



Watershed Management in Highlands of Ethiopia: A Review

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Abstract

Watershed is not only a hydrological unit for hydrologist but also a socio-political-ecological entity for rural community. Ethiopian highlands hailing as the cradle of humanity and home to about 80% of the population helped shelter from foreign conquest and making a strong base of rural community. The area is threatened with erosion and loss of agricultural productivity. The soil and water conservation program initiated in 1970 achieved only limited success due to its failure in addressing to the problems of local people. The prominent reasons assigned were lack of community participation, ignoring indigenous knowledge, adopting top down approach and poor institutional collaboration. The present government taking lessons from the past, started community based integrated watershed management program removing all the shortcomings through the instrument of new policies for improved livelihood and living conditions of rural communities.

Keywords

Watershed, Evaluation, Soil Erosion, Land Degradation, Soil and Water Conservation, Community Based Watershed Management

Subject Areas: Environmental Sciences

1. Introduction

Watershed is not simply the hydrological unit but also a socio-political-ecological entity which plays decisive role in determining the socio-economic security and it helps to support the livelihood of rural community. Watershed resource degradation is a serious problem in the Ethiopian highland threatening agricultural development and rural livelihood. Since the economy of the country is agrarian in nature, the decline in agricultural productivity adversely affects the economic growth of the country [1]-[3]. Literatures reveal that Ethiopian highlands are seriously eroded and becoming unsuitable to cultivation. Watershed management in Ethiopian highlands

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therefore urgently needs improvement and conservation of their natural resource for sustainable development and improving food security. In Ethiopia, soil and water conservation program started in 1970. However, it achieved limited success due to its failure in addressing the problems of local people. This failure put a question mark on the continuation of watershed and management program in the country. Therefore the project got low priority in subsequent national planning. Reports also revealed that the practices of soil and water conservation project did not involve community participation, in appropriate application of soil and water conservation techniques, in adequate research support and poor technical understanding of field technicians etc. [1] [3] [4]. The present government started community based integrated watershed management practice. Keeping these in view the study entitled “Watershed Management in Highlands of Ethiopia: A Review” was undertaken.

2. Ethiopia

Ethiopia is a large country having 113 million hectares that is endowed with diverse climatic and physiographic condition, with a huge potential of water resource it accounts 122 BMC annual surface runoff and 2.9 BMC groundwater, though it is characterized by uneven spatial and temporal distributions. Between 80% - 90% of the country’s surface water resources are found within four major river basins—Abay (Blue Nile), Tekeze, Baro Akobo and Omo Gibe (Table 1 and Figure 1) and as can be seen in Figure 2 rainfall in the country ranges between 2250 mm per year in the south-western highlands and less than 200 mm in the North and South-East with a further decrease of less than 100 mm per year in the North-East [1] [5]. Temperatures are also very much modified by the varied altitude of the country. Mean annual temperature ranges from <15°C over the highlands to >25°C in the lowlands.

As can be seen from Table 2 the land use pattern of Ethiopia, 31.69% of the land surface is covered by agricultural land, livestock grazing covers 18.11%, 12.7% is covered by arable land, about 9.44% is covered by water surface area, wood vegetation and natural forest covers 11.52%, only 0.94% of the land surface is covered

Table 1. Major river basins of Ethiopia.

River basins	Catchment area (thousand km ²)	Runoff (MCM/year)	Rainfall (mm/year)
Abay (Blue Nile)	199.8	54.8	1400
Tekeze	82.3	8.2	950
Baro Akobo	75.9	23.6	1650
Omo Ghibe	79.0	16.6	1150
Wabishebele	202.7	3.16	950

Source: Integrated river basin master plan studies carried out during 1997-2007, GOE [6].

Table 2. Land use pattern of Ethiopia.

S. No.	Land use	Area (t-Km ²)
1	Water surface area	104.3
2	Agricultural land	350.7
3	Arable land	140.4
4	Permanent crops (orchards)	10.4
5	Pastures and grassland	200.0
6	Forest area	127.2
7	Other uses	171.3
Total geographical area		1104.3

Source: www.worldstat.info/Asia/Ethiopia/Land, (2014) [9].



Figure 1. River basins of Ethiopia, Source: [7].

