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Adoption monitoring study of sustainable intensification agricultural technologies in southern Ethiopia

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Abstract

Conducting adoption monitoring study of SIMLESA technologies used by farmers in the intervention areas used as a framework to identify the strength and weaknesses of the current systems and led to recommendations to improve their wider coverage and usage. Structured interviews were used to collect data from a randomly selected one hundred households of Hawassa Zuria, Misrak Badwacho and Meskan Districts the Sidama, Hadiya and Gurage zones of SNNPRs. The data analysis was performed using SPSS. This signifies that the respondents incorporated in this study had a close contact and knowledge of the project in each intervention woredas. Based on this study, majority of the farmers who were aware of maize bean intercropping, Hawassa dume and BH-543 were adopted the technology and in 2013 the number of farmers practicing the technology were increased apart from the previous years. However, the farmers who were aware of maize bean rotation and minimum tillage were adopted the technology and in 2013 the number of farmers practicing the technology were decreased as compared to the previous years. According to table 19 above, among the five SIMLESA technologies, Maize bean intercropping, Minimum tillage, Hawassa dume, BH-543 and Maize bean rotation ranked from first to least as the most liked technologies respectively. The finding of this research revealed that the stakeholders should design the possible way of expanding the best bet technologies the adjacent farming systems and able to validate and refine the technologies and the extension system to come up with wider impact in order to play a critical role in agricultural development.

Keywords: SIMLESA technologies, conservation agriculture, adoption monitoring

1. Introduction

Soil is one of the important resources. Healthy soil is key component to the efficient utilization of soil nutrients in the production of food in sustainable manner. Soil properties vary within the farmland or at the landscape scale (F. Laekemariam, *et al*., 2018 [4] and B. Iticha and C. Takele, 2019) [2]. The causes for spatial variation are both inherent soil-landscape and human-induced across farms differing in resources and practices (R. Panday, *et al*., 2019 and P. Tittonell, *et al*., 2013) [9, 7]. Information on spatial heterogeneity of soil properties within farmland/landscape scale is crucial in determining production constraints and taking appropriate management practices (R. Panday *et al*., 2019) [9]. In Ethiopia, agriculture is the mainstay of the majority of the population and major driver of the national economy. Agricultural production has been highly dependent on natural resources for centuries (Amsalu *et al*., 2007) [1]. However, increased human population and other factors have degraded the natural resources in the country thus seriously threatening sustainable agriculture and food security (Tsegaye *et al*., 2010 and Zeleke *et al*., 2000) [12, 14]. Moreover, decline in soil fertility is the major constraint to agricultural production and food security in Ethiopian farming systems. Farmers have very limited capacity to invest in fertilizers or soil conservation measures. As a result, yields are low and many farmers are forced to put fallow and marginal lands into production to meet their food needs (Tilahun, 2004) [10].

Consequently, in order to reverse soil fertility problem, integrated soil fertility management (ISFM) is taken as a key approach to solve the soil fertility problem. But to make a best out of ISFM approach, there is need to include improved germplasm and adapt the system to local condition Accordingly, ISMF is defined as “Soil fertility management practice which necessarily include the use of fertilizer, organic input and improved germplasm, combined with knowledge on how to adapt these practices to local conditions, aiming at maximizing agronomic use efficiency of applied nutrients and improving crop productivity” (Vanlauwe, 2010) [13].

In an effort to curb soil erosion and nutrient depletion, government of Ethiopia (GoE) in collaboration with local community and several donors have been implemented large national soil and water conservation (SWC) program since the 1970s (MOARD 2005) [5].

Moreover, in southern Ethiopia, various attempts have been made for about four decades to restore the fertility of degraded arable lands since the early 1970s. The aim of these efforts was to improve the crop and livestock productivity and to increase the production of raw materials for domestic use and for export. Greater emphasis was given to the promotion the use of modern inputs such as improved seeds and mineral fertilizer. Facilitating the provision of fertilizer and promoting soil fertility replenishing technologies received continuous attention in all past extension programs. Soil fertility is declining most rapidly and resulted in low crop yields and livestock numbers that led to reduced food security and increased poverty in the highlands of Southern Ethiopia, which are characterized by high population, high rainfall and sloppy lands (Tilahun Amede *et al*., 2006) [11].

