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Research Article

IMPACT OF PARTICIPATORY INTEGRATED WATERSHED MANAGEMENT ON HYDROLOGICAL, ENVIRONMENT OF WATERSHED AND SOCIO-ECONOMIC, CASE STUDY AT SOMODO WATERSHED, SOUTH WESTERN ETHIOPIA.

Gizaw Tesfaye[1], Yalemtsehay Debebe[1], Tesfaye Yakob[1]
[1]Ethiopian Institute of Agricultural Research, Jimma Agricultural Research Center, Ethiopia

Correspondence should be addressed to **Gizaw Tesfaye**

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ABSTRACT

Watershed is not simply the hydrological unit but also socio- political and ecological entity which plays crucial role in determining food, social, and economical security and provides life support services to rural people and its management through integrated participatory approach is useful strategies for reducing poverty, improving livelihood resilience and sustainability. Integrated and sustainable watershed management is an effective way to address complex water and land resource challenges and its implementation has not been successful in most countries including Ethiopia. Also there is no enough understanding on integrated watershed management in most parts of the country including South-Western part of Ethiopia. This paper mainly aimed to assess the suitability, acceptability and impact of participatory integrated watershed management at Somodo experimental watershed. Primary data was obtained through semi-structured questionnaires and group discussion with experimental group (60 HH) and control group (40 HH).These data were arranged with the help of Microsoft excel and analyzed by SPSS version 20 software. The study was under taken for five years, 2011 to 2015, through managing the watershed by intensifying technologies to solve the identified problems of the watershed, and to improve the livelihood of the community through participatory and integrated approach. Soil erosion, decline in soil fertility, deforestation, crop and animal disease, fodder and forage problems are the leading ones. Major actions taken to overcome these problems were introduction of biological and physical Soil and water conservation measures; fertility enhancement activities, establishment of community nursery and plantation of niche compatible multipurpose trees, introduction high yielding crops, introduction of apiculture and poultry technologies, and introduction of improved energy saving stoves. The study showed that participatory integrated watershed management have a Positive impact on hydrology, socio-economic and environment of the watershed. And the study recommended participatory integrated watershed management for successive development of watersheds with the problem similar to Somodo watershed. Any study, model based, in the watershed on hydrological behavior and others is also appreciable.

KEYWORDS: Participatory integrated watershed management, Impact assessment and Experimental watershed.

INTRODUCTION

In Ethiopia land degradation in the form of soil erosion and declining fertility is serious challenge to agricultural productivity and economic growth [1]. Land degradation in Ethiopia is also intensified by soil nutrient depletion, arising from continuous cropping together with removal of crop residues, low external inputs and absence of adequate soil nutrient saving and recycling technologies [2]. To address

the land degradation and loss of soils, extensive conservation schemes were launched in Ethiopia, particularly after the famines of the 1970s. Since then, huge areas have been covered with terraces, and millions of trees have been planted [3].

Watershed is not simply the hydrological unit but also socio-political and ecological entity which plays crucial role in determining food, social, and economical security and provides life support services to rural people [4]. Managing watersheds for sustainable rural development is concerned not only with stabilizing soil, water and vegetation, but also with enhancing the productivity of resources in ways that are ecologically and institutionally sustainable [5]. Integrated watershed management (IWM) is being promoted as a suitable strategy for improving productivity and sustainable intensification of agriculture in rain fed drought-prone regions of the world. Watershed management (WM) encompasses the holistic approach to manage watershed resources that integrates forestry, agriculture, pasture and water management, which can be broadened to rural development with a strong link to the livelihoods of the local people [6].

The watershed program was strengthened since the mid 1990s through new initiatives and creation of new institutional structures that aimed to increase community participation, sustainability and program impacts. The strategy emphasizes the need to go beyond conservation technologies to include multiple crop-livestock interventions that support and diversify livelihood opportunities for the poor and create synergies between targeted technologies, policies and institutions to improve productivity, resource use sustainability and market access [7, 8]. Integrated watershed management (IWM) interventions and improved access to markets and agricultural innovations are useful strategies for reducing poverty, improving livelihood resilience and sustainability in less-favored areas. Some benefits of IWM are non-tangible public goods, and hence not fully captured by individual resource users [9].