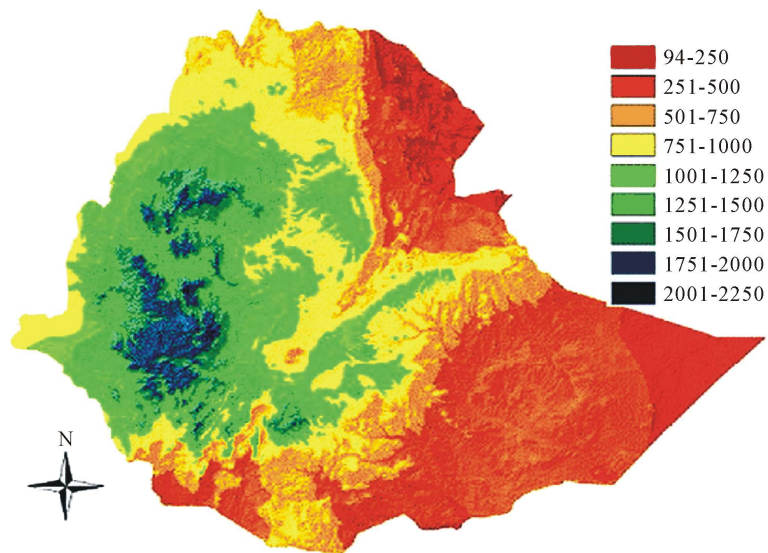


Figure 2. Annual precipitation of Ethiopia, Sources: <http://www.nationalparks-worldwide.info/eaf/ethiopia/ethiopia-weather.html> [8].

by Orchards and the remaining 15.5% of the land declared as unusable. Large number of livestock population encroached grazing land and consequently the competition for land is intense between livestock and crops, negatively affect watershed sustainability.

The economy is primarily based on agricultural production, it accounts for 47% of the total GDP as compared to 13.3% from industry and 39% from services [10], 90% of the total export revenue, and employs about 85% of the labour force in the country [11], as of recently the industry and service sectors are taking more share of the GDP. It is characterized by predominantly subsistent in nature. As of natural resource is the foundation of the

economy of the country, it put pressure on sustainability of the natural resource. Exploiting these natural resources may generate economic benefits in the short term. Nevertheless, in the long term unsustainable use of these natural resources increases tension not only environmental, but economic growth and livelihood opportunities [12]. The objective of this study is to review the problems and solution of watershed in Ethiopia to ameliorate the situation.

3. Watershed Management Problems

In recent years, environment has become a key issue in Ethiopia. The main environmental problems of the country include land degradation, soil erosion, and deforestation of natural resource, desertification and loss of biodiversity, and recurrent drought resulting in declining productivity and continuing in food shortage. Huge part of the country has fragile ecosystem which includes dry, humid, sub-humid, semi-arid, semi dry and arid conditions (Figure 3). This is frequently exposed to desertification and recurrent drought. The highlands constituting majority of land is currently under stress due to rising population pressure and their conservative socio economic practices.

The extent of fertile land available for agriculture is decreasing due to increased soil erosion. Land degradation is caused by deforestation and faulty management practices (cultivating along the slope) of the natural resources, (soil, forest resource and water). It leads to both loss of agricultural production and increased risks of flooding, siltation and sedimentation [14].

The soil erosion and deforestation reduces the production potential of land and the overall utility of land resource, and thus making it unsustainable to produce sufficient to feed for the growing population. It also increases farmers' susceptible to food shortages and threatens their survival. Food insecurity in Ethiopia is directly linked to the problems of natural resource degradation [2].

In Ethiopia, soil erosion and declining fertility are posing serious challenge to agricultural productivity and economic growth through land degradation [15]. Several studies have shown that extensive areas of the highlands have under serious erosion. In the mid-1980s it was estimated that around 4% of the highland part of the country (2 mha) had been so much eroded that it could not support cultivation, while 52% of the highlands suffered moderate or serious degradation [16].

Average soil loss from cultivated land varied from 21 to 42 t/ha/year [17]. The magnitude soil loss in Ethiopian highland (Table 3) from different category of lands use is estimated to be 1863.6 mt/year (Hurni, 1985). Of this enormous soil loss, about 90% is deposited in valley and remaining 10% is transported with water to Egypt. The degradation of agricultural land in high mountains is a serious risk to food production in Ethiopia [17] [18].