To address low soil fertility and soil moisture retention problems, maize and legume intercropping under conservation agricultural practices (i.e. minimum soil disturbance, crop rotation and crop residue retention) has been proposed as a sustainable intensification of food crop production which aims to increase resilience of maize-based farming systems to progressive climate change. The "Sustainable Intensification of maize-legume Farming Systems for Food Security in Eastern and Southern Africa (SIMLESA)" is an example of the pioneer effort led by The International Maize and Wheat Improvement Center (CIMMYT) and its partners in Eastern and Southern Africa with support from the Australian Centre for International Agricultural Research (ACIAR). The project is currently on-going in Kenya, Tanzania, Ethiopia, Malawi and Mozambique and targeting maize and five main legumes grown in the region (Beans, Pigeon pea, Groundnut, Cowpea and Soybean).

In doing so, Sustainable Intensification of Maize Legume Cropping System in Eastern and South Africa (SIMLESA) project is working in the rift valley farming system of Ethiopia. The Hawassa researchers team have been tried to induce and work for the wider coverage of SIMLESA project research technologies in to the project intervention areas of Hawassa Zuria, Meskan and East Badwacho Woredas of Southern Nations nationalities and People's Regional State as of the inception workshop which has been held at Addis Ababa in 2010 by devising innovation plat forms in different hierarchical stages. Therefore, it is important to study the status of SIMLESA technologies which was tested and takeover by the respective users in the intervention areas in order to enhance and validate the inventions and dissemination path ways.

2. Objectives

- To monitor the adoption of SIMLESA technologies by the respective users.
- To identify the challenges faced in disseminating the agriculture technologies and
- To forward the possible recommendations that enhances the wider coverage of the proven technologies.

3. Methodology

3.1 Study area, Sampling Technique and Size

This survey was conducted in three woredas of Sidama, Hadiya and Gurage zones of Southern Nation Nationalities and Peoples Regional State namely Meskan, Hawassa Zuria and East Badwacho in 2014, which was being working as the project intervention areas. Fifty households were selected from each district from the sampling frame which was listed out prior to the commencement of the survey by random sampling technique. Thus the study sample composed of total 150 households.

3.2 Data Type and Analysis

This study was conducted based on primary data. The primary data which was directly obtained through a well structured and pre-tested questionnaires from the households of the study area. Thereafter, data were analyzed, tabulated and interpreted in the light of objective of the study using appropriate statistical package.

4. Results and Discussion

4.1 Socio economic Characteristics of the respondents

A total of 150 households have been interviewed in this study. Based on figure from table one, about 8 and 92% female and male farmers, respectively, participated in the survey process. This indicates that more of the SIMLESA technology users were male farmers. However, from the three technology intervention woredas, there was a better female participant in Meskan woreda as compared to the rest.

Table 1: Sex of Household Head

No.	Woreda	Sex	Frequency	Percent
1	Meskan	Female	7	14.0
		Male	43	86.0
		Total	50	100.0
2	Mesrak Badwacho	Female	1	2.0
		Male	49	98.0
		Total	50	100.0
3	Hawassa zuria	Female	4	8.0
		Male	46	92.0
		Total	50	100.0
	Total	female	12	8.0
		male	138	92.0
		Total	150	100.0

Source: own data, survey 2014.

A result from table two indicates that the age distribution of the respondents ranges between 20 and 80 years. The average age of the respondents was about 39 years with standard deviation of 11.67. They had an average educational level of 5.08 years with standard deviation of 2.95. The minimum education level is zero and the maximum being 13 years. Hence, the respondents of the study area are in a position of average age and education which helps to enhance the technology intake with good farming experience and able to use and understand different methods of technology transfer.

Table 2: Descriptive statistics of the respondents.

Parameter	N	Minimum	Maximum	Mean	Std. Deviation
Age of respondent	150	20.00	80.00	39.2333	11.67422
Age of household head	150	.00	80.00	39.8733	11.80166
Education level	150	.00	13.00	5.0800	2.95496
Total farm size	150	.07	4.00	1.1970	.65187
Maize land area	150	.00	3.00	.4894	.37576
Area under legume	150	.00	1.00	.2136	.17894
Area under maize legume intercropping	150	.00	1.00	.2068	.21484
Area under rotation	150	.00	1.00	.1245	.16385

Source: own data, survey 2014.

