Hindawi
Advances in Agriculture
Volume 2021, Article ID 6674606, 14 pages
https://doi.org/10.1155/2021/6674606

Research Article

Constraints of Adoption of Agricultural Extension Package Technologies on Sorghum Crop Production at Smallholder Farm Household Level: Evidence from West Hararghe Zone, Oromia, Ethiopia

Muhammed Shako [1], Adunea Dinku [1], and Waktola Mosisa [2]

[1]*Department of Agricultural Economics, College of Agriculture, Oda Bultum University, Chiro, Ethiopia*
[2]*Department of Plant Science, College of Agriculture, Oda Bultum University, Chiro, Ethiopia*

Correspondence should be addressed to Muhammed Shako; falafidi2015@gmail.com

Received 19 December 2020; Accepted 22 July 2021; Published 30 July 2021

Academic Editor: Laszlo Vasa

An effective and efficient agricultural extension system can enhance the agricultural productivity and production of smallholders through the development of innovative, systematic, and farmer-owned agricultural extensions. This study identified major constraints of adoption of agricultural extension package technologies such as adoption of inorganic and organic fertilizers, improved seeds, row planting, and crop protection chemicals at smallholder household level on sorghum crop production. The study used cross-sectional survey data collected from 201 sample respondent household farmers. To analyze data, descriptive statistics, ranking indexes, graphs, and tables were used. The study identified the major constraints of agricultural extension package technologies. High price, problem of on-time provision, shortage and uneven distribution of rainfall, and problem of accessibility were the major constraints that hinder the use of inorganic fertilizer. Using sources of organic fertilizer for other purposes, insufficient availability, undeveloped infrastructure, and facilities and requirement of more labor were the major constraints to the use of organic fertilizer.

1. Introduction

Agriculture is the most important sector for sustaining growth and reducing poverty in Ethiopia. It is one of the largest components of the Ethiopian economy, contributing 34% to the country's gross domestic product (GDP) and 71% to employment [1]. Crop production contributes up to 72% to the total agricultural GDP and over 75% to total export earnings [1].

The majority of the population in Africa relies on agriculture that is subsistence in its nature and is mainly undertaken by smallholder farmers [2]. Food security is an important agenda in most African countries. As the production of agricultural crops could not satisfy food demand in Africa, importing huge tons of food is very common in most African countries. To these facts, Nigeria relies on food imports to meet its domestic demand, with the import bill for wheat, rice, sugar, and fish estimated at USD 6.4 billion per annum [3]. To divert the problem, different countries used different systems. Among them, Ethiopia started using an agricultural extension system in the early 1950s, even though the implementation is challenged by different obstacles.

An effective and efficient agricultural extension system can enhance the agricultural productivity and production of smallholders through the development of innovative, systematic, and farmer-owned agricultural extension [4]. Considerable efforts have been made by the state to improve agricultural development and reduce poverty through the agricultural extension service [5]. The professional capacity of extension has also dramatically increased; over 60,000 development agents (DAs) have graduated from the agricultural technical and vocational education and training (ATVET) colleges in the past six years with three-year diplomas prior to 2000; the existing 15,000 DAs had received about nine months of training [6].

Even if the agricultural extension is intended to ensure food security, it has never led to a breakthrough in the agricultural sector in Ethiopia, especially in the interests of smallholder farmers [5]. Although efforts were undertaken to make the extension system effective and efficient, the system is not producing the desired results [4].

In the case of the West Hararghe zone, the adoption of full package of agricultural extension technologies (use of inorganic fertilizer, organic fertilizer, improved sorghum seed varieties, row planting, and crop protection chemicals) is very low for the sorghum crop due to different factors and constraints. According to [7] and the planning and program section report of the West Hararghe Zone of Agricultural Office [7], only 9% of the total cultivated land is covered by full extension package technologies in the 2016/2017 crop year for all cereal crops. This indicates that the adoption of full extension package technology is very low, even though the adoption level from technology to another technology deviates.

There are research finding so far undertaken on identifying of factors affects adoption decision of using different technologies. However, there are limited research findings that identify constraints raised by small household farmers on the production of agricultural crops, specifically sorghum crop production in which major agricultural technologies adoption is very low when compared with other major crops. Thus, the study was intended to identify constraints that hinder the adoption of agricultural extension package technologies at the smallholder household level on sorghum crop production in the West Hararghe zone of Oromia regional state.

2. Review Literature

2.1. Definitions of Terms. *Extension*: It is defined as "systems that should facilitate the access of farmers, their organizations and other market actors to knowledge, information, and technologies; facilitate their interaction with partners in research, education, agribusiness, and other relevant institutions; and assist them to develop their own technical, organizational and management skills and practices" [8].

Agricultural Extension: Agricultural extension is the entire set of organizations that support and facilitate people engaged in agricultural production to solve problems and obtain information, skills, and technologies to improve their livelihoods and well-being [6]. Moreover, it is defined as a service or system that assists farm people, through educational procedures, in improving farming methods and techniques, increasing production efficiency and income, bettering their levels of living, and lifting the social and educational standards of rural life [9].

Adoption: It is defined as the mental process that an individual passes from first hearing about an innovation to the final adoption [10]. Specifically, final adoption at the individual farmer's level is defined as the degree of use of new technology in long-run equilibrium when the farmer has full information about the new technology and its potential. It is also defined as the integration of innovation into farmers' normal farming activities over an extended period [11].

2.2. Overview of Agricultural Extension System in Ethiopia. The agricultural extension system in Ethiopia started in 1952 during the imperial regime with objectives of high-level manpower training, agricultural extension promotion, and dissemination of research output and scientific information using agricultural extension as a network [12]. To fulfill the above objective, the Alemeya College of Agriculture, the now Haramaya University, was established in the same year [13]. Under the military regime, two major extension programs were applied; the Minimum Package Project II (MPP II) and the Peasant Agricultural Development Extension Project (PADEP) [14]. However, PADEP came in as a result of the shortcomings of MPP II in 1985 resulting from the limited resource capacity of the country towards developing technology that fits into a highly diversified ecological and social setup. The current government, EPRDF, opts for agricultural development-led industrialization (ADLI) as a general strategy of food security and poverty reduction in the country. To realize the strategy, Participatory Demonstration and Training Extension System (PADETES) was adopted as a national extension system as of 1994/95 [12]. However, the approach followed by PADETES was first introduced in the country by an NGO called Sasakawa Global 2000 [14].

The objective of PADETES was to achieve pro-poor sustainable development in rural areas [13–15]. Almost in its two decades' life, the PADETES program has increased the number of public development agents (DAs) dramatically from 2,500 to 47,500 during the period of 1995 to 2008 through the provision of a three-year diploma program at agricultural technical and vocational education training colleges [16]. This rapid expansion has been accompanied by the establishment of farmers training centers (FTCs) to become the focal point of extension support, and each FTC is to be staffed by three DAs (one each in the areas of crops, livestock, and natural resource management) [17]. Each DA is expected to train 120 farmers per year in his or her field of specialization. However, the DAs recruitment and training has largely succeeded in meeting its numeric targets, while FTCs have lagged behind [17] due to lack of basic infrastructure and facilities, skill, funding for operational costs, appropriate approaches, and tools and linkage for accessing knowledge and information [18].

2.3. Challenges and Achievements of Agricultural Extension System in Ethiopia. There are several challenges that the agricultural extension program faced in many levels with different approaches such as the promotion of inappropriate technology, inappropriate criteria for making research and recruiting extension staff (i.e., not based on scientific publications and professions), poor research and extension linkages, and lack of "real" participation of framers [13], specifically in the production of sorghum crop in the study areas. To this evidence, the study conducted by [19] explained that Ethiopia, like any other rural households in developing countries, is faced with various constraints such as imperfect or missing input and credit markets, high transaction costs, and unemployment. Moreover, evidences suggest that the intensity of crop technology package adoption was ranked highest for potato (71%) and lowest for sorghum (29%) across the four regions [20]. Furthermore, staff turnover, blanket recommendation of packages developed and tested, lack of entrepreneurship training for extension workers, lack of finance to run FTCs, impositions from Woreda office of agriculture to work as general practitioners, limited access of transport and office facilities, and non-extension administrative workloads are the problems to forward the extension system in Ethiopia; thus, they hinder effective adoption of new agricultural extension technology packages [21].