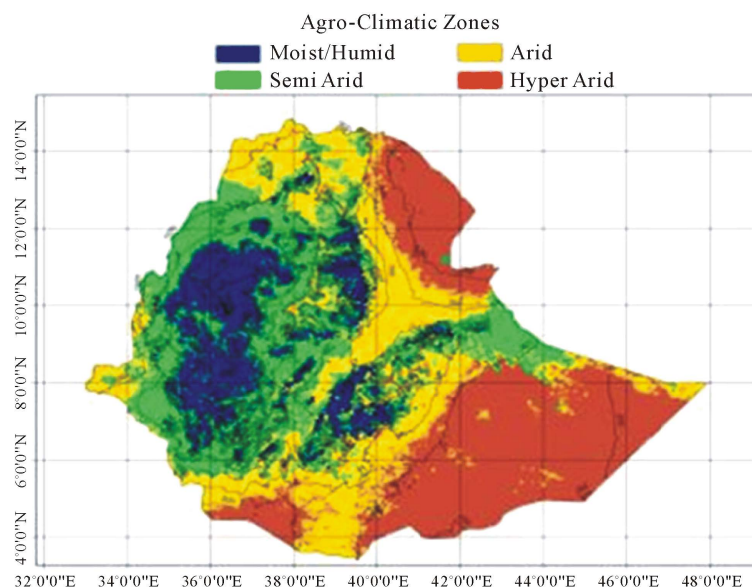


Figure 3. Agro climatic zone of Ethiopia, Sources: <http://awm-solutions.iwmi.org/ethiopia-1.aspx> [13].

Table 3. Magnitude of soil loss in Ethiopia.

S. No.	Land use type	Area (t·Km ²)	Rate of loss (t/ha/year)	Total loss (mt/year)
1	Crop land	104.4	42	438.4
2	Perennial crops land	10.4	8	8.3
3	Pasture land	200.0	5	100.0
4	Waste land	171.3	70	1199.1
5	Uncultivable land	110.1	5	55.0
6	Forest land	127.2	1	12.7
7	Wood land	100.2	5	50.1
	Total	823.6		1863.6

Source: [21].

Land degradation in Ethiopia is also linked with soil nutrient loss due to continuous cropping with poor management practices [19]. FAO conducting the survey of 38 sub-Saharan Africa countries, including Ethiopia reported the magnitude of soil nutrient loss as 41 kg N/ha/yr, 6 kg P₂O₅/ha/yr and 26 kg K/ha/yr [15] [20].

4. Aggravation of Watershed Degradation

In Ethiopia the problem of watershed degradation is aggravated with the natural and manmade reasons.

Weather condition: Agro climate is variable ranging from humid to arid and desert (Figure 3). The physiographic condition of the country, very much impacted the problem of land degradation problem. Rainfall is spatially (highlands receive high rainfall) and temporally (highest rain in between July to mid September and lowest rain is in between October to January [22].

Population pressure: Population growth (2.8%) is one of the underlying causes for deforestation in highlands [23]. Increasing population pressure leads to increased demand for farm land and forest resource for fuel and home construction. In the country, about 74% houses in rural area and 72% houses in urban area constructed using forest resource [24]. The ever increasing population is a driving force for increased deforestation.

Poor infrastructure: The most crucial factor for poor watershed management is the lack of infrastructure (road, agricultural inputs etc) and market to facilitate agricultural activities and create job opportunity for livelihood in rural areas. Although the present government is giving special attention to rural roads and link it to regional markets but will take time. At present poor facilities of farm produce movement to market places discouraging farmers from improved cultivation practices [22].

Poverty: Poverty and exploitation of natural resources are interdependent. On one hand the degraded resources (eroded and deforested lands and loss of biodiversity) has adversely impacted the agricultural production and made the farmers poverty ridden. On the other hand poverty is the cause for natural resource degradation because the poor people in rural areas rely more on natural resource for their survival and livelihoods.

Lack of awareness: The low level of awareness of the society about the linkage between watershed and economic development is coupled with poor participation of farmers in the planning and management activities of watersheds. Farmers independently cultivated on steep slopes with poor agronomic practices based on their traditional knowledge for their livelihood. Unawareness of government policies of soil and water conservation has immensely contributed for land degradation [7].

5. Consequence of Natural Resource Degradation

Loss in water resource: The decrease in forest resources resulted into increased surface runoff that silted up different water storage structures (ponds and reservoirs). As a result there is shortage water even for drinking by animal and human. The shortage of water has lead to increased conflict between farmers, wildlife and labors [25].