As it is depicted in the above table two, the average total land holding of the study area was 1.2 hectare. From the total land holding of the area on the average .48 hectare, 0.21 hectare 0.21 hectare, and 0.012 hectare was a allocated for sole maize, sole legume, maize legume intercropping and for rotation production in 2013 production year. This shows that more land was allotted for sole maize production and the least for the rotation of maize and legume crops.

4.2 SIMLESA Technologies Awareness, Adoption and Dis-adoption

Technology Awareness

According to this study, 145 farmers which account 96.7% were aware of activities conducted by SIMLESA project in their village. Based on their reply, 13 farmers were participating as a host farmer for testing and demonstration of the technologies. Also 55.3% of the respondents were member of the innovation platform for the expansion of targeted technologies. The study also revealed that 88.7%, 81.3% and 54% of the respondents were visited demonstrations, attended in field days and participated in exchange visits respectively. This shows that the respondents incorporated in this study had a close contact and knowledge of the project in each intervention areas.

4.3 Technologies awareness and adoption

SIMLESA project induced and working for the expansion of compatible technologies for wider coverage and intensity in the three distinct woredas located in southern region of Ethiopia. The technologies are namely maize bean intercropping, maize bean rotation, minimum/ zero tillage, BH-543 (Maize) and Hawassa Dume (bean) with their full packages.

Maize Bean Intercropping

From the interviewed households 141 (94%) of the respondents were aware of maize bean inter cropping. The source of information for technology awareness were accounts 70%, 14.7%, and 10% from SIMLESA demonstration/ host farmer, innovation platform and other fellow farmers respectively. From these households 22.7%, 20%, 10%, and 37.3% have been tried the technology for the first time in 2010, 2011, 2012 and 2013 year in that order. Out of these, 134 (89.3%) were still using the maize bean intercropping technology in their crop production system. However, farmers who were aware and stopped using was due to maize production decreases taken as a main reason, which accounts 1 (.7%). Moreover, the farmers who were aware and never used the technology was due to lack of cash and lack of seed as a main reason, which accounts 2.7% and 0.7 % respectively. This indicates that majority of the farmers who are aware of maize bean intercropping were adopted the technology and in 2013 the number of farmers practicing the technology were increased apart from the previous years.

Table 3: Area under Maize Bean Intercropping.

Woreda	Mean	Std. Deviation	Minimum	Maximum
East Badwacho	.2896	.22892	.01	.75
Hawassa zuria	.3248	.34180	.01	1.50
Meskan	.1781	.15819	.02	.50
Total	.2656	.26365	.01	1.50

Source: own data, survey 2014.

Based on table 4 above, the average area allocated for maize bean intercropping was 0.29 hectare, 0.34 hectare and 0.17 hectare in East badwacho, Hawassa zuria and Meskan Woreda respectively. From this it is clear that East Badwacho and Hawassa Zuria Woreda's allocated land ahead of the average. However, Meskan Woreda land allocated for the technology was beneath the total average of the three project intervention areas. The ANOVA result in table 5 shows that there is a significant difference in area allocation of land for maize bean intercropping at 5% significance level.

Table 4: ANOVA

			Sum of Squares	df	Mean Square	F	Sig.
Area under maize bean intercropping * woreda	Between Groups	(Combined)	.530	2	.265	3.980	.021
	Within Groups		8.716	131	.067		
	Total		9.245	133			

Source: own data, survey 2014.

As table 6 depicted below, the minimum and maximum yield increment due to the technology intervention was 0% and 300% respectively. However, the average yield change by using maize bean intercropping was 52.31% which asserts that the technology has a positive impact in yield increment, food security and income generation as well.

Table 5: Percent of yield change due to the technology

N	Valid	134
	Missing	16
Mean		52.3134
Std. Deviation		33.14729
Range		300.00
Minimum		0.00
Maximum		300.00
Sum		7010.00

Source: own data, survey 2014.