Ethiopia has a history of watershed management initiatives dating back to the 1970s. The basic approach has shifted from top-down infrastructure solutions to community-based approaches. There is now a supportive policy and legal framework in the form of policies that facilitate decentralized and participatory development, institutional arrangements that allow and encourage public agencies at all levels to work together, and an approach to natural resources that reflects local legislation and tenure practices [10].

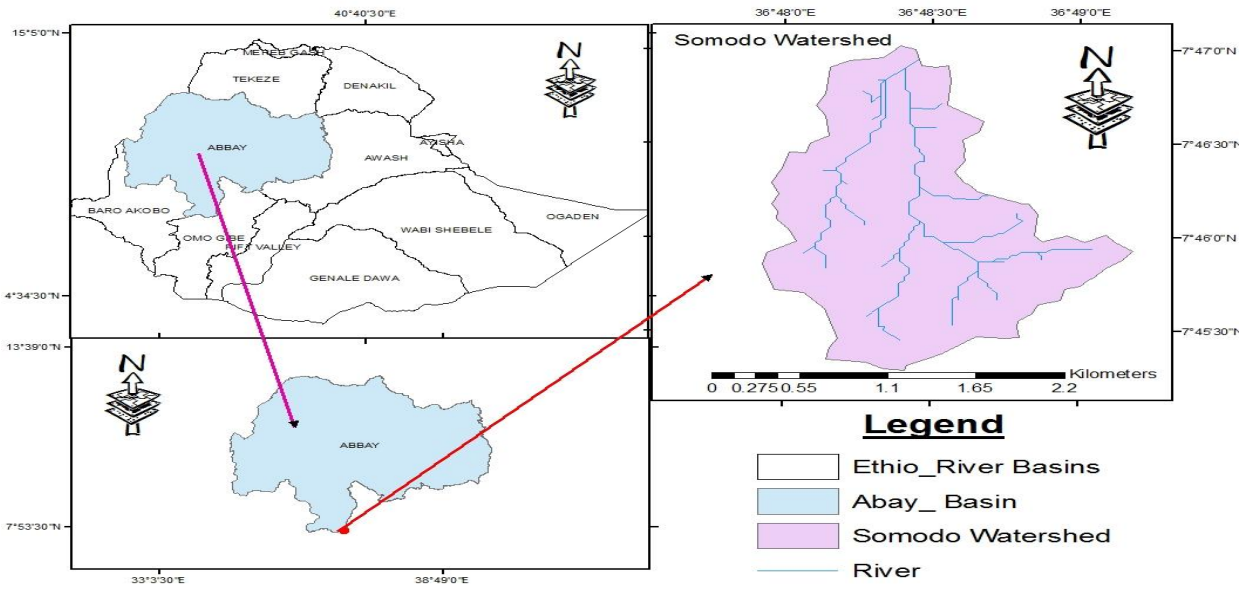
For several decades, integrated and sustainable watershed management has been suggested and tried in several countries in the world, as an effective way to address complex water and land resource challenges. However its implementation has not been successful in most cases, due to various barriers in different parts of Ethiopia. Because of this, the study was initiated to assess the effect of participatory integrated watershed management on socio-economy and environmental sustainability of Somodo experimental watershed with the intensification of different technologies through multi disciplinary approach.

MATERIALS AND METHODS

Description of the study area

Somodo experimental watershed is located at the upper part of Dhidhessa catchment in the Nile basin, in South-western part of Ethiopia Oromia region state, Jimma zone. It lies between 7°46'00" - 7°47'00"N latitude and 36°48'00" - 36°47'00"E longitude with altitude ranging from 1900-2050m a.s.l.

