirmed the effectiveness of CBWSM in restoration of degraded land. Accordingly, bush/shrub land and agroforestry have shown an increasing trend; on the other hand bare land exhibited a sharp decline following the measures taken. For the period 1987-2015 bush/ shrub land coverage increased from 171ha to 617ha in 2015 and in contrary bare land coverage decreased from 147ha to 6 ha. LUCC intensity index have shown that bush/ shrub land has the highest index, followed by grassland (19.3%). On the other hand, LUC Dynamic Index showed agroforestry having the highest index (12.39%) followed by bush/shrub land (9.31%) and bare land (3.42%) areas. Result obtained from the different indices confirms that there exists a positive change in LUC during the study period and this is predominantly attributed to the implemented watershed management activities. Specifically improvement in bush/ shrub and agroforestry, and decline in the proportion of bare land is viewed as a remarkable achievement of the implemented CBWSM.

The local people have witnessed that because of restoration of the degraded land, wild animals that disappeared from the area were seen in the watershed. Small springs have emerged as a result of which the local people began to fetch water at small distance from their residence. Before the implementation of watershed development program in the area, women and children had to travel long distance to fetch water. However, the introduction of watershed development program brought the emergence of water points in the watershed. Due to restoration of plants, particularly grass, rock outcrops have been covered with soils. Indigenous trees such as *Millitia ferruginea*, *Ficus vasta*, *Cordia Africana*, *Croton Macrostachyus*, *Podocarpus procera* were seen emerging in all parts of the watershed. Part of the watershed that failed to support crops due to infertility of the soils regained its fertility and started to support plants. Almost all participants claim that the productivity of their land had shown a remarkable improvement since the introduction of watershed management program.

As it is depicted in Figure 6, a parcel of land with rock outcrop in the 2010 was covered by grass in 2015 due to ex-closure. Most farmers perceived an increase in the productivity of their land which is attributed to an improvement in fertility status of their soils. Remarkable changes were observed in terms of availability of water resource in the watershed.

Participatory watershed development conducted on 147 hectares of bare land resulted in restoration of biodiversity (See Figure 6). Different wild animals have been seen in the watershed. Restoration of biodiversity also is expected to have a huge impact on climate change mitigation through carbon sequestration and also minimizing the amount of carbon which could be released to the atmosphere. Studies elsewhere in northern Ethiopia [14,15,16] also reported the effectiveness of sustained conservation efforts at catchment level in controlling soil erosion and in improving land cover land use of a watershed and land productivity.

(a) Before the intervention (2010)   (b) After the intervention (2015)

Figure 6. Part of Elemo watershed in 2010 with the presence of bare land here and there and improved situation in 2015

6. Conclusion

Effective implementation of a community based participatory watershed management approaches that was sensitive to the local situation, built on the existing cultural values and carried out at micro-watershed scale were indicated as a key to success of watershed management in countries like Ethiopia where there exist inadequacy of financial and human capital. In this regard the watershed development was successful in participating majority of the local community particularly during the second phase of intervention (2011 – 2015). The change observed in terms of restoring the degraded areas and managing the existing resources available in the watershed was significant. Thus, it can be concluded that the watershed development program implemented at micro-watershed scale has been effective in controlling the loss of soil, improving the fertility status of soils, contributing to climate change mitigation through carbon sequestration and restoring the already degraded biodiversity. Moreover, the watershed program implemented in the area has brought changes in the living condition of the community residing in the watershed.

References

[1] Turner, B.L. II and B.L. Meyer, "Global Land-use and Land-cover Change: An Overview" . In W. M. II (Ed.), *In Changes in Land-use and Land-cover: A Global Perspective* (pp. 3-10.). Cambridge: Cambridge University Press, 1994.

[2] Lambin, E. F.,Geist, H. J.,& Lepers, E., "Dynamics of land-use and land-cover change in tropical regions". *Annual review of environment and resources, 28*, 205-241, 2003.

[3] Reenberg, A., “Agricultural land-use pattern dynamics in the Sudan-Sahel towards an event-driven framework”, *Land Use Policy, 18*, 30-319, 2001.

[4] Lambin, E. F., & Geist, H. J., "Proximate Causes and Underlying Driving Forces of Tropical Deforestation", *BioScience, 52*(2), 2002.

[5] Winterbottom R., Reij C., Garrity D., Glover J., Hellums D, Mcgahuey M, and Scherr S., Installment 4 of “Creating a Sustainable Food Future” Improving land and waetr management. Working paper. *World Resource Institute*, 2013.

[6] Tiwari, K. R., Bajracharya, R. M., & Sitaula, B. K., "Natural Resource and Watershed Management in South Asia: A Comparative Evaluation with Special References to Nepal", *The Journal of Agriculture and Environment, 9*, 2008.

[7] Hudson, N. W., *A Study of the Reasons for Success or Failure of Soil Conservation Projects. Rome. FAO soil bulletin, 64*. Rome, Italy, 1991.

[8] Peraz, C. and H. Tschinkel, Improving Watershed Management in Developing Countries: A Framework for Prioritizing Sites and Practices. *Agriculture Research and Extension Network*. U.K., 2003.

[9] Hurni, H. and K. Tato, (eds.) *Soil Conservation for Survival. Soil and Water Conservation Society*. USA, 1992.

[10] Johnson, N. L., H. M. Ravnborg, O. Westermann and K. Probst, "User Participation in Watershed Management and Research", *Water Policy, 3*, 507-520, 2001.

[11] Pender, J. and S. Ehui, Policies for Sustainable Land Management in the Highlands of Ethiopia", *International Food Policy Research Institute (IFPRI)*, Washington, D.C., 2000.

[12] Schumache, E. F., *Small is Beautiful Economics As if People Mattered*. London: Blond & Briggs, 1973.