Maize Bean Rotation

Based on the interviewed households of this study, 63.3% of the respondents were aware of maize bean inter cropping. The source of information for technology awareness were accounts 44%, 12%, and 6% from SIMLESA demonstration/ host farmer, innovation platform and other fellow farmers respectively. From these households 24%, 16%, 4%, and 11.3% have been tried the technology for the first time in 2010, 2011, 2012 and 2013 year respectively. Out of these, 55.3% were still using the technology in their crop production scheme. However, that who were aware and stopped using was as due to maize production decreases as a main reason, which accounts 1 (.7%). Moreover, those farmers aware and never used the technology was due to lack of cash and lack of seed as a main reason, which accounts 4.7% and 3.3% respectively. This shows that most of the farmers who were aware of maize bean rotation were adopted the technology and in 2013 the number of farmers practicing the technology were decreased as compared to the previous years.

Table 6: Area under Maize Bean Rotation

woreda	Mean	N	Std. Deviation
East Badwacho	.2230	28	.11335
Hawassa zuria	.2588	29	.24297
Meskan	.1785	26	.09061
Total	.2216	83	.16725

Source: own data, survey 2014.

Based on table 7 above, the average area allocated for maize bean rotation was 0.29 hectare, 0.34hectare and 0.17 hectare in East badwacho, Hawassa zuria and Meskan Woredas respectively. Hence, East Badwacho and Hawassa Zuria Woreda's allocated land above the average land area. Also in Meskan Woreda the land allocated for the technology was below the total average of the three project intervention areas. Based on the ANOVA result in table 8, there is no significant difference in area allocation of land for maize bean rotation.

Table 7: ANOVA

			Sum of Squares	df	Mean Square	F	Sig.
Area under Maize Bean Rotation * woreda	Between Groups	(Combined)	.089	2	.044	1.6	.21
	Within Groups		2.205	80	.028		
	Total		2.294	82			

Source: own data, survey 2014.

As it is shown in table 9 below, the minimum and maximum yield increment due to the technology utilization was 10% and 200% respectively. It is also noted that the average yield increment using the technology was 58.08% and this means that the technology has encouraging reward for the technology users.

Table 8: Percent change due to maize bean rotation

N	Valid	83
	Missing	67
Mean		58.0843
Std. Deviation		27.53012
Range		190.00
Minimum		10.00
Maximum		200.00

Source: own data, survey 2014.

Minimum/ zero tillage

This study revealed that 130 (86.7%) of the respondents were aware about the minimum tillage. The source of information about the technology accounts 44.7%, 12%, and 6% from SIMLESA demonstration/ host farmers, innovation platforms and other fellow farmer respectively. The respondents accounts 24%, 16%, 4%, and 11% for the technology utilization for the first time in 2010, 2011, 2012 and 2013 year respectively. About 55.3% farmers were still using the technology in their crop production practice. However, those who were aware and stopped using was as due to maize production decreases as a main reason accounts 0.7%. Moreover, those farmers aware and never used the technology was due to lack of cash and lack of seed as a main reason accounts 4.7% and 3.3% respectively.

Table 9: Area under minimum/zero tillage

woreda	Mean	N	Std. Deviation	Minimum	Maximum	Sum
East Badwacho	.2230	28	.11335	.02	.50	6.25
Hawassa zuria	.2588	29	.24297	.01	1.00	7.51
Meskan	.1785	26	.09061	.02	.50	4.64
Total	.2216	83	.16725	.01	1.00	18.39

Source: own data, survey 2014.

Based on table 10 above, the average area allocated for minimum tillage was 0.22 hectare, 0.25hectare and 0.18 hectare in East badwacho, Hawassa zuria and Meskan Woreda respectively. The ANOVA result in table 11 shows that there is no significant difference in area allocation of land for minimum tillage.

Table 10: ANOVA

			Sum of Squares	df	Mean Square	F	Sig.
Area under Minimum Tillage * woreda	Between Groups	(Combined)	.089	2	.044	1.61	.207
	Within Groups		2.205	80	.028		
	Total		2.294	82			

Source: own data, survey 2014.

From table 12 depicted below, the minimum and maximum yield increment due to the technology intervention was 10% and 200% respectively. The average yield change due to maize bean intercropping was 58.08% which is a good indicator for the sustained utilization of the technology.