The watershed covers 400 hectares and comprises about 300 households. On average it receives 1800mm annual rainfall. Nitisol is a dominant soil type and about 68% of the watershed soil is extremely acidic (PH value 3.75 to 4.5). The watershed is characterized by different land use types with cultivation land domination and less forested area. Coffee based and agro-forestry systems are common farming systems in the watershed. The average land holding size of household is 1.08 ha and half of the house hold owns less than 0.75ha of land.



Methods

In the watershed different steps were followed by stakeholders to be successful in the study. These steps were: Awareness creation and participatory site selection for integrated watershed management based research; Characterization, identification and prioritization of major constraints and potentials in the selected watershed, and preparation of action plan for intervention, monitoring and evaluation.

For Awareness creation and participatory site selection 40 participants from Woreda (Office of Administration, Office of Agriculture and Rural Development, Office of Women Affair, Office of Health), Somodo Kebele (Office of Administration, Development Agent and women from Health Extension), Jimma University College of Agriculture and Veterinary Medicine and Jimma Agricultural Research Center (case teams and seed multiplication and center development representatives) were participated and integrated watershed management team was formulated from participants. This team selected Somodo watershed from three candidate watersheds and formulated community watershed team after awareness creation for the community of the watershed.

Integrated watershed management teams were indentified 14 major problems in the watershed and ranked 1-12 through a preliminary survey in 2011. These problems were; Soil Erosion, Soil fertility decline, Deforestation, shortage of drinking Water, lack of improved forage, Land shortage, Population increment, human and animal disease, crop disease, lack of agricultural input, lack of bio-fuel and energy, and credit respectively. To hinder these problems participatory integrated watershed management plan was developed by the team to be implemented for five years starting from April 2011 to 2015.

Biological and physical soil and water conservation practices(vetivar hedge rows and bunds), soil fertility enhancement activities (demonstration and evaluation of liming for acid soil reclamation, Promoting the use of organic fertilizer such as bio-fertilizer, composting, conservation agriculture, etc), intensification of crops and introduction of high yielding and disease resistance crops, introduction and evaluation of forage crops and feeds, introduction and evaluation of poultry technologies, introduction and evaluation of apiculture technologies, establishing community nursery site, introduction and plantation of niche compatible multipurpose tree species, assessment of woody and non woody fuel biomass resource availability and forest cover improvement, introduction and demonstration of improved energy saving stoves were intervention activities proposed to overcome the problems identified and prioritized in the watershed.

To take these proposed activities, more than 190 hectare land was covered by soil and water conservation (SWC) measures to control soil erosion. Vetiver hedge row was introduced and evaluated for soil conservation as an stabilizing structure for physical SWC measures and alone. At the outlet of the watershed hydrological station was installed to monitor discharge and sediment yield. River depth data was taken twice a day (morning and afternoon) and one liter water sample was taken after every storm for further laboratory analysis. Lime technology was widely introduced and evaluated for different crops. Bio-fertilizer for pulse crops, vermin-culturing, composting and conservation agriculture were also introduced and evaluated for soil fertility enhancement purpose. To improve crop production high yielding and disease resistant crops like kuncho teff, wheat, barley, fruit trees, were introduced and adapted in the watershed.

To minimize deforestation and increase the forest coverage of the watershed activities like establishment of community nursery site, introduction and plantation of niche compatible multipurpose tree species, and introduction, evaluation and demonstration of improved energy saving stoves.

