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Farmers Adoption of Agricultural Mechanization in Rainfed Sector, Gedarif State, Sudan

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ABSTRACT

The present study seeks to investigate the adoption of agricultural mechanization by rainfed small-scale farmers, in Gedarif State, Sudan. A field survey was used to collect data from 100 rainfed small-scale farmers, in Gedarif State, Sudan. A close-ended questionnaire was constructed and the personal interview technique was used to administer the questionnaire. The collected data were coded, fed to the computer, statistically analyzed using (SPSS), discussed and interpreted using descriptive statistics and the chi-square test. Using the descriptive statistics the results showed that the majority of farmers (98%) used tractor sizes 75-125, the majority of them (87%) used wide level disk (WLD), the majority of them (85%) their time of tillaging preparation is June-July, the majority of them (94%) used WLD as a row planter, the majority of them (96%) used the semi-mechanical weeding, (58%) of them used the manual harvest and the majority of them (77%) reported that they renting the machines from other farmers. Chi-square test result revealed that there was no significant association between the adoption of tractor sizes used, adoption of the type of agriculture equipment used for land preparation, adoption of time of tillaging, adoption of the type of seeders used, adoption of the type of weeding used, adoption of harvest type and farmers adoption of kind of machine ownership and farmers': Age group, education level, and farm size. From this study, it can be concluded that the farmers are not adopting the complete package of the recommended agricultural mechanization in the study area. The study recommends that determinants facing farmers in this subsector should be solved.

Keywords: agricultural mechanization, adoption, field survey, statistically analyzed.

1. Introduction

Agriculture is the backbone of Sudan's economy and food security. According to FAO (2015) "Sudan's agriculture sector contributes around 30 percent to the GDP, provides a livelihood to approximately two-thirds of the population, employs about 60 percent of the labour force and supplies raw material needed by the agro-based industries, and generates demand for industrial consumer goods. It supplies about all people's requirements of sorghum and millet, which together form the bulk of the staple food, in addition to most of the domestic needs for oilseeds, vegetables, fruits, and livestock products".

As in other developing countries, the majority of Sudanese people live in rural areas and depend on agricultural production as the main source of their income and food security. The country has two main agricultural subsectors irrigated and rainfed (traditional and mechanized) subsector. The traditional rainfed sector represents 60% of the total cultivated area in the country. The majority of farmers in Sudan were found in the traditional rain-fed sector of the country. The area of this subsector was estimated to be more than 9 million hectares. This subsector is produced about 90 % of millet production, about 35 % of sorghum, and 100 % of Gum Arabic in Sudan in addition to other crops. Animal production is considered as an important part of this subsector (Sudan Assessment Mission Report 2014/2015). The optimum season of planting in this subsector is early June to late July.

As a response to increases demands for agricultural products, intensification in agricultural production, and the increased use of agricultural inputs, agricultural mechanization can be seen as a key component of the technology that allows agricultural production to be intensified (Daio *et al.,* 2016).

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Farm mechanization increased agricultural productivity and profitability on account of timeliness of operations, better quality of work, and more efficient utilization of farm inputs. Several studies pointed out that agricultural mechanization increased the production of different cultivated crops due to the timeliness of operations, the better quality of operations, and precision in the application of the farm inputs and greatly helped the farmers to increase their marketing returns and consequently the standards of living of rural people. In farm societies in which both large and small farmers were found, tractors were considered an essential pillar for expanding the cultivated area of large farms because hired farm labour represents a high proportion of their production cost. The economic use associated with a large machine such as a tractor has made agricultural mechanization more attractive technology to such farms (Binswanger 1986). As a result, the first tractor owners in most developing countries are typically larger farmers, who also provide hiring services to non-owners when it helps them maximize their tractors' utilization (Daio *et al.,* 2016). Farmer demand for agricultural mechanization was considered by Boserup (1965) and Pingali *et al.,* (1987) to be a result of the agricultural intensification process, which is fundamentally driven by agro-ecological conditions, and population pressure, and market demand.