Table 11: Percent of yield change due to minimum/ zero tillage

N	Valid	83
	Missing	67
Mean		58.0843
Std. Deviation		27.53012
Minimum		10.00
Maximum		200.00
Sum		4821.00

Source: own data, survey 2014.

Mize (Bh-543)

Among the interviewed households of the study, 136 (90.7%) of the respondents were aware of BH_543. Their source of information for technology accounts 62.7%, 15.3%, and 10% from SIMLESA demonstration/ host farmer, innovation platform and other fellow farmer respectively. 23.3%, 20%, 7.3%, and 36% of the respondents have been tried the technology for the first time in 2010, 2011, 2012 and 2013 year respectively. 85.3% of the respondents were still using the technology in maize production. Furthermore, the farmers aware and never used the technology due to lack of cash and seed as a main reason accounts 3.3% and 0.7% respectively.

Table 12: Area under BH-543

woreda	Mean	Std. Deviation	Minimum	Maximum	Sum
East Badwacho	.1892	.18008	.01	.75	8.70
Hawassa zuria	.2183	.23570	.01	1.00	8.95
Meskan	.1066	.10462	.02	.50	4.37
Total	.1721	.18605	.01	1.00	22.02

Source: own data, survey 2014.

According to table 13 above, the average the land allocated for BH-543 production was 0.19 hectare, 0.21hectare and 0.10 hectare in East badwacho, Hawassa zuria and Meskan Woreda respectively. Meskan Woreda land allocated for the technology was lower as compared to the total the two project intervention areas. The ANOVA result of the study in table 14 shows that there is a significant difference in area allocation of land for the technology at 5% significance level.

Table 13: ANOVA

			Sum of Squares	df	Mean Square	F	Sig.
area under BH-543 * woreda	Between Groups	(Combined)	.277	2	.138	4.20	.017
	Within Groups		4.119	125	.033		
	Total		4.396	127			

Source: own data, survey 2014.

The analysis result depicted below in table 15 shows that the minimum and maximum yield increment due to the technology intervention was 0% and 300% respectively. In the mean time, the average yield change by using BH-543 was 54.36% reveals that the technology has a good economic importance for the continuous production in the project intervention areas.

Table 14: Percent yield change due to BH-543

N	Valid	128
	Missing	22
Mean		54.3672
Std. Deviation		35.76429
Minimum		.00
Maximum		300.00

Source: own data, survey 2014.

Legume (Hawassa dume)

94.7% of the respondent households were aware of Hawassa dume. Awareness created about the technology was accounts 59.3%, 22%, and 12.7 % from SIMLESA demonstration/ host farmer, innovation platform and other fellow farmer respectively. Also 22.7%, 19.3%, 8%, and 46% have been used the technology for the first time in 2010, 2011, 2012 and 2013 year respectively. It is also known that 94% of the interviewed households were still using the Hawassa dume technology in their production of legumes. This is an implication of that most of the farmers who were aware of Hawassa dume were adopted the technology.

Table 15: Area under Hawassa dume

woreda	Mean	N	Std. Deviation	Sum	Minimum	Maximum
East Badwacho	.1757	46	.16008	8.08	.01	.75
Hawassa zuria	.1609	46	.23895	7.40	.01	1.50
Meskan	.0939	50	.09754	4.70	.01	.50
Total	.1421	142	.17611	20.18	.01	1.50

Source: own data, survey 2014.

According to table 16 above, the average area allotted for Hawassa dume production was 0.17 hectare, 0.16 hectare and 0.09 hectare in East badwacho, Hawassa zuria and Meskan Woreda respectively. The land coverage in Meskan Woreda by the technology was minimal as it is compared with the total average of the two project intervention areas. Based on the ANOVA result in table 17 below, there is a significant difference in area allotment of land for Hawassa dume at 10% significance level.

Table 16: ANOVA

			Sum of Squares	df	Mean Square	F	Sig.
Area under Hawassa dume * woreda	Between Groups	(Combined)	.184	2	.092	3.06	.050
	Within Groups		4.189	139	.030		
	Total		4.373	141			

Source: own data, survey 2014.

Based on table 18 below, the respondents minimum and maximum yield increment due to the technology utilization was 0% and 300% respectively. In addition, the average yield change by using the technology intervention was 55.49%. This shows that the technology had a good return for the respective users in the study area.