Data Analysis

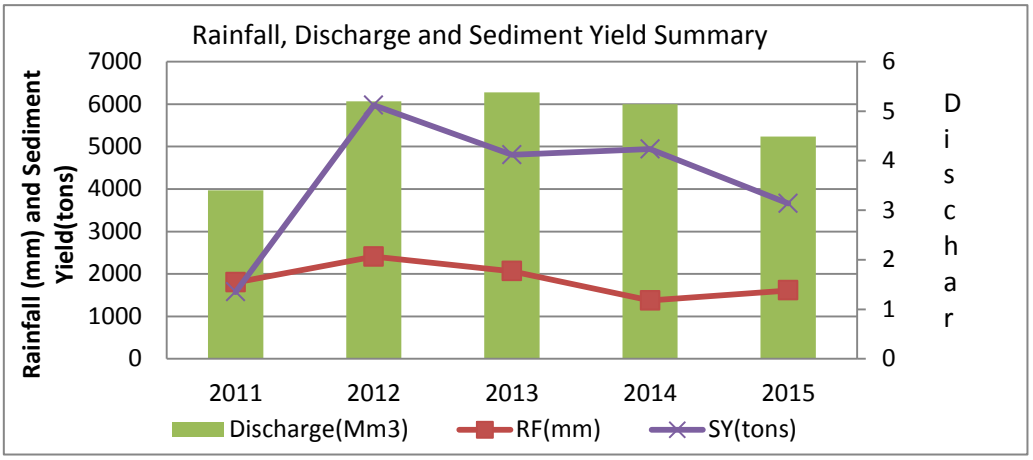
Impact, suitability and acceptability of intervened technologies in the watershed were assessed by multidisciplinary team in 2016. For this assessment 100 households (HH) were selected, 60 HH from the watershed under intervention as an experimental group and 40 HH from outside of the watershed with no intervention as a control group. Using semi-structured questionnaires data were collected from both experimental and control group. And then the collected data were arranged and filled in Microsoft excel. SPSS version20 and Microsoft excel were implemented for data analysis and interpretation.

RESULT AND DISCUSSION

Hydrological Impact

In 2012 mean annual rainfall was found 2405 mm and river discharge was $5.2x10^6$ m^3 $year^{-1}$. With this river discharge 5971 tons $year^{-1}$ sediment was lost. And in 2014 mean annual rainfall was decreased to 1374.9 mm and river discharge was $5.14x10^6$ m^3 $year^{-1}$; while the sediment load is 4941 tons $year^{-1}$. Mean annual rainfall, annual river flow and sediment load at the out let of the watershed was shown in figure below from 2011 to 2015.

Figure 2: Yearly Rainfall, Discharge and Sediment Yield of the Watershed from 2011 to 2015.



From 2012 to 2014 the amount of annual rainfall was reduced and showed some increment in 2015. However, river discharge and sediment yield of the watershed was reduced from 2012 to 2015 due to integrated watershed management specially biological and physical soil and water conservation measures implemented on farm lands. Similarly, due to integrated watershed management implementation in the watershed amount of annual soil loss from the watershed was reduced. [11] reported that the mean wet monthly flow for 2011 land cover increased by 39% compared to the 1985 land cover. On the other hand, dry average monthly flow decreased by 46% in 2011compared to 1985 land cover in Angereb Watershed, Ethiopia.

Socio-Economic Impact

Crop diversification

Table 1: Crop variety and inputs used by farmers by experimental and control groups.

Variety and other inputs	Experimental group	Control group
Improved variety	82.50%	57.6 %
Local variety	17.50%	42.4 %
Fertilizer(kg)	23%	20%
Manure(ton)	60%	24%
Compost(ton)	62%	31%
Mulching(ton)	45%	30%

About 82% of households in the watershed use improved crop seed varieties and only 57% of the control group. Fertilizers, manure, compost and mulch used by control groups is less than experimental groups by 3%, 36%, 31% and 15% respectively.

Due to awareness created for the community, experimental group, and introduction of different high yielding crop varieties crop production was diversified and production was improved in Somodo watershed. Many of the small and medium farmers have moved from mono cropping to diversified cropping system like soybean, teff, wheat, barley, seasam, niger; and fruit trees like banana, mango, avocado. Improved coffee seed varieties were also introduced and coffee based agroforestry is now common practice in the watershed. This implies that there is awareness gap between households inside and outside the watershed. The type of Seed used by the farmers also have great impact on product and production as the respondents stated.

Mean yield change was also assessed on major crops for both groups and resulted the newly introduced crops mean yield change in the watershed is 100%. Mean yield change for major crops such as maize, teff and coffee is more in experimental groups than control groups.

