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Impacts of Soil Conservation Based Technological Interventions on Livestock Productivity in Ojoje Watershed of Doyogena District, Southern Ethiopia

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Abstract
A study was undertaken to evaluate impacts of soil conservation based technological options to smallholder farmers in Ojoje watershed of Kembata Tembaro zone, southern Ethiopia. Information were collected using baseline survey (March to May 2010) and impact assessment, conducted after five years of technological interventions (March to May 2016). 180 participants from three villages were selected using purposive sampling technique to include experienced, youth and women livestock owners. Structured questionnaires were administered to collect information from the selected households. Descriptive statistics and paired samples t-test were used to analyze the data. Livestock number increased ($P < 0.01$) after intervention per household due to feed and forage interventions. On average, milk yield increased by 0.4 liters/cow/day after interventions due to improved forages production and management practices. Age at first mating local & crossbred cows, and ewes showed significant ($P < 0.01$) differences after technological interventions. Age at first parturition of crossbred cows and local ewes was significantly ($P < 0.01$) lower after interventions. The results indicated that demand-driven technology dissemination and participatory evaluation resulted in profound improvements in soil stabilization and fertility status, and an associated increase in productivity of food and forage crops. Additionally, the results clearly indicated that technologies with multiple impacts in terms of welfare of the farmers and sustaining natural resources are essential to re-vitalize crop-livestock mixed production systems.
Keywords: Livestock productivity; technology intervention, soil conservation

1. Introduction

Rugged and undulating topography is one of the challenges of smallholder farmers in enset (*Ensete verticosum*) based livestock production system of central southern Ethiopia. Soil erosion and degradation in these regions results in reduced soil fertility and the associated low crop productivity. Livestock is an integral component of Ojoje watershed, Kembata Tembaro zone of southern Ethiopia, and contributes significantly to the livelihood of crop-livestock mixed farming system. Most importantly, enset is a food security crop in the watershed providing a dry season livestock feed when feed shortage is a serious problem. Traditional livestock production practices, which depend on limited indigenous feed sources, have drawbacks that limit productivity (Wolka *et al*., 2013; Talore *et al*., 2015).

Feed scarcity both in quality and quantity is one of the impediments for promotion of improved technologies in the livestock sub-sector. Animals are usually kept on permanently grazed open grazing lands, road sides, valley bottoms, etc. In watersheds like Ojoje, with steepy sloppiness and extremely undulating topography, animals cannot access feeds near mountain areas and are specifically kept near to valley bottoms and at marshy and swampy lands. Marked seasonality due to climate variability (drought, frost, deforestation due to human interferes) put an additional pressure on the productivity of livestock of the watershed community. The available pieces of private grazing lands are degraded due to steeply sloppiness of the watershed. The hypothesis of the study was watersheds like Ojoje would be improved through provision of soil conservation based technological options. Hence, this was study was aimed at assessing impacts of livestock productivity under various soil conservation based technology provision scenarios: improved forages (Napier grass, *Pennisetum purpureum*; 'desho', *P. pedicellatum*) poultry breed (white *leghorn*) and health management (seasonal vaccination and treatments) as intervention options.

2. Materials and methods

2.1 Description of study site

Ojoje watershed is located in northern part of Doyogena woreda, Kembata Tembaro zone of southern Ethiopia. It is typically a crop-livestock mixing farming system with strong complementarities among the system components. The watershed is characterized with very steep sloppiness, in which the residents of the area suffering. The watershed covers a total land area of 386.2 ha. It is situated at latitude and longitude of E037'47.936 and N07' 21.473, respectively, with an altitude ranges between 2300-2600 meters above sea level (m.a.s.l). The average annual rainfall ranges between 800 to 1200 mm with the temperature ranges between 15-25 °C. The watershed delineated has three villages, namely Wagebeta, Gomora and Ancha Sedicho, each of which covers over 60 ha of land. All the three major agro-ecologies (lowland, midland and highland) are found in the area, the lowland characterized with irregular and erratic rainfall. Farmland, communal grazing land, forest land and swampy land constitute 45, 22, 20 and 13%, respectively.