The present agricultural extension system acknowledges the participation of stakeholders in the package implementation process, which plays a significant role even though the participation of the stakeholders, which can be explained as a critical challenge for the implementation of the agricultural extension program, is limited [22]. To these facts, evidences show that the number of extension agents grew from less than 15,000 around the year 2000 to more than 60,000 in 2019 [23]. In addition, recent studies have shown some sign of improvement in the adoption of major cereal crops and mineral fertilizer that is about 40–47% [24]. Furthermore, Ethiopia has seen a 50% and 30% improvement in uptake of seed and fertilizer technologies, respectively, over the past 15 years [25, 26]. Since 2002, more than 8,489 FTCs have been built at the kebele (the lowest administrative division) level [27].

3. Materials and Methods

3.1. Description of Study Areas. The study was conducted in the Gemechis and Mieso districts of the West Hararghe zone, Oromia region state, Ethiopia (Figure 1).

According to basic data of the West Hararghe zone of agriculture and natural resource office [28], the Mieso district is located at about 300 km from Addis Ababa to the east in West Hararghe administrative zone of Oromia regional state and 25 km to the west of Chiro town, capital of the zone, whereas the Gemechis district is at 343 km east of Addis Ababa and about 17 km south of Chiro. The district of Mieso covers an area of 186,716 ha and has 31 rural and 1 urban area. With a total of 31,456 household members, the district of Gemechis covers an area of 77,785 ha and has 35 rural and 1 urban area, with 38,700 household members in total [29]. According to the CSA [30], the population projection of the Mieso district has 144,750 total populations of which 82,796 and 61,954 are males and females, respectively, whereas the Gemechis district has 235,638 total populations of which 119,485 are males and 116,153 are females in 2019. The altitude of the Mieso district is within 900 to 2,500 m above sea level with an average annual rainfall of 790 mm, whereas the Gemechis district is found within the altitude of 1,300 to 2,400 m above sea level with an average annual rainfall of 850 mm. The two districts receive a bimodal rainfall where the short rain season is between March and April, while the main rain season is between July and September. Mixed agriculture is the economic foundation of the population of the two districts, which is the production of crops and livestock. The major crops grown in these districts are sorghum, maize, and haricot bean.

3.2. Data Types, Sources of Data, and Sampling. Both primary and secondary data were the basis of the study. It employed primary data that were collected from the sample household farmers. Focus group discussion and key informant interviews were undertaken with concerned stakeholders. The Gemechis and Mieso districts were purposively selected for the study because it is assumed that the two districts can represent the highland, midland, and lowland parts of the West Hararghe zone. Thus, as indicated in Table 1, the selected kebeles were selected based on three agroecological considerations .

Seven crop-producing kebeles (Figure 1) were selected from the two districts: three from Mieso and four from Gemechis. Finally, 201 sample household farmers were randomly selected from selected seven kebeles for the study (Table 1). The number of sample household farmers per kebele was decided based on the probability proportional to size.

3.3. Methods of Data Collection and Analysis. Based on interview scheduled, primary data was collected by employing a semistructured questionnaire modified after conducting an informal survey using trained enumerators. Focus group discussions and key informants' interviews were also made with concerned stakeholders.

To address the objectives of the study, descriptive statistics data analysis methods were employed using the stata12 data analysis software package tool. In the descriptive part, simple measures of central tendencies and variations, frequency, mean, *t*-test, rank index, and percentages were used to identify characteristics of sample respondent household farmers and assess constraints of agricultural extension package technologies.

Following [31], the rank index is specified as follows:

$$\text{rank index} = \frac{\left(R_n C_1 + R_{n-1} C2 + - - - + R_1 C_n\right)}{\sum \left(R_n C_1 + R_{n-1} C2 + - - - + R_1 C_n\right)}, \quad (1)$$

where R_n = value of the least rank of constraint a (if the least rank is 7th, then $R_n = 7$, $R_{n-1} = 6$, and $R_1 = 1$) and C_n = counted value of the least-ranked level (in the above example, C_n = the count of the 7th rank and C_1 = the count of the 1st rank).

4. Results and Discussion

This section is mainly concerned with the description and interpretation of the findings of the study based on the analysis of the cross-sectional data collected using a semi-structured questionnaire that was administered to 201 sample

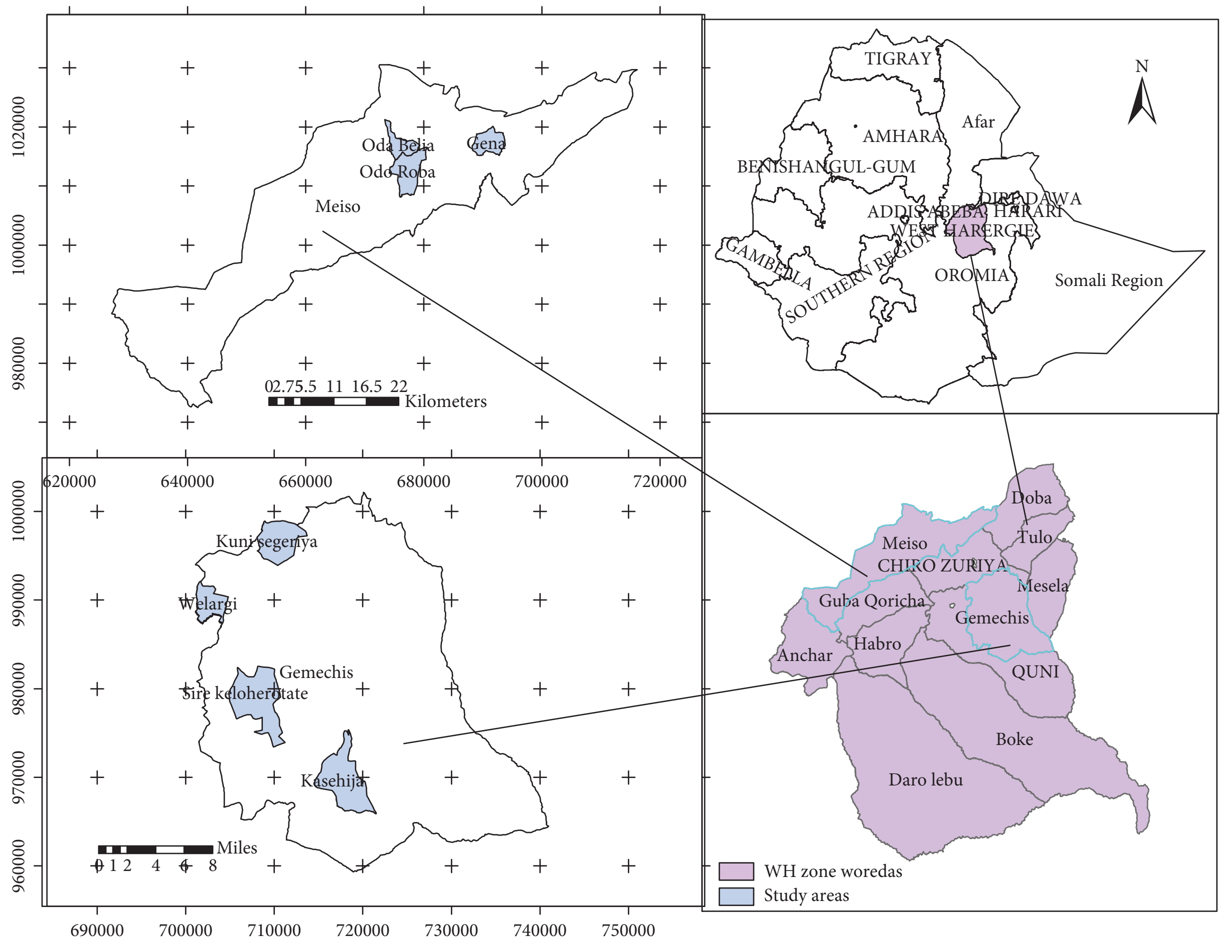

Figure 1: Location map of the study areas. Source: West Hararghe Zone Agriculture Natural Resource Office (2019).

Table 1: Sample kebeles, agroecologies, total households, and distribution of sample HHs.