Loss of livestock production: Natural resource degradation has aggravated both the quality and quantity of livestock production due to shortage of fodder [25].

Unemployment and rural-urban migration: In the degraded areas, production of crop and livestock is drastically reduced and area is unable to support the population. The reduced farm activities reduce the opportunity of farm employment therefore migration of rural people to urban areas is increased.

Food insecurity and incidence of drought: As we know the livelihoods of 85% population in Ethiopia is dependent on agriculture. Degraded watersheds are unable to support the rural population causing food insecurity under recurring drought situation. Rural communities are also exposed diseases and malnutrition. The successfully developed and community managed watersheds create multiple opportunity for the livelihood in rural community [25].

6. Measures Taken to Control Degradation in Ethiopia

In order to extensively address the problem of natural resource degradation, conservation schemes were introduced, especially after the occurrence drought and famines in 1970s. Starting from 1970s and onward, huge areas have been taken under soil and water conservation activities, and millions of indigenous tree species were planted, through community participation covering huge area by trees, forest and community woodlots (Herweg, 1993; Yeraswork, 2000 as cited [19]. Food for work project funded by World Food Program was implemented with the objectives to employ labor force of the farmers to participate into the plantation, soil and water conservation activities in lieu of food grain and edible oil.

The drawback in the implementation of this program was its poor involvement and participation of local people in the planning and implementation of the scheme, shortage of skillful man power, ill planned and ill defined soil and water conservation policy, lack of commitments to address the problem, ignoring the interests of rural communities, theoretical emphasis given on natural resources conservation, lack of scientific approach and lack of technical knowledge [3] [15] [26]-[29]. After the withdrawal of Food for Work program most of the farmers refused to participate in the activity. Even some of the farmers removed soil and water conservation structures from their fields. They also destroyed community woodlots [7] [30].

During 1980-90, the government implemented rehabilitation of natural resources in Ethiopia through watershed development and management on pilot basis with the support of FAO and aimed at developing extension agents through capacity building for Ministry of Natural Resources [25]. The project used the sub-watershed as the unit area for planning and management involving the participation of local people [25] [31]. This was the initial stage in the evolution of the participatory planning approach to watershed development.

Ever increasing population posed pressure on watershed resource especially in mountainous region resulted into deteriorating condition of natural resources. In order to reverse this process of natural resources degradation, the government of Ethiopia adopted top down approach in management. This undermined the needs of the participation of local community, therefore recorded limited success in sustainable watershed management [32]. The program implementation committee reviewed the problem and adopted bottom-up approach involving local communities in planning and management of natural resource through watershed project [33]. The problems of local community towards watershed planning and management were addressed using local & indigenous knowledge and supported by scientific research and innovative technology [34]. Local community had rich understanding of indigenous techniques about climate, soil fertility and biodiversity problems confronted by the farmers.

Limited efforts made to link watershed management activities with scientific research, transfer of sites technologies, involvement of local communities and establishment of extension services adversely affected the adoption and up-scaling of scientific findings to different watersheds.

Another problem was related to researchers. They were unable to translate their scientific research into solution of site-specific problems. In view of this, majority of the farmers participated in the government program of watershed management activities superficially unwillingly and they preferred to continue with their own traditional practices [3] [35].

In 1991, the Ethiopian government designed a new economic policy based on Agricultural Development-Led Industrialization. Natural resource conservation-based agriculture development became the primary objectives of industries. Industries gave impetus to improved watershed management adopting, different soil and water conservation practices, and rehabilitation of watershed through afforestation, community woodlots development and construction of micro and small scale irrigation projects [26] [29]. Watershed development and management in Ethiopia has been taken up under poverty alleviation and environmental conservation program [31]. It started

through Community based Watershed Development Programme as a comprehensive development concept for sustainable and efficient utilization of natural resources for the benefit of the local community with special attention to the rural poor [12].

Participatory watershed planning and management is fostered by community participation under diverse socio-economic and biophysical situations and suitable organizational institutional structures that are being established in Ethiopia. It is often argued that watershed planning and management program should be restructured so that it is site-specific, embraces livelihoods, productivity and sustainability to varying socio-economic conditions [36].