Table 2: Mean yield change of major crops after intervention for experimental and control group.

Major crop types	Mean yield change of experimental group	Mean yield change of control group
Maize	25.50%	20.20%
Teff	52.97%	32.96%
Coffee	34.36%	26.55%

Since the initial year, there were yield change on all crop types both for experimental and control groups, but yield change in experimental group was greater than that of control group. The mean yield change for teff was much greater for experimental groups due to introduction of kuncho teff in somodo watershed and different soil fertility enhancement technologies, lime technology and improved and specialty coffee seeds at the community nursery site for coffee yield improvement in the experimental watershed. Crop diversification not only provides a wider choice in production of various crops but also minimizes the risk and increases profit- ability besides harnessing the potential of land, water, human and climate [12].

There was also yield improvement in the control group and the reason for this yield change was somodo watershed as seed source for improved seed types and high yielding crop types, and also advice from woreda agricultural and rural development office as the farmers stated. This result is in agreement with the finding reported by [13] in Adarsha watershed Kothapally, India.

Source of Income Generation

The results from the selected source of income generation indicators evaluated during the assessment on the basis of base year (before integrated watershed management intervention) clearly indicated that the farmers belonging to marginal and small land holdings got relatively higher benefits from the watershed development activities, specially income generating activities like poultry technologies, energy saving stoves, community nursery sites. This result is in parallel with the result reported by [12] which is, the watershed program increases the employment opportunities for all categories of farmers due to various activities related to agriculture, horticulture, floriculture, afforestation, animal husbandry and small enterprises.

Table 3: Share of different income sources of HH for experimental and control groups.

Source of incomes	Experimental group	Control group
Agriculture/crop production	75%	85%
Livestock	17%	12%
Other products	5%	2%
Business	3%	1%

Farmers outside the watershed were highly depended on agriculture or crop production than those in the watershed. This implies that source of income was diversified in the experimental watershed than control watershed. 17%, 5% and 3% of households in the experimental watershed income is dependent on livestock, other products and business respectively; and only 12%, 2% and 1% for the control watershed respectively. The rest 75% and 85% of HH depends on crop production in the experimental watershed and control watershed respectively as shown in table 3. above.

Wealth Status of the Community

In addition to crop production and other income sources number of livestock and small ruminants are the indicators of wealth status in the community of the study area and surroundings. The result in the following table shows the total number of animal category per households and it is why presented in a decimal form.

Table 4: Numbers of livestock and small ruminant per HH before and after base year.

Animal category	Experimental group		Control group	
	Mean before base year	Mean after base year	Mean before base year	Mean after base year
Oxen	1	1	1	1
Cows	1	1	1	1
Heifer	-	1	-	-
Calves	-	1	-	1
Sheep	1	1	1	1
Total mean	5	9	5	6

Mean number of different livestock and small ruminants per household was increased from 5 to 9, which is more than 80% in the experimental watershed and only about 20% in control watershed as shown in Table 4. As the respondents in the experimental watershed stated the reason for number of livestock increment are crop production improvement and diversification of income source.

During impact assessment number of farm tools one household owns was assessed and it was increased by 38% and 9% for experimental group and control group respectively since base year. This also shows that farmer's wealth to afford farm tools is improved and found greater in experimental group than control group.

Introduction of different forages (Rhodas grass, Elephant grass and multi-purpose trees) had also played vital role for the increment of livestock numbers per HH in experimental groups. But in the case of control group change in number of livestock was not observed and remains constant. This result implies that participatory integrated watershed management can play important role in improvement of wealth status of the community.

Environmental Impact

During the participatory integrated watershed intervention several measures were undertaken to minimize soil loss, land degradation, and to improve surface and groundwater resources, vegetative cover and other ecological factors.

Table 5: Land management practices done per HH since base year.