The advent of mechanization in developing countries in Asia, Africa, Latin America, and the Caribbean after independence during the 1960s was equated to "tractorization" and became the dominant development paradigm in these countries. The number of tractors in use in any country is used as the main indicator of mechanization level in the databases of several development agencies. The tractor (4WT and 2WT) and the grain milling hammer mill represent the two main types of agricultural machinery technology disseminated (with varying degrees of success) on a relatively large scale over the past seven decades in Africa (FAO, 2018). The tractor represents the pillar of agricultural mechanization and the key to the utilization of other machines/equipment for various agricultural activities such as plowing, harrowing, ridging, planting, weeding, fertilizer/pesticide application, harvesting, and transportation of farm produce Nkakini *et al.,* (2009). Farmer demand for agricultural mechanization was considered by Boserup (1965) and Pingali *et al.,* (1987) to be a result of the agricultural intensification process, which is fundamentally driven by agro-ecological conditions, population pressure, and market demand.

The rainfed agriculture subsector in Gedarif State is considered one of the most important areas of Sudan's agricultural production. It includes both traditional and mechanized farming practices. Mechanized rainfed farming in Gedarif State started in the mid-1940s. From that time, it was expanded in area and by the early sixties constituted around 30% of the total sorghum area in Sudan (Ahmed, 1994), in addition to the cultivation of sesame, livestock rearing, and forestry. Recommended agricultural practices are usually provided to farmers in Sudan by the Agricultural Research Corporation (ARC) and with the collaboration of the Sudanese-Canadian project in the study area, both of them have administratively been working with the State Ministry of Agriculture. The aim of the recommended cultural practices was to achieve both a high level of yields and preserve soil fertility taking economic constraints into consideration (Mustafa, (2006).

This subsector faces a number of determinants which include low production, high production cost, lack of available loans, and poor infrastructure. In addition to uncontrollable weather conditions, unavailability of machinery services for the small farmers, poor access to agricultural marketing, and other factors such as land renting and ownership and price uncertainties (Abbadi and Elhag, 2006). Mohamed (2011) mentioned that the most important determinants of productivity in this subsector are traditional technology used, lack of rural savings and credit institutions, poor access to marketing services, inadequate infrastructure, and safe water resources. The objective of this study was to assess the adoption of agricultural mechanization by rainfed small-scale farmers, in Gedarif state, Sudan

2. Materials and Method

2.1. Area of the study

This study was conducted in Gedarif State. Gedarif State lies in the Eastern part of Sudan between latitudes 12.67º and 15.75º N and longitudes 33.57º and 37.0º E, covering 71,000 km2(Figure 1). The State stretches from North to South through three climatic zones; dry, semi-dry, and semi-humid zones (Adam, 2008).

Source: Google Maps 2022

2.2. Study population, sample size and data collection and analysis

The total number of small-scale farmers in the study area was estimated to be 1000 farmers in the 2020/2021 growing season. Ten percent of the population was selected using the simple random sampling technique to obtain a fairly accurate result at a reasonable cost. The population was used to assess the adoption of agricultural mechanization by rainfed small-scale farmers, in Gedarif state, Sudan. A questionnaire consisting of eight questions was constructed and the personal interview technique was used to administer the questionnaire. The collected data were statistically analyzed and interpreted using percentage, frequency distribution, and Chi-square test.

3. Results and Discussion

3.1. Selected socioeconomic profile of farmers

The results of the socio-economic profile of farmers were presented in Table (1). The variables investigated in the study cover: age, sex, farm size, and education level. In terms of education level, 32% of farmers had Khalwa education, 38% acquired elementary education, and 23% had secondary education. Only 7% of farmers possessed a university education and above. This indicates that the farmers in the study area obtained the basic education required for a better understanding and ability to embrace the adoption of farm technologies. It is generally thought that the level of education enhances the ability to comprehend and adopt relevant agricultural information, which is in conformity with Sennuga *et al.,* (2020).

The age of farmers ranged from 15 to 55 years and above. 01% of them fell within the age of 15-24 years, 19% of them fell within the age of 25-34 years, 50% of the fell within the middle age of 35-44 years, 26% of them fell within the age of 45-54 years and 04% of them fell within the age of 55years and above. Generally, the assumption is that younger people tend to be more productive than their older counterparts. In terms of farm size, only2% possess farm size fell within the range of 1- 5 fed, 16% possess farm size fell within the range of 6- fed. , 25% possess farm size fell within the range of 11-15 fed., 10% possess farm size fell within the range of 1620 fed., and 47% possess farm size fell within the range of 21 and above fed.