Well managed watersheds play a key role in the improvement of the life of watershed communities through access to fodder for their livestock, expansion in off-farm economic activities, reduction in natural resource degradation and socio-economic conditions. Access to employment opportunities outside farming could help to reduce the pressure on natural resources and emerging landlessness. Land tenure certification encourages farmers to invest in long-term soil and water conservation activities, to obtain credits, to adopt intensive farming practices and to make sustainable use of watershed land [4].

7. Impact of Watershed Management Practice on Productivity, Erosion, Employment, and Water Resource

Ministry of Agriculture and Rural Development in collaboration with donor agencies such as the World Food Programme in Amhara, Oromia, and Tigray National Regional States various conservation and rehabilitation of natural resources were implemented as a result of positive impacts were achieved [37] (Table 4).

The watershed management practices played a crucial role in arresting runoff and help to reduce erosion hazard. In view of that at the pilot watershed level a total of 297 km hillside, 27,783 trenches, 446 m³ Gabion, 3167 m³ stone check dam, and 854 m³ sediment storage, 586 m³ gully rehabilitation/re-vegetation, 80 ha bund stabilization, 25 km construction of recharge pits have been constructed over the degraded hillsides [39] [40]. For the same pilot watershed in 2006, over 35 ha of closed hillside and 2.5 ha gullies were planted with pigeon pea (edible seed), and sesbania and about 77,945 tree lucern forage seedlings were planted [39].

Following watershed management practice, local communities observed the natural resource rehabilitation, different species of shrubs, grass, sesbania (*Sesbania sesban*), acacia (*Acacia decurrens*) and wildlife were visible which were not in the past. Landless community members to whom the treated land was allocated and getting economic benefit from selling grass, in addition to these there are different micro-enterprise development for gabion wire box production, which contribute to unemployment reduction [39] (Table 5).

Report in 2006 indicates that in Lenche Dima, Yeku and Gumet watersheds, conservation practices have been carried out at the same year 255,906 multipurpose tree species seedlings were planted [39].

Water Resource Development

Soil and water conservation measures used to increase the availability of surface and subsurface water for different uses. According to [40], in the Medego watershed, ground water increased up to 2.5 m and the number of hand dug wells also increased (Table 6).

Table 4. Impact of watershed management practice on production and productivity.

Watershed	Average farm size of households (ha)	Reduction in soil loss (%)	Increased production area (%)	Crop production and productivity increment	Improvement of fodder availability (%)
Gereb Shilina	0.75	50	5	5% - 20%	80
Abraha Atsbeha	0.75	80	20 - 50	3 folds	100
Becheti	0.4	60	5 - 20	2 - 5 folds	50
Goha Cheri	0.36	75	5 - 20	20% - 50%	60
Bedesa Kela	0.5	35	5 - 20	5% - 20%	50
Karaba	0.25	90	5 - 20	2 folds	95

Source: [37] [38].

Table 5. Income generation from Gabion production.

Year	No. trained farmers	Users group members	Gabion production and income generation		Working day
			Number	Income (\$US)	
2004	15	6	41	1230	20 - 30
2005	15	""	57	1710	""
2006	15	""	28	1120	""
2007	15	""	59	1850	""
Total			185	5910	

Source: [39].

Table 6. Impact of soil and water conservation measure on water resource development in Medego watershed.

Performance criterion	Indicators
Surface water storage capacity and spring development	Increased many times from almost nil to the present situation
Extent of irrigated area	Increased by more than 300 times
Water level in wells	Increased by 0.5 m to 2.5 m
Ground water recuperation rate	Increased 15 times

Source: [40].

Before implementation of soil and water conservation, it is not possible to water by digging 3 - 4 m deep, but after project implementation, communities have the possibilities of having plenty water at this depth [40].

Watershed development and management practice also played a significant role in determining the size and composition of livestock [41]. Before introduction of watershed management practice in Ethiopia, the livestock number were decreased due to shortage of livestock feed. Following implementation of watershed management project resulted excessive impact in increasing both quality as well as quantity of livestock which accounts 90% [3] [39].

Due to positive impact of watershed management practice, recently there are attitudinal changes within the community. Through facilitating role of the community watershed management organization, community participate 30 - 40 percent free labour for watershed management practice [42].