Practices	Mean by control group	Mean by experimental group
Soil bund (km)	14.726	38.5255
Drainage Ditch (km)	1.3158	1.7626
Cutoff drain (km)	3.75	4.4975
Vetivar hedge (km)	9.3421	39.7259

Mean land management practices (soil bund, drainage ditch, cutoff drain and vetiver hedge row) to control soil erosion per household by experimental group was much greater than that of control groups. Totally about 85 km and 29 km soil and water conservation measures were implemented by each HH of experimental and control group respectively.

Farmers perception on soil erosion level both in the experimental watershed and control watershed since base year was assessed and the result is presented in Table 6, below. According to the respondents soil erosion severity in the experimental watershed was decreased more than that of in the control watershed due to the applied land management practices presented in Table 5 above.

Table 6: Farmers perception on Soil Erosion compared to base year.

Farmers perception on soil erosion compared to base year	Experimental group	Control group
Much worse	1.50%	1.2 %
Worse	5.30%	28%
The same	12.10%	0%
Better	33.50%	45.1%

About 5.3% of households in the experimental group stated that soil erosion is worse when compared to base year while 47.1% stated it was much better when compared to base year. But in the control group or outside the intervention watershed more HH was stated soil erosion is worse when compared to base year. As shown in Table 6, 28% of households stated soil erosion is worse now compared to base year.

Similarly, farmers perception on soil quality compared to base year was assessed and the result is presented in Table 7. The result showed 8% of households in the experimental watershed stated soil quality is worse when compared to base year and 39.8% of households stated it is much better. But in the control watershed 30.5% of households stated soil quality was worse and 12.2% stated it is much better when compared to base year.

Table 7: Farmers perception on Soil Quality Compared to base year.

Farmers perception on soil quality compared to base year	Experimental group	Control group
Worse	8.30%	30.5 %
The same	5.30%	0%
Better	45.60%	53.7%
Much better	39.80%	12.2%

Generally, as these farmers stated soil erosion problem was minimized and soil quality was improved in the experimental watershed due to integrated watershed management intervention; and in the control watershed soil erosion problem was increased and soil quality was declined.

This had great impact on product and productivity of the land and ecosystem balance. During the implementation of integrated watershed management more than 25,000 trees were planted in the experimental watershed.

Table 8: Coffee shade and other multipurpose tree seedlings raised at nursery sites in Somodo Watershed and distributed for farmers

No	Species	Unit
1	Acacia abyssinica	Number
2	Fedherbia albida	Number
3	Grevillea robusta	Number
4	Cordia Africana	Number

This multi-purpose trees were introduced and planted to increase the forest coverage of the watershed, as stabilizing agent for physical soil and water conservation structure and as a forage for animals.

CONCLUSION AND RECOMMENDATION

Watershed management encompasses the holistic approach to manage watershed resources that integrates forestry, agriculture, pasture and water management, which can be broadened to rural development with a strong link to the livelihoods of the local people.

As the result of the study showed from 2012 to 2014 mean annual rainfall and sediment yield were reduced from2405 mm to1374.9 mm and 5971 tons year^{-1} to 4941 tons year^{-1} respectively, while discharge of river remains the same which was about $5.2x10^6$ m^3 year^{-1} due to implemented soil and water conservation structures in the watershed. Due awareness created by different trainings, field days and demonstration of high yielding crop technologies crop production was diversified in the watershed. Also production of major crops in the watershed was improved by more than 20% since base year. Source of income which was generally dependent on the agricultural product was diversified in the experimental watershed than control watershed. Because of this diversified income number of livestock, indicator of wealth status of the community, in the watershed was increased by more than 100%. Soil erosion was decreased and soil fertility was improved in the watershed since the base year because of implemented soil and water conservation structures and soil fertility enhancement technologies. To improve forest coverage of the watershed more than 25,000 multi-purpose trees were planted.

Participatory integrated watershed management to improve the hydrology, socio-economy and environmental sustainability of a watershed with a problem similar to Somodo watershed is highly suggested by this study. In addition, any study in the watershed specially the effect of integrated watershed management on ground water or water balance and land use land cover is also appreciated by this study.

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