District	Kebele	Agroecology	Total HH heads	Sample HH heads
Gemechis	Harotate	Midland	1,494	34
	Kuni Sagariya	Highland	1,319	30
	Kase Ija	Lowland	1,320	30
	Walargi	Midland	1,187	27
	Subtotal		5,320	121
Mieso	Gorbo/Gene	Lowland	1,175	27
	Oda Bal'a	Lowland	1,207	27
	Oda Roba	Lowland	1,165	26
	Subtotal		3,547	80
	Total		8,867	201

Source: District Agricultural Offices (2019). "Kebele" is the smallest administrative unit of local government; HH = household.

respondent household farmers. Under this section, characteristics of sample household farmers, agricultural extension package technologies used, and constraints of agricultural extension package technologies are presented and discussed.

4.1. Socioeconomic and Demographic Characteristics and Inputs Used by Sample HHs. For the sample household farmers, the average family size was around 7.09 individuals and ranged between 2 and 15 individuals. The average age of the sampled household heads was 41.81, with a maximum age of 75 and a minimum age of 22. The household's average education level was 2.05 years (Table 2).

Khat (Catha edulis) refers to a plant that contains a psychoactive substance, cathinone, which produces central nervous system stimulation analogous to amphetamine [32].

The average area of the cultivated, homestead, grazing land, and forest land owned by the sample household farmers of the two districts was 0.74, 0.072, 0.048, and 0.034 hectares, respectively (Table 2). The average land size of the

Table 2: Age, family structure, crops grown, and inputs used by HHs during the 2017/18 production year.

Variable description	Mean			Std.	t-statistic
	Gemechis	Mieso	Both		
Age	42.59	40.62	41.81	9.57	1.43
Family size	6.89	7.41	7.09	2.32	−1.55
Adult equivalent	5.20	5.59	5.36	1.60	−1.60
Man equivalent	2.87	2.59	2.77	1.07	1.88*
Education level (years of schooling)	1.80	2.43	2.05	2.86	−1.54
Cultivated land (ha)	0.47	1.16	0.74	0.49	−13.38***
Homestead area (ha)	0.029	0.136	0.072	0.096	−9.24***
Grazing land (ha)	0.044	0.054	0.048	0.187	−0.36
Forest land (ha)	0.052	0.006	0.034	0.127	2.55**
Total farmland (ha)	0.58	1.46	0.93	0.72	−10.60***
Home to plot average distance (min)	12.81	26.97	18.44	15.98	−6.81***
Number of plots	1.42	1.58	1.48	0.59	−1.95*
Farming experience (years)	25.25	20.27	23.27	10.48	3.38***
Livestock holding (TLU)	2.87	4.39	3.47	2.44	−4.53***
Total cultivated land (ha)	0.519	1.397	0.865	0.76	−10.78***
Maize (ha)	0.125	0.395	0.232	0.27	−7.79***
Sorghum (ha)	0.25	0.917	0.515	0.45	−14.93***
Other crops (ha)	0.016	0.003	0.012	0.043	2.15**
Vegetables (ha)	0.033	0	0.020	0.06	3.98***
Khat	0.066	0.006	0.0422	0.097	4.48***
NPS (kgs)	27.24	8.75	19.88	27.63	4.90***
Urea (kgs)	10.51	4.53	8.13	17.39	2.41***
Farmyard manure (Qn)	10.89	4.57	8.38	12.87	3.5***

***, **, and * represent significance at 1%, 5%, and 10% probability level, respectively. Source: survey result (2019). ha = hectare, TLU = tropical livestock unit, kgs = kilograms, min = minute, and Qn = quintal.

household is 0.924 hectares (Table 2). As indicated in Table 2, the average number of plots of the sample household farmers during the survey time was 1.48. Farm plots of the household farmers take 18.44 walking minutes (Table 2) from the residence of the household farmers. Farming experiences of sample household farmers range from 9 to 52 years (Table 2), with a mean value of 23.27 years. The result of the survey showed that the average livestock holding was 3.47 tropical livestock units (TLU) (Table 2). As indicated in Table 2, on average, 0.232, 0.515, and 0.042 hectares of land were allocated for maize, sorghum, and *khat* production, respectively, during the main season of the 2017/18 crop year by sample household farmers.

As shown in Table 2, the average amount of fertilizers such as NPS, urea, and farmyard manure used by the sample household farmers was 19.88 kgs, 17.39 kgs, and 8.38 quintals, respectively. As can be seen from the t-statistic, there is a significant difference between using these technologies between these two districts (Table 2). Due to numerous factors such as agroecology and rainfall distribution, the Gemechis district is better than Mieso districts in using these technologies.

Agricultural Extension Package Technologies (AEPTs) Used by Household Farmers. The result of the survey indicates that 43.28% and 23.38% of the sample HHs used inorganic fertilizers such as NPS and urea with other inorganic fertilizers, respectively (Table 3). Concerning organic fertilizer, farmyard manure and compost are the major inputs used by the farmer in the study areas. Most of the sampled household farmers used farmyard manure (62.19%), and 13.43% of the sampled household farmers used compost

Table 3: Farmers adopted inorganic and organic fertilizers and other inputs in the 2017/18 production year.

Inputs used	Gemechis		Mieso		Both	
	Freq.	%	Freq.	%	Freq.	%
No use of any fertilizer	46	38.02	66	82.50	112	55.72
NPS (all kinds)	73	60.33	14	17.50	87	43.28
NPS only	24	19.83	0	0.00	24	11.94
NPS boron	18	14.88	0	0.00	18	8.96
NPS boron and urea	13	10.74	0	0.00	13	6.47
NPS and urea	19	15.70	13	16.25	32	15.9
Urea (with other fertilizers)	34	27.27	14	17.50	47	23.38
Urea only	1	0.83	1	1.25	2	1.00
Farmyard manure (FYM)	95	78.51	30	37.50	125	62.19
Compost	24	19.83	3	3.75	27	13.43
Improved sorghum seed	8	6.60	3	3.75	11	5.47
Crop protection chemicals	16	13.22	9	11.25	25	12.44
Row planting	49	40.50	1	1.25	50	25

Source: survey result (2019). Freq. = frequency.

(Table 3). As shown in Table 3, of the total respondents, only 5.47% used improved sorghum varieties in the study areas. Farmers use crop protection chemicals for controlling weeds, pests, insects, and diseases. While some farmers have used crop protection chemicals to suppress weeds, most farmers prefer manual weeding. Of the total respondents, just 12.44% used chemicals for crop protection. Of the total household farmers interviewed, only 25% used row planting on the production of the sorghum crop (Table 3).

Sample household farmers used different types of inorganic fertilizers provided by the local government. Among the supplied inorganic fertilizers, NPS and urea are the common ones. Of the total sample household respondents, 55.72% did not use any type of inorganic fertilizer (Table 3). When we compare the two districts, 82.5% of sample household farmers of the Mieso district did not use any kind of fertilizer as this district has unsuitable agroecology for crop production and low annual rainfall amount and distribution (Table 3).

Of the total household respondents, 11.94%, 8.96%, and 1% used NPS only, NPS boron, and urea, respectively (Table 3). Of the total respondents, 6.47% used NPS boron and urea in combination, and 15.9% used NPS and urea in combination (Table 3).

4.2. Constraints to Use AEPTs on Sorghum Crop Production

4.2.1. Constraints to the Use of Inorganic Fertilizers. Respondent household farmers provided a lot of problems for not using inorganic fertilizers or using a small quantity of inorganic fertilizers for different reasons on sorghum crop production. Among the major constraints that hinder the utilization of inorganic fertilizers, which were raised by sample respondent household farmers, were the high cost of fertilizer, shortage and uneven distribution of rainfall, problem of providing inorganic fertilizer on time, problem of accessibility at the nearest place, and shortage of money to purchase inorganic fertilizer that ranks from one to five, respectively (Table 4).

Other constraints of using inorganic fertilizers were the problem of providing inorganic with credit, absence of insurance for crop production, unpredictable rainfall amount and distribution, problem of supplying sufficient amount, negative impact of inorganic fertilizer on the plot, bureaucratic process of providing inorganic fertilizer, quality and quantity problem, effect of inorganic fertilizer on human health, and less effect inorganic fertilizer on increasing productivity of agricultural crops ranks from 6 to 14, respectively (Table 4).