2.1.2 Selection procedure of site and participant farmers

A team composed of various disciplines (crop, livestock, natural resource management and socio-economics) participated in assessing the baseline scenarios of the watershed. Over 180 farmers (60 from each village) representing the watershed community were participated in livestock problem identification and prioritization. All the watershed communities were identified and recorded. The participants were then selected based on experiences in livestock production and husbandry, gender proportions and knowledge of the watershed in general. The same team who participated in the assessment of the baseline scenarios participated to assess the changes after five years of technological interventions. Other than individual interview, focus group discussions (FDG), were implemented to assess the before and after intervention effects. Improved food crops (various wheat varieties, faba bean, etc) and forage crops (such as Napier, *Pennisetum purpureum* and '*desho'*, *P. pedicellatum*), improved poultry breed (white leg horn breed) and bee hives (transitional and modern) were distributed to the watershed communities. In addition, over sowing leguminous forages were done on communal and private grazing lands to improve forage availability and quality. Both primary and secondary sources of information were utilized to assess the scenarios. Primary data were collected through face to face household interviews while secondary information was obtained from the local Bureau of Agriculture (OA). The interview and focus group discussions were facilitated by the extension agents of OA, who participated at all stages of the assessment.

2.1.3 Statistical analysis

Data were analyzed using descriptive statistics to describe qualitative parameters. Probabilities were analyzed using chi-square tests. Data collected before and after technological interventions were analyzed using paired t-test to assess the impact of technological interventions on livestock productivity parameters.

3. Results and discussion

3.1 Livestock and poultry holdings

Soil and water conservation is a key component of any watershed to rehabilitate soil and crop and livestock productivity. Crop, livestock and natural resources management is a central component of the watershed management. Changes in landscape and soil fertility generally improve livestock productivity. **Table 1** shows livestock and poultry holding before and after technological interventions, soil conservation and proven livestock technologies. Livestock did not show significant changes while number of chicken showed significant ($P < 0.01$) changes after technological interventions. Source of chicken varied significantly ($P < 0.01$), home born and purchase having the largest share compared with either home born or purchased or other sources.

Institutional arrangements were considered well in the watershed improvement program although some institutions did not involve actively. According to Addisu *et al* (2013) investigated that only technological approaches were adopted while institutional arrangements were not well organized in watershed project elsewhere in Ethiopia. The same author indicated that the adoption rate of soil and water conservation was usually high while unlike the current results Addisu *et al*. (2013) showed that the adoption rate of crop and livestock technologies were medium to low. For the watershed to be successful strong linkages among local institutions is required (Tiki *et al*., 2016).

3.2 Trend of livestock population

Livestock number showed an increasing trend in nearly half of the interviewed respondents (48.3%) after intervention (**Table 2**). Due to increasing number of human population in most highlands of the country, there is encroachment crop cultivation so that grazing land is diminishing. In contrary to this more respondents said that the number of livestock population showed an increasing trend (P < 0.05) after intervention. This could be attributed to the shifting of extensive (grazing) system to homestead tethering and using cut and carry system. Key informants and group discussion also strengthen this idea that most of the households were using cut and carry system from those stabilizers (Elephant grass, *Pennisetum purpureum*, leacenea (*L. Lecocephala*) and others intervened on the dams.

According to majority of the respondents (56.85%), the overall condition of the animal was good (P < 0.01) after intervention. This due mainly attributed to soil conservation, fertility build up and homestead forage development.

26.1% of the interviewed farmers suggested that the change is due to feed conservation for dry season while 10.9% suggested the reason is related to rehabilitation of degraded lands **(Table 2).** According to Addisu *et al.* (2013) and Tiki *et al.* (2016) soil stabilization usually improves a watershed and an associated crop and livestock improvements.