[13] Kerr, J., "Watershed management: lessons from common property theory", *International Journal of the Commons, 1*(1), 89-110, 2007.

[14] Fikir A., Nurhussen T., Jan N., Atkilt G., Amanuel Z., Mintesinot B., Seppe D., Jean P., "The impacts of watershed management on land use and land cover dynamics in Eastern Tigray, Ethiopia", *Resources, conservation and recycling, 53*, 192-198, 2008.

[15] Nigussie H., Ademnur B., Atsushi T., Mitsuru T., and Derege T., "Integrated Watershed Management as an Effective Approach to curb Land Degradation: A case of Enabred Watershed in Northeren Ethiopia", *Environmental Management, 50*, 1219-1233, 2012.

[16] Nyssen, J., Haile, M., Naudts, J., Munro, N., Poesen, J., Moeyersons, J., Frankl, A., Deckers, J. & Pankhurst, R., "Desertification? Northern Ethiopia re-photographed after 140 years", *Science of the Total Environment, 407*, 2749-2755. 64, 273-320, 2009.

[17] Roba, B., *Traditional Methods of soil conservation and management practice, the case of Tuniticha and Amba peasant Association, WonagoWereda*. unpublished Msc. thesis, 2003.

[18] Wonago wereda rural and agricultural development office. *Wonago Wereda agriculture and rural development annual report*. Wonago,Gedeo zone: Unpublished, 2015.

[19] Ndabula C., Averik P. D., Jidauna G.G., Abaje I., Oyatayo T. K., and E. O Iguisi. "Analysis of the Spatio-Temporal Dynamics of Land use/ Land cover Structures in the Kaduna Inner core City Region, Nigeria", *American Journal of Environmental Protec, 1*(4), 112-119, 2013.

[20] Legesse, A., T*he Dynamics of Gedeo Agroforestry and Its Implications to Sustainability*. PhD Dissertation, *UNISA*. South Africa, 2014.

[21] Debelo A.R., Legesse A., Milstein T., Orkaydo O., "“Tree Is Life”: The Rising of Dualism and the Declining of Mutualism among the Gedeo of Southern Ethiopia", *Front. Commun., 7*(2), 2017.

[22] Kippie, T., *Five Thousand Years of Sustainability? A Case Study on Gedeo Land Use (Southern Ethiopia). Phd Dissertation*. Wageningen University, The Netherlands, 2002.

[23] Beilin, R., Lindborg, R., Stenseke, M., Pereira, H.M., Llausàs, A., Slätmo, E., Cerqueira, Y., Navarro, L., Rodrigues, P., Reichelt, N., Munro, N., & Queiroz, C.. "Analysing how drivers of agricultural land abandonment affect biodiversity and cultural landscapes using case studies from Environ Monit Assess (2015) 187: 452 Page 15 of 17 452 Scandinavia, Iberia and Oceania. 36. *Land Use Policy*, 60-72, 2014.

[24] Broadbent, E.N., Almeyda Zambrano, A.M., Dirzo, R., Durham,W.H., Driscoll, L., Gallagher, P., Salters, R., Schultz, J., Colmenares, A., Randolph, S.G, "The effect of land use change and ecotourism on biodiversity: a case study of Manuel Antonio, Costa Rica, from 1985 to 2008", *Land sc. Ecol., 27* (5), 731-744, 2012.

[25] Campbell, D., Lusch, D.,Smucker, T., &Wangui, E., Multiple Methods in the Study of Driving Forces of Land Use and Land Cover Change: A Case Study of South East Kajiado District, Kenya. *Human Ecology, 33*(6), 33-45, 1991.

[26] Dessie, G. & Kleman, J., "Pattern and magnitude of deforestation in the South Central Rift valley region of Ethiopia", *Mountain research and development, 27*, 162-168, 2007.

[27] FAO, *Land Cover Classification System*: *Classification Concepts and User Manual*. *Series 8*. Rome, Italy, 2005.

[28] Garedew, E., Sandewall, M., Söderberg, U. & Campbell, B. M., "Land-use and land- cover dynamics in the Central Rift Valley of Ethiopia", *Environmental Management, 44*, 683-694, 2009.

[29] Getachew, H., Mohammed, A. & Abule E. "Land use/Cover dynamics and its Implications since the 1960s in the Borana rangelands of Southern Ethiopia", *Livestock Research for Rural Development, 22*(7), 2011.

[30] Guan, D., Li, H., Inohae, T., Su, W., Nagaie, T., & Hokao, K., "Modeling urban land use change by the integration of cellular automaton and Markov model", *Ecological Modelling, 222*, 3761-3772, 2011.

[31] Reenberg, A., and Lund, C., "Land-use and land right dynamics—determinants for resource management options in Eastern Burkina Faso", *Hum. Ecol., 26* (4), 599-620, 1998.

[32] Solomon A., *Land use dynamics, soil degradation and potential for sustainable use in Metu Area, Illubabor Region. Ethiopia*:. 119. University of Berne Switzerland, Institute of Geography, 1994.

[33] Tesfaye Habtamu. *Assessment of Sustainable Watershed Management Approach Case Study in Lenche Dima, Tsegur Eyesus and Dijjil Watersheds* (Master’s Thesis). Cornell University, U. S.A. 2011.

[34] Weng Q., "Land use change analysis in the Zhujiang Delta of China using satellite remote sensing, GIS and stochastic modeling". *Journal of Environmental Management, 64*, 273-284, 2001.

[35] Wood, A.I., Natural resource management and rural development in Ethiopia. In S. F. Pause wang (Ed.), *Ethiopia: Options for Rural Development*. London and New Jersey: Zed Books Ltd, 1990.