High Price of in Inorganic Fertilizer. As it is well known, the price of fertilizer is increasing from time to time. Thus, most of the farmers complain about the price of inorganic fertilizer supplied by the government. The high price of fertilizer is the main constraint among the constraints listed by the sample respondent household farmers. Due to many constraints, fertilizer usage in Ethiopia, as in most SSA countries, is very limited [33–35] suggested that fertilizers are more expensive in Africa as compared to other developing regions, such as Asia. To these facts, respondent farmers mentioned high price of inorganic fertilizer as major constraint to use inorganic fertilizer because of different reasons such as limited or absence of insurance for crop production if crop failure is occurred as a result of shortage of rainfall which is common and crop pests to compansate the cost of inorganic fertilizer. The price of fertilizer is expensive not only because of the high price of the commodity itself but also because of the high cost of transportation to arrive at the place of the farmer.

Shortage and Uneven Distribution of Rainfall. The shortage and uneven distribution of rainfall are the most prevailing problems in the study areas. The shortage of rainfall is also related to the price of inorganic fertilizer. Low use of fertilizer has been partially attributed to variable rainfall and absence of irrigation [36].

This is because when the crop is failed because of a shortage of rainfall, farmers are forced to lose another important asset of their own as they have to pay the money they have taken with credit from credit service institutions. According to [37], farmers in drought-prone areas of the country are still not willing to adopt fertilizer due to burning effects resulted from moisture deficit. As there is no insurance because of the failure of crop production and the shortage of rainfall, farmers fear to accept this risk to use inorganic fertilizer for their crop production. The problem is more prevalent in the lowland part of the zone than in highland and midland areas. Thus, more lowland farmers complain about the shortage of rainfall than farmers in the midland or highland part of the study areas. This is one of the reasons why farmers in the Mieso district that is found in lowland agroecologies use less amount of inorganic fertilizer than farmers in the Gemechis district.

Problem of Provision of Inorganic Fertilizers on Time. The other problem in using inorganic fertilizer raised by the respondent farmers was the provision of inorganic fertilizer on time. It is well known that rain-fed agriculture is season-sensitive by its nature. One-week late has a significant impact on the production of the crop in the study areas which are rain-fed agricultural areas. Thus, most of the farmers complain about the problem of on-time delivery of inorganic fertilizer in the study areas. To these facts, the study by [38] indicated that in most cases, farmers' physical unavailability or untimeliness of inputs or limited access to the right kind of fertilizer at the right time was probably an important constraint to technology adoption in much of African countries. Thus, the household respondent farmers mentioned that fertilizer is not provided by the concerned body at the nearest place on time.

Problem of Accessibility at the Nearest Place. Another constraint related to the absence or low rate of adoption of inorganic fertilizer that was raised by the respondent farmer was the problem of accessibility of inorganic fertilizer at the nearest place. According to the response of sample respondent household farmers, inorganic fertilizer is not supplied at the spot of development areas. Farmers need to go to the district or other centers to get inorganic fertilizer that needs another extra transportation and labor cost. To these facts, the study by [39] indicates that one of the significant constraints to the low or no use of inorganic fertilizer is the limited reach of distribution networks in contexts where the appropriate application can enhance yields. Furthermore, the study by [40] pointed out that distance to input supply institutions had a negative sign and a significant effect on the probability and intensity of adoption of inorganic fertilizer. This indicates that accessibility of the nearest place or distance of agricultural inputs has a negative impact on the utilization of inorganic fertilizer.

Table 4: Constraints of adoption of inorganic and organic fertilizers and their rank indexes.

No.	Description of the constraints to use inorganic fertilizers	Index	Rank
1	High price of inorganic fertilizer	0.111	1
2	Problem of on time provision of inorganic fertilizer	0.090	3
3	Negative impact of inorganic fertilizer on farm plot	0.057	10
4	Problem of accessibility at the nearest place	0.087	4
5	Shortage and uneven distribution of rainfall	0.109	2
6	Quality and quantity problem of inorganic fertilizer	0.049	12
7	Sufficient fertilizer is not supplied	0.064	9
8	Less effect in increasing productivity of agricultural crop	0.039	14
9	Effect on human health	0.048	13
10	Not provided with credit	0.077	6
11	Bureaucratic process of providing the inorganic fertilizer	0.055	11
12	No insurance if the crop failure is happened	0.067	7
13	Shortage of money to purchase inorganic fertilizer	0.082	5
14	Unpredictable rainfall amount and distribution	0.065	8
No.	Description of constraints to use organic fertilizers	Index	Rank
1	Less availability of organic fertilizer	0.144	2
2	Shortage of rainfall	0.098	5
3	Need more labor to collect and transport organic fertilizer	0.101	4
4	Less effect in increasing productivity	0.079	8
5	Some organic fertilizer is used for other purposes	0.156	1
6	Negative impact on next crop season	0.045	10
7	Need further process to be decomposed in the soil easily	0.086	6
8	Undeveloped infrastructure and facilities to transport organic fertilizer to the farm plot	0.132	3
9	Problem of awareness creation on the advantage of organic fertilizer	0.085	7
10	Problem of unimproved management system of organic fertilizer	0.074	9

Source: survey result (2019).

Shortage of Cash to Purchase Inorganic Fertilizer. The shortage of cash among farmers is another problem with the use of inorganic fertilizer. The majority of the farmers in developing countries has a shortage of liquid cash to purchase agricultural inputs such as inorganic fertilizer. Thus, respondent household farmers mentioned the shortage of cash as one of the constraints to the use of inorganic fertilizer. The study by [40] found that access to off-/non-farm income had influenced the intensity of the use of inorganic fertilizer by household farmers positively. The possible justification for this result is that off-/non-farm income earned might solve the financial constraints to hire labor and purchase farm inputs such as fertilizer. The study by [41] also found that annual income was found to determine significantly and positively DAP use intensity in potato production. This could be due to the fact that farmers with better income do not face financial constraints for purchasing inorganic fertilizer.

Inaccessibility of Credit to Use Inorganic Fertilizer. Inaccessibility of credit is one of the constraints that were raised by sample respondent household farmers to use inorganic fertilizer. Credit access is one of the bottlenecks in the adoption of new technologies in the rural areas of our country. Credit is given with high bureaucracy and high interest rate for rural household farmers in the study areas in particular and in the rural areas of Ethiopia in general. The majority of the farmers in the study areas are Islam in their religion. In Islam, it is forbidden to take credit with interest. Thus, even though some farmers have the willingness to take money with credit, they are hindered by the rule of their religion to take credit with the credit structure implemented by credit provision institutions at this time. With this evidence, certain research findings show that accessibility of credit positively affects adoption decision and intensity use of inorganic fertilizer. Access to credit had a significant positive influence on the adoption of chemical fertilizer [40, 42–44]. Moreover, the result of [45] indicates that lack of access to credit critically restricts access to agricultural inputs and technologies, such as improved seeds and fertilizers.

Absence of Insurance for Crop Production. Absence of insurance for crop production is one of the hindrances for the adoption of new agricultural technologies and improved inputs for crop production. Some previous studies support this evidence. To this juncture, the study by [46] reported that conventional insurance for the protection of crops and a livestock production loss due to weather is extremely rare and generally available only to large, export-oriented producers. Agriculture is a risky business especially in developing countries where the major share is rainfall-based. The common risks include yield losses due to bad weather, pests, and diseases; postharvest losses during storage and transport; and unexpectedly low market prices. To minimize these risks and make farmers confident, the availability of insurance is very crucial for farmers who often face the possibility of devastating losses in certain situations, such as when crops or livestock are damaged by drought, fire, or new outbreaks of pests or when lives and properties are lost due to severe weather events such as hurricanes and floods [47].

As the major part of agricultural production in Ethiopia is undertaken based on rainfall, crop failure is common. Crop production is a risky economic activity under such conditions. Thus, under the threat of a possible weather shock, poor people avoid taking risks. By taking expensive agricultural inputs such as inorganic fertilizer smallholder, farmers face challenges even on paying credit for agricultural inputs they take. The agricultural sector in Ethiopia is dominated by subsistence farming where more than 95% is rain-fed farming of which more than 90% is owned by smallholder (mostly less than half a hectare) poor farmers [48]. These smallholder farmers are highly vulnerable to the adverse effects of climate change, which are primarily reflected in rainfall shortages. In the absence of formal insurance, farmers often trade off a significant amount of potential income by adopting low-risk, low-return strategies [49]. Thus, absence insurance was raised as one of the constraints to adopt inorganic fertilizer in the study areas.