3.3 Productive and reproductive parameters

The impact assessment results showed that productivity and production of livestock in the study areas (in three villages of the watershed) were significantly higher for most parameters after intervention (P < 0.01) (**Table 3 & Figure 1**). The decrease in age at first mating by about 68% for local cows and 103% for crossbred cows after technological interventions showed a significant (P < 0.01) difference compared with after interventions. Similarly, age at first mating of local ewes decreased by 42%, which was significantly (P < 0.05) lower in after intervention compared with the before. Age at first parturition of crossbred cows, as well as local ewes was significantly (P < 0.01) lower after interventions. This agrees with reports of various authors (Deribe *et al*. 2014; Wolka *et al*. 2013) that improving feed base can improve age at first mating and calving/kidding/lambing interval in domestic animals. However, in this study it is only crossbred cows whose parturition interval shortened due to interventions. Weaning age (months) of lambs significantly (P < 0.01) decreased after technological interventions. On the other hand, milk production of local cows (1.5 liters/cow/day) is higher by 0.4 liter after interventions compared with before technological interventions (1.1 liters/cow/day). The milk yield obtained in this study after intervention is higher by about 15.4% than reports of average milk yield (1.32 liters/cow/day) for local cow (CSA, 2015). This is due mainly to improved feeding management (almost all households) use cut and carry feeding by tethering their livestock around home stead. Furthermore, lactation period elongated from 5 months to 7 months (i.e milking season elongated). Animals also did not lose energy trekking long distances searching for feed and water, rather would have been converted feed energy to milk and meat or growth of calves or lambs (Deribe *et al.* 2014).

3.4 Impacts of technological interventions on livestock and poultry productivity

Milk and egg production showed an increasing trend after technological intervention across the three villages of the watershed (**Table 4**). Majority (100%) of the farmers in Gomora and Ancha Sedicho suggested increasing trends of milk yield/cow of crossbred cows except Wagebeta, 33% suggested no changes in milk yield after technological interventions. Reasons for such improvements are mainly related to improve breed and improved feeding and awareness created on livestock management under changing faming conditions across *kebeles*. The improvement in milk yield could be attributed to better feeding (stabilizing of different improved forage trees on soil and water conservation structures and soil bunds) among others, awareness created for improvement of livestock management system with collaborative work of extension of Woreda Agricultural office and research. The case of Wagebeta had a bit different scenario because Wagebeta *kebele* is located in water logging and marshy parts of the watershed. Key informants and group discussants also strengthen this reason for general improvement of livestock production.

3.5 Management and policy implications

The watershed considered in this study had steepness varies between 30-65%, which is practically not convenient for cultivation. However, due to land shortage farmers are cultivating while conserving the natural resources. Once soil and water conservation barriers constructed, there were efforts to formulate or establish community bylaws and binding rules with active participation of land owners not to disturb the soils again. In addition to already available government policy, the community of the Ojoje watershed formulated local bylaws and binding rules to protect soil from erosion and manage natural resources. This approach agrees with the previous reports (Butterworth *et al*. 2010; Addisu *et al.* 2013) who pointed out the importance of strong policy reforms and community binding rules for community-based watershed management. From this study it has been realized that there is relatively high technology adoption due to increased awareness and demand driven approach unlike top-down approaches and scenarios reported before (German *et al.* 2006; Kebebe *et al.* 2015).

4. Conclusion

Technology adoption visibly increased due to demand driven technology evaluation and dissemination in Ojoje watershed of southern Ethiopia. Soil conservation improvement has been resulted in visible changes in soil stabilization and fertility status, and an associated increase in improvement of food and forage crops The increment in milk yield, meat and egg implies that participatory watershed management approach that is based on technological interventions would bring significant changes in similar watersheds of the region or elsewhere in the country. Additionally, the results clearly indicated that technologies with multiple impacts in terms of welfare of the farmers and sustaining natural resources are essential to re-vitalize crop-livestock mixed production systems.

5. Acknowledgments

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Table 1 Livestock holding pattern (%) before and after intervention

Livestock holding parameters	Before	After		***Paired T*-test**
Number of cattle			NS	
Own	71.40	76.40		
Shareholding	11.90	18.20		
Ribi	2.40	0.00		
No cattle	11.90	1.80		
Own & Shareholding	2.40	3.60		
No answer	0.00	0.00		
Number of chicken				
Owned	14.70	90.00	39.6	**
Shareholding	8.80	0.00		
*Ribi**	2.90	0.00		
No cattle	73.50	6.70		
Own & Shareholding	0.00	3.30		
Source of Cattle				
Family/parents	30.60	1.90		
Born	11.10	35.20	40.2	NS
Purchased	19.40	51.90		
Gift	0.00	5.60		
Born & purchase	11.10	3.70		
No cattle	11.10	1.90		
Family & born	5.60	0.00		
No answer	11.10	0.00		
Source of Chicken				
Family/parents	0.00	0.00	28.5	**
Born	3.00	31.00		
Purchased	21.20	51.70		
Gift	0.00	0.00		
Born & purchase	75.80	10.30		
No cattle	0.00	6.90		
Family & born	0.00	0.00		
No answer	0.00	0.00		