8. Up Scaling of Watershed Management Practice in Ethiopia

8.1. Constraints

Despite the growing concern over management of watershed in view of environmental and economic implication, there was confusion as why watershed should be considered as a conservation and development planning units. Watershed development and management project received low priority because of unattractive direct and immediate benefit. There was no consistence in the basic framework of the project. The soil and water conservation activities failed without achieving the desired objective. Several reasons could be assigned are listed below:

1) Inadequate community participation: The top-down approach ignoring the participation of local communities was focused on technical and physical works alone without giving due recognition to environmental, economic and social issues.

2) Lack of professional standard: Even though the government designed good Natural Resource Policy and Strategies to alleviate watershed development and management problem, but could not be properly implemented due to lack of technical capabilities of field technician. Unfortunately, quality work was sidelined and extensive area was adopted out focusing the objectives [22].

3) Poor linkage between concerned institutions: Even though the government provided sufficient fund for setting up intuitions (agricultural research, education and extension centers) both at national and regional but they could not be integrated. Poor research support adversely affected the transfer of technology program from laboratory to farmer's field [22] [43].

4) Poor sharing of information between different departments: Sharing of experience for improved economic benefit to watershed and loss to watershed degradation was religiously not followed. Even though some effort had been made to improve the working condition, but the ground level situation did not change the real problem [22] [43].

5) Policy implementation constraint: It is true that designing sound policy and strategy plays a pivotal role in addressing problems, but without execution it is valueless. In order to properly implement and solve the problems of the communities, approach needs to be appropriately modified [22] [44].

6) Inappropriate technological preference: Introduction of new technology without giving due consideration to the socio economic condition was rejected by the society [22].

7) Lack of site specific conservation plan: Investigation of watershed management site specific practice was not undertaken. More emphasis was given on economic return to farm land owners and landless community was ignored. The system suggested for crop production did not match with the soil and water conservation practices of the watershed. No limit on land slope for crop production was suggested to safeguard the interest of indigenous forests and soil fertility [7].

8.2. Opportunities

The government of Ethiopia in collaboration with non-governmental organization has embarked on implementing ambitious climate resilient green economy strategy through watershed management practice. There are many opportunities that foster successful watershed planning and management for improving the economy of rural areas. Some of the opportunities are listed below:

1) Strengthening of environmental policy: Excellent environmental policies and strategies of Ethiopia links economic growth, reduction in poverty and sustainability sustainable development for poverty reduction program 2000-2004, plan for accelerated and sustained development to end poverty plan 2005-2009 and growth and transformation plan 2010-2014. It aims in addressing different environmental concern in a comprehensive manner. It set goal and objectives for sustainable use of natural resource [12].

2) Management and use of agricultural land through expanding conservation and rehabilitation activities: It gives more emphasis on rehabilitating the area to reverse the natural resource degradation process because it serve as a source of income generation for farm households. Watershed based harvesting of water as well as introducing the new high value diversified crops, livestock and agro forestry development are added in the new policy and strategy.

3) Land tenure certification: Various regions of Ethiopia have already started land tenure certification to the farmers, which strongly supported the development and management of watershed in participatory mode [25].

4) Good start and experience in community based watershed management: Government of Ethiopia realized the need for community based participatory watershed management and prepared guideline that supported the program and implemented through ministry of agriculture and rural development [25].

5) Integration of concerned institution and organization: The integration of ministry of agriculture and rural development at the federal level with agricultural bureau at regional to zonal level and extending to Woreda, kebele and village community level. There are Ethiopian agricultural research institute at federal level and agricultural research center at regional level liaison with international research organization. They also prepare plan to be submitted to the funding agencies for capacity building and successful implementation of watershed management in the country [14].

6) Integration of indigenous and advance technology: Local communities have good indigenous knowledge. Once supported by advance technologies, it helps them for the successful watershed management. Recently in Ethiopia many research organizations in collaboration with ministry of agriculture and rural development played a key role in disseminating indigenous and advance technologies for further refining the community's indigenous knowledge [14] [22] [30].

7) Income generation from degraded lands: The soil and water conservation initiatives also incorporated household income-generating activities along with the rehabilitation of degraded lands.

9. Conclusion

In the past, watershed development and management program in Ethiopia did not yield satisfactory results in achieving the intended goal due to the lack of indigenous knowledge, top down approach and lack of institutional collaboration. The participatory watershed management approach started yielding positive result when some of the shortcoming was removed through the instrument of new policies. The long term community based participatory watershed management could be an appropriate vehicle for improvement of living conditions of rural communities.

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