Other Constraints to the Use of Inorganic Fertilizer. Other constraints to the use of inorganic fertilizer in the study areas are unpredictable rainfall amount and distribution, insufficient amount of inorganic fertilizer, negative impact of inorganic fertilizer, bureaucratic process of providing inorganic fertilizer, quality problem, and less impact of inorganic fertilizer on increasing productivity of agricultural crops that were listed by the sample respondent household farmers.

In addition to the shortage of rainfall and the unpredictability of rainfall amount, time and distribution become uncertain because of changing climatic conditions in the world. A study undertaken in Niger [48] shows that the probability of using modern inputs and organic fertilizer is negatively correlated with variability in rainfall and temperature. Sometimes, inappropriate planning for the demand of inorganic fertilizer for upcoming cropping season makes to supply less than the amount of inorganic fertilizer demanded by farmers. Sometimes, rainfall amount and distribution are better; as a result, more amount of inorganic fertilizer is demanded by the farmers than supplied.

As it is well known, fertilizer is supplied by the government in Ethiopia. Because of the bureaucratic nature of state-owned supplier of inorganic fertilizer organization, supplying inorganic fertilizer needs more time to arrive at the plot of the farmer. Thus, the bureaucratic nature of providing inorganic fertilizer was raised as one of the constraints to decide to adopt and use more amount of inorganic fertilizer. Other problems are related to quality and quantity. A study of Ethiopian smallholders by [50] found that 32% reported underweight bags and 25% complained of poor quality. An other problem related to the use of inorganic fertilizer is the effect of inorganic fertilizer on human health. As it is well known, overuse of artificial chemical fertilizer directly or indirectly has a negative impact on human health. Thus, from this sense, few farmers perceived that the use of inorganic fertilizer may have a negative effect on their health. Low impact in increasing productivity of agricultural crops is another constraint in hindering the use of inorganic fertilizer. As a blended recommendation of inorganic fertilizer is common in our country, the use of inorganic fertilizer has a low effect on increasing crop productivity. Moreover, farmers in lowland areas face a shortage of rainfall to use inorganic fertilizer. In this case, inorganic fertilizer may not have an expected impact on productivity as it needs sufficient water to be dissolved in the soil so that it can be used by the plant.

4.2.2. Constraints to the Use of Organic Fertilizer. Using organic fertilizers such as farmyard manure, crop residues, compost, and decomposable home waste materials is very important to maintain or increase soil organic matter so that the productivity of agricultural crops can be increased. Soil organic matter has crucial importance for maintaining soil quality by improving biological, physical, and chemical soil conditions. In order to sustain agricultural productivity in the long term, soil organic matter needs to be maintained by the continuous addition of organic residues and amendments. However, utilization of these organic fertilizers by smallholder farmers is impeded by several constraints on sorghum crop production in the study areas. Sample respondent household farmers pointed out a lot of constraints that hinder the utilization of organic fertilizer in the study areas. The major constraints to the use of organic fertilizer in the study areas were discussed as follows.

Using Various Sources of Organic Fertilizer for Other Purposes. In the study areas, livestock farmyard manure and crop residues are the major sources of organic fertilizer. However, farmers in the study areas are using farmyard manure and crop residues for other purposes. Farmyard manure in the study areas is used for fuel for cooking foods. Crop residues in the study areas are used for livestock feed, fuel, and sale for urban dwellers.

The survey result reveals that respondent household farmers use farmyard manure for different purposes. Even though the majority of farmers (57.71%) used farmyard manure for soil fertility, 6.47% and 5.47% of the respondent farmer household used farmyard manure for fuel and sold it, respectively. There are other farmers who do not use farmyard manure for any purpose because of a lack of awareness about the benefits of farmyard manure and different socioeconomic factors. From the respondent household farmers, 17.91% of the farmers did not use farmyard manure for any purposes (Figure 2). As can be seen in Figure 2, farmyard manure, which is assumed to be the main source of organic fertilizer, is used for fuel, sold, and not used for any purpose by the farmers.

Respondent household farmers were interviewed to know for what purposes they use crop residues such as stalk of sorghum and maize, straw of wheat and barley, and leaves of *khat*. The majority of the respondent household farmers responded that they use crop residues for livestock feed and fuel. Of the total respondents, 35.82%, 38.81%, and 11.94% use crop residue for livestock feed, livestock feed and fuel in combination, and soil fertility in combination with other purposes, respectively (Figure 3). This shows that because of the shortage of livestock feed and fuel, the byproducts of crop production are now mainly used for livestock feed and fuel.

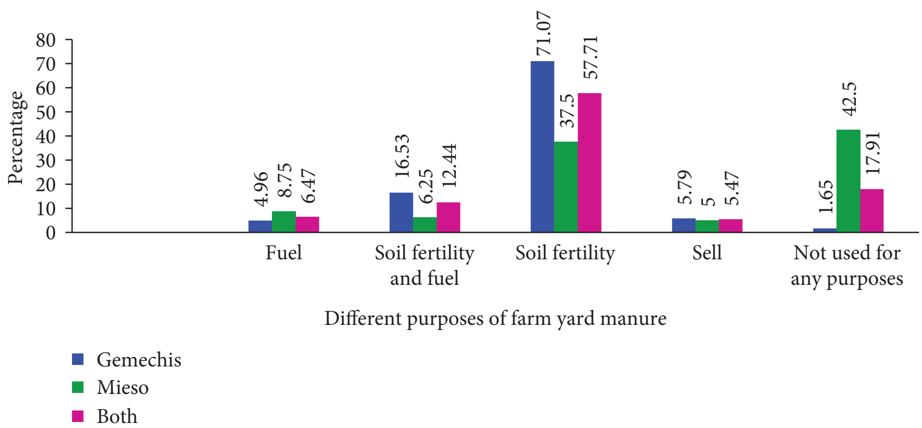

Figure 2: Purposes of farmyard manure. Source: survey result (2019).

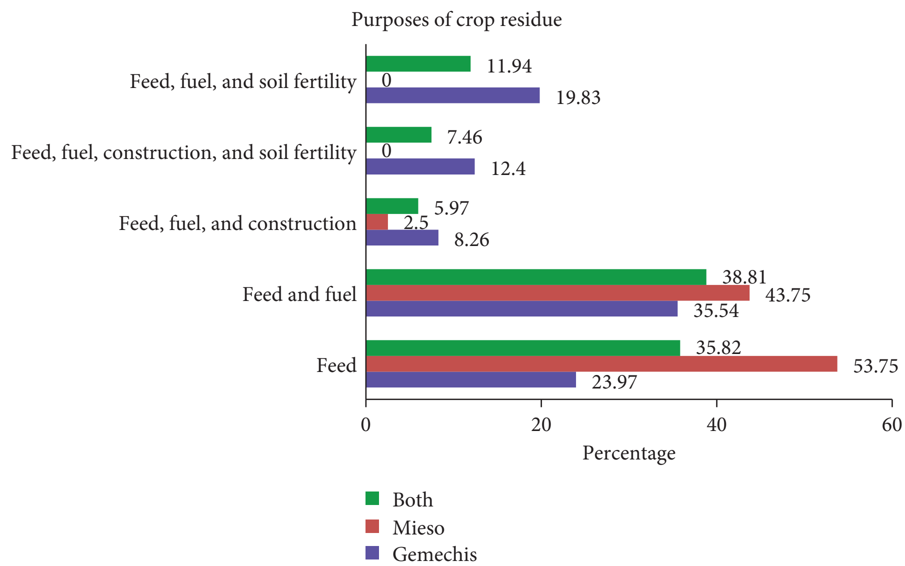

Figure 3: Purposes of crop residues. Source: survey result (2019).