Ribi* is animals that are given by rich and/or land shortage to other resource poor farmers but have land to equally share offspring; N=number of observations; SD, standard deviation; NS, not significant; ***t-test*; ns, P > 0.05

Table 2 Reason for changing trends of livestock population number after technological interventions

Tend Parameters	Intervention Before	After	***Paired T- test***
Livestock Population (%)			
Increasing	23.5	48.3	12.4*
Decreasing	73.5	36.2	
No change	2.9	15.5	
Reason of trend increased of population			
Due to improved forage development (bund stabilizers)	31.6	70.4	11.97
Purchasing	57.9	11.1	
Reproduction and purchase	10.5	14.8	
No answer	0.0	3.7	
Over all condition of the animal			
Good	43.1	61.1	
Medium	13.9	56.9	26.1**
Poor	25.0	0.0	
Reason for good condition			
It is related to the treatment of degraded areas	22.0	10.9	52.6**
Improvement of grazing land	14.6	2.2	
Soil stabilization & backyard forage production	2.4	56.5	
Feed conservation for dry season and supplementing concentrate feeds	4.9	26.1	

N=number of observations; SD, standard deviation; NS, not significant; ***t-test***; ns, P > 0.05

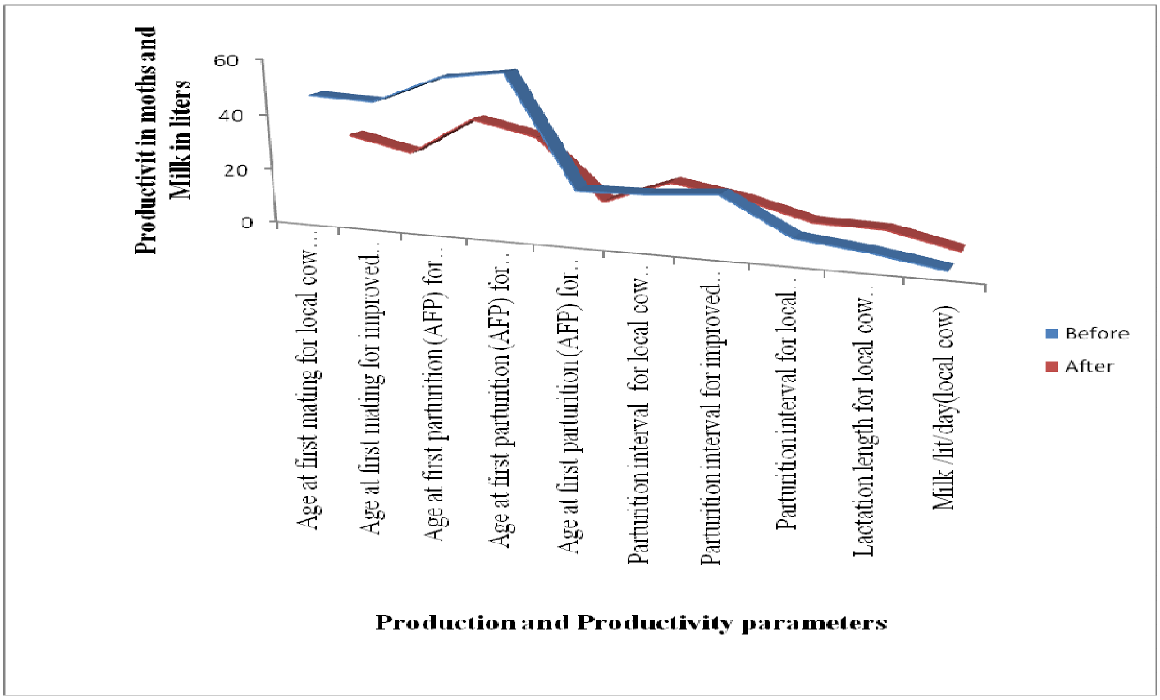

Figure 1 Trends of some production and productivity before and after watershed management intervention.