Table 17: Percent yield change due to Hawassa dume

N	Valid	142
	Missing	8
Mean		55.49
Std. Error of Mean		3.44
Std. Deviation		41.01
Range		300.00
Minimum		.00
Maximum		300.00
Sum		7880.00

Source: own data, survey 2014.

4.4 Like-disliked of SIMLESA Technologies

Most liked technology

According to table 19 below, among the five SIMLESA technologies, Maize bean intercropping, Minimum tillage, Hawassa dume, BH-543 and Maize bean rotation ranked from first to least respectively. 62% of the respondents is due to yield increment, 10.7%due to it lowers labour number, 5.3% of them is due to it decreases production cost and it maintains soil fertility given as the first reason. Whilst 39.3% is due to it maintains soil fertility, 16.7 due to yield increment and 5.3% due to it makes possible for double cropping. 5.3% is due to yield increment and 4% due to it maintain soil fertility depicted as a third reason.

Table 18: Most liked SIMLESA Technologies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Maize Bean Intercropping	88	58.7	59.5	59.5
	Maize Bean Rotation	1	.7	.7	60.1
	Minimum tillage	26	17.3	17.6	77.7
	BH-543	15	10.0	10.1	87.8
	Hawassa dume	18	12.0	12.2	100.0
	Total	148	98.7	100.0	
Missing	99.00	2	1.3		
Total		150	100.0		

Source: own data, survey 2014.

4.5 Most Disliked SIMLESA Technology

As it is shown in table 20 above, amongst the five SIMLESA technologies maize bean intercropping, minimum tillage and BH-543 were selected by the respondents as the most dislike technologies respectively as their order of rank respectively. However, when we see the frequency count of these respondents, the data is not as such relevant and it has no significant implication to dislike the mentioned technologies.

Table 19: Most Dislike SIMLESA Technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Maize Bean Inter cropping	2	1.3	40.0	40.0
	Minimum Tillage	2	1.3	40.0	80.0
	BH-543	1	.7	20.0	100.0
	Total	5	3.3	100.0	
Missing	99.00	145	96.7		
Total		150	100.0		

Source: own data, survey 2014.

4.6 Host Farmer's Demonstration Plot Expansion and Knowledge sharing

According to this survey all of the host farmers expand their plot for the induced five technologies beyond SIMLESSA demonstration plot. This survey also identified that all the host farmers shared their knowledge on the technology to the respective followers.

5. Conclusion and Recommendations

The expansion of cultivated areas to compensate for low yields, exploitation of soils without restoration of soil fertility, changing climatic patterns and the lack of well-adapted technologies have been identified as some of the major problems of soil fertility management in SSA. The conservation, recapitalization and maintenance of soil fertility are therefore essential to improve efficiency of input use and increase productivity (FAO, 2001). According to Pound and Ejigu Jonfa (2005) [6], causes of soil fertility decline are clearing of forests, removal of crop residues from the fields, land fragmentation, overgrazing, low fertilizer inputs, cultivation of slopes not suited to agriculture without adequate soil conservation, cropping of marginal lands, poor soil management, increased pressure on land due to increased population and reduced in livestock numbers (and therefore manure). Continued cultivation of crops with low levels of nutrient inputs being the major cause for the declining in soil fertility (Zingore, 2011) [15], the washing away of the fertile top soil by water erosion is also decreasing the productivity of arable lands in the highlands. Based on this study, the technologies that have been induced in the project intervention areas intended to conserve the environment and enhance productivity sustainable was successful. It is therefore the study concluded that intensification of crop production systems using SIMLESA technologies is an important lesson in order to increase crop productivity by maintaining the moisture management system and thereby improving soil fertility status in the study area. In light of this, the following recommendations have been forwarded:-

- Seed supply system should be enhanced for Hawassa dume and BH-543 varieties.
- Extension system of SIMLESA technologies should be revised to have a wider coverage.
- Input supply should be facilitated and organized for the effective herbicide application of minimum tillage practice.
- We should have to deliver diversified SIMLESA technologies other than the five availed technologies in order to have options.
- There should be strong coordination and collaboration work between stakeholders.

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