Less Availability of Sources of Organic Fertilizer. Less availability of sources of organic fertilizer is another main problem that hinders the use of organic fertilizer in the study areas. The main sources of organic fertilizer are farmyard manure and crop residue. There is a shortage of farmyard manure because livestock holding in West Hararghe is fewer in number when compared to other parts of the region. The survey result shows that on average, a household owns 3.47 TLU of livestock (Table 2). This figure is even higher because household farmers in the lowland part own more livestock even though they do not use farmyard manure as organic fertilizer. Household farmers in the midland and highland parts owned small numbers of livestock though they are interested to use farmyard manure as organic fertilizers. Using different sources of organic fertilizer such as farmyard manure and crop residues for different purposes in the study areas makes the availability of sources of organic fertilizer scarce. As can be seen from Figure 3, respondent household farmers use crop residue for different purposes such as livestock feed, fuel, and construction that made it scarce to use for soil fertility.

Undeveloped Infrastructure and Facilities to Transport Organic Fertilizer. Underdeveloped infrastructure and less availability of equipment for transporting organic fertilizer to the farm plot in the study areas are other bottlenecks to use organic fertilizer for household farmers in their farm plots. Few farmers rarely have hand-and-animal back-pulling cart to transport organic fertilizer to their farm plot. A huge amount of organic fertilizer is needed to replace a small amount of artificial inorganic fertilizer. Transporting huge amounts of organic fertilizer to farm plot needs transporting facilities. Thus, this is one of the hindrances to using organic fertilizer on their farm plots. Infrastructure such as roads in the rural part of our country is underdeveloped to transport agricultural inputs such as organic fertilizer.

Other Constraints to the Use of Organic Fertilizer. Transporting and collecting organic fertilizer need more labor that hampers the utilization of these inputs. Collecting and transporting not only need transportation facilities but also need more labor force. Thus, requiring more labor for utilization of organic fertilizer is one of the constraints that are raised by sample respondent household farmers. A sufficient rainfall amount is needed to use both organic and inorganic fertilizers. If there is a shortage of rainfall using organic fertilizer affects the growth of plants since it cannot be soluble and decomposed in the soil easily. Thus, farmers use less amount of organic fertilizer in where rain is deficit than those in where sufficient rain is available.

The other constraints of using organic fertilizer such as farmyard manure, *khat* leaves, and homemade waste materials need more time and process to be decomposed in the soil to be used for plant growth. Sources of these organic fertilizers are not easily decomposed in the soil so that they should be collected at a place and compressed one on another. These collected sources of organic fertilizer should stay for plenty of weeks. Lack of awareness especially in the lowland parts of the study areas is one of the other bottlenecks to use more organic fertilizer. Another problem to use an organic fertilizer is that more amount of organic fertilizer is needed to substitute a small amount of artificial fertilizer. It has less impact on increasing agricultural crop productivity if huge tons of organic fertilizer is not used. Thus, the use of organic fertilizer is constrained by its less effectiveness in increasing productivity. The other problem of using organic fertilizer is the unimproved management system of organic fertilizer by a rural community in the study areas. Waste materials in the study areas that can be converted to useful organic fertilizers are thrown away by the community. Other farmers mix important sources of organic fertilizer with indecomposable waste materials.

4.2.3. Constraints to the Use of Improved Seed Varieties. Several constraints were raised by sample respondent household farmers to use improved sorghum seed varieties. Among this, the shortage of supply of improved varieties, high price of available improve seed varieties, inaccessibility of credit to use improved seed varieties, inappropriateness of new improved seed varieties with local agroecologies, low preferences farmers for new improved seed varieties, shortage of rainfall, and limited insurance were the major constraints raised by sample respondent household farmers to use improved sorghum seed varieties in the study areas (Table 5).

The shortage of supply of improved sorghum varieties is among the main problem of using improved seed varieties in the study areas. For instance, only few sorghum seed varieties were released yet to use by farmers who produce the sorghum crop. Thus, a limited supply of improved sorghum seed varieties is the number one and ranks first among constraints to the use of improved sorghum seed varieties in the study areas. Another problem of using improved seed varieties is the high price of improved sorghum seed varieties released by concerned institutions. The high price of improved seed curtails adopting new improved technologies such as improved sorghum seed varieties. Another problem related to the adoption of improved seed varieties is the absence of credit service to use improved seeds. Limited or lack of credit service is the common constraint to the use of improved technologies in general and improved sorghum seed varieties in particular.

Another constraint related to the use of improved sorghum seed varieties is some released varieties that do not fit with agroecologies and attributes farmers need. Some of the varieties released grow smaller biomass such as fewer leaves and shorter stock size. Farmers in the study areas do not only use sorghum crop production for human feed, but they also grow for livestock feed and fuel. Thus, farmers prefer to produce local varieties they know that have better biomass for their livestock and other purposes. The shortage of rainfall is another constraint to the use of improved sorghum seed varieties. Because of the shortage of rainfall, crop failure was common especially in the lowland parts of the study areas. Thus, taking improved seeds with high costs is risky; as a result, farmers prefer to use local varieties that are cheaper in price. Moreover, the limited and absence of insurance is also another constraint to the use of improved sorghum seed varieties. As it is well known, the limited and absence of insurance service for agricultural crop production in our country is a known problem. Lack of awareness creation, less productivity of some released sorghum seed varieties, and lack of preferences of some released sorghum seed varieties by farmers to produce on their very expensive small size of cultivation land were some of the constraints that were mentioned by sample respondent household farmers, which deter adoption of improved sorghum seed varieties.

4.2.4. Constraints to the Use of Row Planting. Requirement for high labor, creating the shortage of livestock feed, limited technology to use row planting, and shortage of livestock feed are the major constraints to the use of row planting technology (Table 5). As it is known, row planting technology is labor-intensive technology as it requires a high labor force to plant crops manually. Thus, of the total respondent sample household farmers, only 25% have used row planting technology. The creation of shortage of livestock feeds is the other constraint to the adoption of row planting. As it is well known, the shortage of livestock feed is a common problem in the study areas. Row planting requires distances between the rows and plants that they may use for growing extra crops that will be used while the crop is on growing or after they harvest the main crop. Farmers in West Hararghe plant more crops with broadcasting. They use these extra plants by thinning them for livestock feed. Thus, they prefer broadcasting to use row planting.

The other constraint to the use of row planting is limited technology. There is limited technology to undertake row planting in the study areas. Since row planting is labor intensive activity, farmers prefer to use the broadcasting method of planting than row planting. Another problem to use row planting is the shortage of cultivated land. The shortage of cultivated land is the known problem to undertake different land consuming technology. Thus, in the West Hararghe zone, farmers perceive that more land is consumed by row planting. Thus, the shortage of land was raised as one of the major constraints to the use of row planting. Other problems related to the adoption of row

Table 5: Constraints of adoption of organic fertilizer and their rank indexes.

No.	Description of the constraints to the use of improved sorghum varieties	Index	Rank
1	Shortage of supply of improved seed varieties	0.145	1
2	Productivity is not attractive	0.082	9
3	Shortage of rainfall	0.114	5
4	High price improved seed varieties	0.121	2
5	Less awareness creation	0.105	7
6	Does not fit with local agroecologies	0.116	4
7	Some varieties not preferred by the farmers	0.091	8
8	Not provided with credit	0.120	3
9	No or limited insurance	0.107	6
No.	Description of the constraints to use row planting	Index	Rank
1	Need huge labor	0.137	1
2	Less awareness creation	0.113	6
3	Creates shortage of animal feed	0.136	2
4	No clear instruction for distance between the rows and plants	0.129	5
5	Limited technology to use row planting	0.135	3
6	No credit to under cost of huge labor needed	0.087	7
7	Limited insurance	0.050	9
8	Shortage of cultivated land	0.130	4
9	Less effect on productivity	0.084	8
No.	Description of the constraints to use crop protection chemicals	Index	Rank
1	Not easily accessible	0.099	2
2	It has a negative effect on humans, livestock, and important insects health	0.087	4
3	Recommendation rate is not clear	0.075	7
4	High price crop protection chemicals	0.107	1
5	Few supplies are available	0.089	3
6	Not supplied on time	0.079	6
7	Illegal traders supplies crop protection chemicals	0.070	8
8	It bring crop failure when used incorrectly	0.061	11
9	Expired crop protection chemicals supplied	0.058	12
10	Some crop protection chemicals not effective	0.069	9
11	Increase cost of production	0.057	13
12	Less availability of instruments to apply crop protection chemicals	0.086	5
13	Not supplied with credit	0.063	10

Source: survey result (2019).

planting are the absence of clear instruction about how to use row planting, lack of awareness creation, absence of credit for implementing row planting, and less impact on increasing crop productivity (Table 5).