Table 3 Livestock productive and reproductive changes (unit change in product per unit input)

Parameters	Before			After			Paired T-test
	N	Mean	SD	N	Mean	SD	
Age at first mating for local cow (Month)	24	46.7	14.4	49.0	27.8	23.4	4.247***
Age at first mating for crossbred cow (Month)	24	45.6	13.6	19.0	22.5	18.1	4.63***
Age at first mating for local ewes (Month)	13	12.5	6.1	25.0	8.8	4.7	1.8*
Age at first parturition (AFP) for local cow (Month)	24	55.3	15.5	23.0	33.8	23.8	5.2***
Age at first parturition (AFP) for crossbred cow (Month)	23	58.3	20.8	8.0	30.5	22.0	4.13***
Age at first parturition (AFP) for local ewes (Month)	12	18.6	6.4	9.0	9.3	5.7	3.49***
Parturition interval for local cow (Month)	24	19.0	9.6	35.0	18.2	9.9	NS
Parturition interval for crossbred cow (Month)	23	20.9	8.8	15.0	14.1	5.3	2.96**
Parturition interval for local ewes (Month)	12	7.8	2.6	20.0	7.6	3.7	NS
Weaning age of the young local calf (Month)	24	9.3	4.8	34.0	7.6	4.3	NS
Weaning age of the young crossbred calf (Month)	23	10.2	5.9	15.0	5.6	4.3	3.92***
Weaning age of the young local ewe (Month)	12	5.3	2.3	22.0	3.8	1.4	2.2*
Lactation length for local cow (Month)	22	5	3.4	35.0	7	2.5	NS
Milk /lit/day(local cow)	42	1.1	0.7	48.0	1.5	0.7	1.9**

N=number of observations; SD, standard deviation; NS, not significant; t-test, ns, P > 0.05

Table 4 Trends (%) of livestock and poultry productivity changes after technological interventions

Trend and Reason Parameters	Kebeles				
	Wagabeta	Ancha sedicho	Gomorra	Total	X^2
Trend of milk/lit/day (cross cow)					
Increasing	66.7	100.0	100.0	83.3	3.6
Decreasing	0.0	0.0	0.0	0.0	
No change	33.3	0.0	0.0	16.7	
Reason for increasing milk/lit/day (cross cow)					
Improved feeding	16.7	33.3	0.0	28.6	2.96
Improved breed	16.7	16.7	50.0	21.4	
Improved feeding and awareness for management	16.7	33.3	50.0	35.7	
others	15.1	16.7	0.0	14.3	
Trend of milk/lit/day (local cow)					
Increasing	52.9	81.8	66.7	60.4	4.07
Decreasing	17.6	0.0	0.0	12.5	
No change	29.4	18.2	33.3	27.1	
Reason for increasing Milk/lit/day (local cow)					
Improved feeding	47.1	25.0	50.0	40.7	5.86
Improved breed	0.0	12.5	0.0	3.7	
Improved awareness for management	41.2	50.0	0.0	40.7	
Others	11.8	12.5	50.0	14.8	
Trend of egg/hen/year(improved)					
Increasing	63.6	100.0	100.0	76.5	2.85
Decreasing	0.0	0.0	0.0	0.0	
No change	36.4	0.0	0.0	23.5	
Reason for Increasing egg/hen/year(improved)					
Improved feeding	0.0	0.0	33.3	11.1	4.13
Improved breed	25.0	0.0	33.3	22.2	
Improved awareness for management	50.0	50.0	33.3	44.4	
Others	25.0	50.0	0.0	22.2	
Trend of egg/hen/year(local)					
Increasing	33.3	40.0	100.0	40.0	2.00
Decreasing	11.1	20.0	0.0	13.3	
No change	55.6	40.0	0.0	46.7	
Reason for increasing egg/hen/year(local)					
Improved feeding	100.0	66.7	100.0	85.7	1.56
Improved breed and awareness for management	0.0	33.3	0.0	14.3	