4.2.5. Constraints to the Use of Crop Protection Chemicals. The high price of crop protection chemicals is the number one constraint to the use of crop protection chemicals. The cost of crop protection chemicals is increasing from time to time. Few crop protection chemicals were supplied by concerned government sectors. Other crop protection chemicals are supplied by private legal and illegal traders. As there is no competition between the few traders, they can increase the price of crop protection chemicals, and they behave like market oligopolies.

Another raised constraint to the use of crop protection chemicals is the accessibility of crop protection chemicals. Common herbicides for weed controlling were supplied by concerned government sectors. Other crop protection chemicals for pests, diseases, and insecticides were not easily available for farmers in the study areas. Thus, the inaccessibility of crop protection chemicals was raised as one of the major constraints to the use of crop protection chemicals. In addition to the inaccessibility problem, only few suppliers of crop protection chemicals are available in the study areas. These few suppliers may not supply important crop protection chemicals on time, with enough quantity and reasonable and affordable price.

Using crop protection chemicals is not recommended unless it is not possible or difficult to control weeds, insects, pests, and crop diseases with manual or biological methods since it has its own side effect. Thus, farmers in the study areas raised effect of crop protection chemicals on human beings, livestock, and important insects such as a bee as one of the major constraints to the use of crop protection chemicals. Another problem related to the use of crop protection chemicals is the problem of accessibility of instruments to use crop protection chemicals. The knapsack sprayer used for spraying is rented for farmers since enough number of knapsack sprayers are not found in the study areas. Another constraint related to the use of crop protection chemicals is not being supplied on time. Crop protection is supplied after weed, insect, pest, and disease infestation.

Crop protection chemicals were supplied and traded by illegal traders who have no knowledge about the appropriate recommendation rates. Thus, an unclear recommendation rate to use crop protection chemicals was raised as one of the constraints to the use of crop protection chemicals. Illegal traders' trade supplies crop protection chemicals who do not take responsibility for the disaster caused for used crop protection chemicals. Farmers did not trust illegal traders who supply crop protection chemicals. Thus, sample respondent household farmers raised illegal traders supply crop protection chemicals as one of the problems to use crop protection chemicals.

Other problems related to the use of crop protection chemicals were less effectiveness of crop protection chemicals, inaccessibility of crop protection chemicals with credit, problem of damage caused by crop protection chemicals if used incorrectly, problem of supplying expired crop protection chemicals, and increased cost of production.

5. Conclusion

Respondent household farmers raised a lot of constraints for not using inorganic fertilizer or using a less small quantity of inorganic fertilizers for different reasons. Among the major constraints that hinder the utilization of inorganic fertilizers that were raised by sample respondent household farmers were the high cost of fertilizer, shortage and uneven distribution of rainfall, problem of providing inorganic fertilizer on time, problem accessibility at the nearest place, and shortage of money to purchase inorganic fertilizer ranks from one to five, respectively. Using sources of organic fertilizer for other purposes, less availability of organic fertilizer, undeveloped infrastructure and facilities, and requirement of more labor to use organic fertilizer were the major constraints to the use of organic fertilizer. Shortage supply of improved seed, the high price of improved seed, and lack of credit were the major constraints to the use of improved seed varieties. The requirement of high labor to undertake row planting, problem of creation of shortage of livestock feed, lack or limited technology to use row planting, and shortage of cultivated land were the major constraints to the use of row planting. High price, inaccessibility of crop protection chemicals, and availability few suppliers were the major constraints mentioned to use crop protection chemicals.

In conclusion, adoptions of agricultural extension package technologies were hindered by different socioeconomic factors and different constraints on sorghum crop production in the study areas. Constraints of five extension package technologies on the sorghum crop were identified and ranked according to their severity. Thus, government concerned stakeholders should give due attention to these constraints to the improvement of the utilization of agricultural extension package technologies. Inaccessibility of credit service is almost the common constraint raised for all technologies. Accessibility of credit service according to the need of the rural farmer should be made available by the concerned bodies. The absence of insurance is also the common constraint raised to the use of inorganic fertilizer, improved seed, and row planting. Thus, government-concerned stakeholders should work on establishing and developing insurance services in the rural areas.

Data Availability

Survey data from 201 sample household farmers were taken from two districts of the West Hararghe zone, Oromia region, Ethiopia, during the 2018/19 main season crop year. Seven kebeles were selected based on the production potential of the sorghum crop. These data were funded by Oda Bultum University. Data can only be given to another body with the permission of Oda Bultum University. The data will be available once they pass certain bureaucratic steps. If the data are mandatory, after some time; the data can be uploaded after getting permission from the research and community service vice president office of Oda Bultum University.

Conflicts of Interest

The authors declare that they have no conflict of interest.

Acknowledgments

The authors would like to acknowledge farmers, district concerned officials, and experts and enumerators who were participated and helped them in the collection of primary and secondary data.

References

[1] Agricultural Transformation Agency (ATA), *Annual Report of 2018-19*, Agricultural Transformation Agency, Addis Ababa, Ethiopia, 2019.

[2] G. I. Neszmélyi, "The motivations for the diversification of the Nigerian economy focusing on sustainable agriculture," *Applied Studies in Agribusiness And Commerce*, vol. 8, no. 1, pp. 7–13, 2014.

[3] D. Gollin, *Smallholder Agriculture in Africa*, IIED, London, UK, 2014.

[4] E. Moa, "National strategy for Ethiopia's agricultural extension system," *Vision, Systemic Bottlenecks and Priority Interventions*, 2014.

[5] G. Leta Dufera, "The Ethiopian agricultural extension system and its role as a development actor," Dissertation, ResearchGate, Berlin, Germany, 2018.

[6] K. Davis, "Extension in sub-Saharan Africa: overview and assessment of past and current models and future prospects," *Journal of International Agricultural and Extension Education*, vol. 15, no. 3, pp. 15–28, 2008.

[7] M. S. Hiko, "Adoption of NPS fertilizer on sorghum crop production by smallholder farmers in Gemechis and Mieso districts of West Hararghe zone, Oromia regional state, Ethiopia," *Journal of Materials Science Research*, vol. 9, no. 2, 2020.

[8] Food and Agriculture Organization (FAO) of the United Nations, *Ethiopia Country Brief*, Food and Agriculture Organization (FAO), Rome, Italy, 2010, http://www.fao.org/countries/55528/en/eth/.

[9] A. Maunder, *Agricultural Extension. A Reference Manual. Rogers, Everett, Diffusion of Innovations*, Free Press, New York, NY, USA, 1972.

[10] E. M. Rogers, A. Singhal, and M. M. Quinlan, *Diffusion of Innovations*, pp. 432–448, Routledge, London, UK, 2014.

[11] G. Feder, R. E. Just, and D. Zilberman, "Adoption of agricultural innovations in developing countries: a survey," *Economic Development and Cultural Change*, vol. 33, no. 2, pp. 255–298, 1985.

[12] D. Abesha, A. Waktola, and J. B. Aune, *Agricultural Extension in the Drylands of Ethiopia*, Drylands Coordination Group (DCG), Addis Ababa, Ethiopia, 2000.

[13] K. Belay, "Agricultural extension in Ethiopia: the case of participatory demonstration and training extension system," *Journal of Social Development in Africa*, vol. 18, no. 1, pp. 49–84, 2003.

[14] Kelemework, F., Kassa, H. and Ababa, A., 2006, Ethiopian Economic Association/Ethiopian Economic Policy Research Institute (EEA/EEPRI).

[15] H. Kassa, "Agricultural extension in Ethiopia: historical evolution, relevant policies and challenges," *Digest of Ethiopia's National Policies, Strategies and Programs*, 469 pages, Forum for Social Studies, Addis Ababa, Ethiopia, 2008.

[16] A. Elias, M. Nohmi, K. Yasunobu, and A. Ishida, "Farmers' satisfaction with agricultural extension service and its influencing factors: a case study in North West Ethiopia," *Journal of Agricultural Science and Technology*, vol. 18, no. 1, pp. 39–53, 2016.

[17] D. J. Spielman, K. Davis, M. Negash, and G. Ayele, "Rural innovation systems and networks: findings from a study of Ethiopian smallholders," *Agriculture and Human Values*, vol. 28, no. 2, pp. 195–212, 2011.

[18] T. Lemma, E. Sehai, and D. Hoekstra, *Status and Capacity of Farmer Training Centers (FTCs) in the Improving Productivity and Market Success (IPMS) Pilot Learning Woredas (PLWs)*, International Livestock Research Institute (ILRI), Nairobi, Kenya, 2011.

[19] W. D. Biru, M. Zeller, and T. K. Loos, "The impact of agricultural technologies on poverty and vulnerability of smallholders in Ethiopia: a panel data analysis," *Social Indicators Research*, vol. 147, no. 2, pp. 517–544, 2020.

[20] T. Tafere, E. Elias, and I. Koomen, *Drivers of Farm-Level Adoption of Crop Extension Packages in Ethiopia*, Wageningen Centre for Development Innovation, Wageningen, Netherlands, 2020.

[21] J. D. Moti, *Strengthening Agricultural Extension Service in Ethiopia: Review of Micro-data Based Research Findings*, CIMMYT, Addis Ababa, Ethiopia, 2016.

[22] A. Berhanu, "The Ethiopian extension and the farmer: a view from the farm," in *Proceedings of the 16th International Conference of Ethiopian Studies*, Trondheim, Norway, April 2009.

[23] N. de Roo, C. Almekinders, C. Leeuwis, and T. Tefera, "Scaling modern technology or scaling exclusion? The socio-political dynamics of accessing in malt barley innovation in two highland communities in Southern Ethiopia," *Agricultural Systems*, vol. 174, pp. 52–62, 2019.

[24] B. Yu, A. Nin-Pratt, J. Funes, and S. A. Gemessa, *Cereal Production and Technology Adoption in Ethiopia*, Vol. 31, Food Policy Research Institute, Addis Ababa, Ethiopia, 2011.

[25] D. J. Spielman, D. Byerlee, D. Alemu, and D. Kelemework, "Policies to promote cereal intensification in Ethiopia: the search for appropriate public and private roles," *Food Policy*, vol. 35, no. 3, pp. 185–194, 2010.

[26] B. Gebremedhin, M. Jaleta, and D. Hoekstra, "Smallholders, institutional services, and commercial transformation in Ethiopia," *Agricultural Economics*, vol. 40, pp. 773–787, 2009.

[27] K. Davis, B. Swanson, D. Amudavi et al., *In-Depth Assessment of the Public Agricultural Extension System of Ethiopia And Recommendations for Improvement*, pp. 193–201, International Food Policy Research Institute, Washington, DC, USA, 2010.

[28] West Hararghe Zone of Agricultural Office (WHZAO), *West Hararghe Zone Agricultural Office Report of Cultivated and Planted Land in 2016/2017 Crop Year*, Unpublished Document, West Hararghe Zone of Agricultural Office (WHZAO), Chiro, Ethiopia, 2017.

[29] M. S. Hiko, W. Mosisa, and A. Dinku, "Determinants of adoption of agricultural extension package technologies by smallholder households on sorghum production: case of Gemechis and Mieso districts of West Hararghe Zone, Oromia Regional State, Ethiopia," *Journal of Agricultural Extension and Rural Development*, vol. 12, no. 3, pp. 62–75, 2020.

[30] Central Statistical Agency (CSA), "Central statistical agency population projection of Ethiopia for all regions," *Federal Democratic Republic of Ethiopia at Wereda Level from 2014–2017*, Central Statistical Agency (CSA), Addis Ababa, Ethiopia, 2013.

[31] L. M. A. Musa, K. J. Peters, and M. K. A. Ahmed, "On farm characterization of Butana and Kenana cattle breed production systems in Sudan," *Livestock Research for Rural Development*, vol. 18, no. 12, 2006.

[32] P. Kalix, "The pharmacology of khat," *General Pharmacology*, vol. 15, pp. 179–187, 1984.

[33] J. U. Agbahey, H. Grethe, and W. Negatu, "Fertilizer supply chain in Ethiopia: structure, performance and policy analysis," *Afrika Focus*, vol. 28, no. 1, 2015.

[34] S. Rashid, N. Tefera, N. Minot, and G. Ayele, *Fertilizer in Ethiopia: An Assessment of Policies, Value Chain, and Profitability*, Discussion Paper 1304; International Food Policy Research Institute: Washington, DC, USA, 2013.

[35] K. Davis, B. Swanson, D. Amudavi et al., *In-depth Assessment of the Public Agricultural Extension System of Ethiopia and Recommendations for Improvement*, International Food Policy Research Institute, Washington, DC, USA, Discussion Paper, 1041, 2010.

[36] J. McIntire, D. Bourzat, and P. Prabhu, *Crop-livestock Interaction in Sub-saharan Africa*, World Bank, Washington, DC, USA, 1992.

[37] A. Reda and A. H. Hailu, "Extensive utilization of inorganic fertilizers in ethiopian agriculture and its possible consequences on soil quality," *Journal of Integrative Agricultural Science*, vol. 13, no. 4, pp. 155–171, 2017.

[38] W. M. Mwangi, "Low use of fertilizers and low productivity in sub-Saharan Africa," *Nutrient Cycling in Agroecosystems*, vol. 47, no. 2, pp. 135–147, 1996.

[39] G. Zelleke, G. Agegnehu, D. Abera, and S. Rashid, *Fertilizer and Soil Fertility Potential in Ethiopia*, International Food Policy Institute, Washington, DC, USA, Working Paper, 2010.

[40] H. Beshir, B. Emana, B. Kassa, and J. Haji, "Determinants of chemical fertilizer technology adoption in North eastern highlands of Ethiopia: the double hurdle approach," *Journal of Research in Economics and International Finance*, vol. 1, no. 2, pp. 39–49, 2012.

[41] D. Kebede and M. Ketema, "Why do smallholder farmers apply inorganic fertilizers below the recommended rates? empirical evidence from potato production in eastern Ethiopia," *Advances in Crop Science and Technology*, vol. 5, no. 265, 2 pages, 2017.

[42] N. Eba and G. Bashargo, "Factors affecting adoption of chemical fertilizer by smallholder farmers in Guto Gida district, Oromia regional state, Ethiopia," *Science, Technology and Arts Research Journal*, vol. 3, no. 2, pp. 237–244, 2014.

[43] C. Yirga and R. M. Hassan, "Determinants of inorganic fertiliser use in the mixed crop-livestock farming systems of the central highlands of Ethiopia," *African Crop Science Journal*, vol. 21, pp. 669–682, 2013.

[44] T. Zegeye, *Adoption of Improved Bread Wheat Varieties and Inorganic Fertilizer By Small-Scale Farmers In Yelmana Densa, And Farta Districts Of Northwestern Ethiopia*, CIMMYT, Addis Ababa, Ethiopia, 2001.

[45] M. E. Hellmuth, D. E. Osgood, U. Hess, A. Moorhead, and H. Bhojwani, *Index Insurance and Climate Risk: Prospects for Development and Disaster Management*, International Research Institute for Climate and Society (IRI), Palisades, NY, USA, 2009.

[46] M. J. Miranda and F. M. Mulangu, *Index Insurance for Agricultural Transformation in Africa. African Transformation Report*, African Center for Economic Transformation, Accra, Ghana, 2016.

[47] U. Hess and P. Hazell, *Innovations and Emerging Trends in Agricultural Insurance*, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn, Germany, 2016.

[48] S. Asfaw, F. Di Battista, and L. Lipper, "Food security impact of agricultural technology adoption under climate change," *Micro-evidence from Niger*, National Advisory Board, Port Vila, Vanuatu, 2014.

[49] H. Alderman and T. Haque, *Insurance against Covariate Shocks: The Role of Index-Based Insurance in Social Protection in Low-Income Countries of Africa*, The World Bank, New York, NY, USA, 2007.

[50] T. Bonger, G. Ayele, and T. Kuma, *Agricultural Extension, Adoption and Diffusion in Ethiopia, Research Report 1*, Ethiopian Development Research Institute (EDRI), Addis Ababa, Ethiopia, 2004.