Table 1: Distribution of farmers according to their selected socioeconomic profile

Selected socioeconomic characteristics		
Education level	**Frequency**	**%**
Khalwa	32	32
Elementary schools	38	38
Secondary schools	23	23
University and above	07	07
Age group	Frequency	%
15-24	01	01
25-34	19	19
35-44	50	50
45 -54	26	26
55 and above	04	04
Farm size/fed	Frequency	%
1-5	02	02
6-10	16	16
11-15	25	25
16-20	10	10
21 and above	47	47

3.2. Tractor size (HP) used

Table (2) showed that the majority of farmers (98%) reported that they used tractor sizes 75-125, while (01%) of them reported that they used tractor sizes 126-180. Only (01%) of them reported that they used tractor sizes 181-230. Similar results were reported by Harbi *et al.,* (1998) who cited that in Sudan the most common tractors in the rainfed areas were 70-90 hp sizes of different makes and models which pull the WLD with seeder box for land preparation and seed broadcasting. Also, tractors of 110, 140, 180, and 250 hp. were introduced by many investors at limited areas for pulling two or three units of WLD aimed to improve timeless of agricultural operations, improve machine capacity as well as fuel and machine efficiency.

Chi-squares test revealed that there was no significant association between the adoption of tractor sizes used and farmers': Age group, education level, and farm size

Table 2: Percentage distribution of farmers according to tractor size (HP) used

Tractor size (HP) used	**Frequency**	**Percentage**	**Age groups**	**Sig.**	**Education level**	**Sig.**	**Farm size**	**Sig.**
75-125	98	98	50		38		45	
126-180	01	01	01	0.519	01	0.010	01	0.970
181-230	01	01	01		01		01	
Total	100	100						

Significance level 0.05 or less

3.3. Type of agriculture equipment used for land preparation

Table (3) indicates that the majority of farmers (87%) reported that they used wide level disk (WLD). (11%) of them reported that they used a chisel. Only (02%) of them reported that they used a heavy-duty disk harrow.

Table 3: Percentage distribution of farmers according to type of agriculture equipment used for land preparation

Type of agriculture equipment used	**Frequency**	**Percentage**	**Age groups**	**Sig.**	**Education level**	**Sig.**	**Farm size**	**Sig.**
Chisel ploughs	11	11	50		38		45	
Heavy duty disk harrow	02	02	01	0.901	01	0.067	01	0.569
Wide level disk	87	87	01		01		01	
Total	100	100						

Significance level 0.05 or less.

This result is in agreement with those reported by Harbi *et al.,* (1998) who reported that wide level disc harrow (WLD) is the most common implement in the rainfed sector of Sudan. WLD is a dual-purpose machine throughout the rainfed agricultural of Sudan. It is used for land preparation as well as seeding of the crop.

Chi-squares test showed that there was no significant association between the adoption of the type of agriculture equipment used for land preparation and farmers': Age group, education level, and farm size.

3.4. Time of tillaging

Table (4) revealed that the majority of farmers (85%) reported that their time of tillaging is June-July. (08%) of them reported that their time of tillaging is May-June. (05%) of them reported that their time of tillaging is April-May. Only (02%) of them and large farmers reported that their time of tillaging before April. This result is in line with the results reported by Mustafa (2006) who mentioned that in the Gedarif area the growing season begins in early June after the first rain. At the beginning of rainfall, the first plowing is done to eradicate early weeds using the wide-level disk. A second disking is carried out between mid-June and mid-July during which, planting is completed.

Chi-squares test indicates that there was no significant association between the adoption of time of tillaging and farmers': Age group, education level, and farm size.

Table 4: Percentage distribution of farmers according to time of tillaging

Time of tillage:	Frequency	Percentage	Age groups	Sig.	Education level	Sig.	Farm size	Sig.
before April	02	02	50		38		45	
April-May	05	05	01	0.519	01	0.010	01	0.970
May-June	08	08	01		01		01	
June-July	85	85	00	00	00		00	
Total	100	100						

Significance level 0.05 or less

3.5. Type of seeders used

Table (5) showed that the majority of farmers (94%) reported that they used WLD as a row planter. (01%) of them reported that they used the mechanical planter. (01%) of them reported that they used broadcast planter. (03%) of them reported that they used the seed drill broadcast planter. (01%) of them reported that they used the precision planter.

The chi-squares test revealed that there was no significant association between the adoption of the type of seeders used and farmers': Age group, education level, and farm size.

Table 5: Percentage distribution of farmers according to type of seeders used

Type of seeders used:	Frequency	Percentage	Age group	Sig.	Education level	Sig.	Farm size	Sig.
Seed drill	03	03	50		38		45	
Precision planter	01	01	01		01		01	
Mechanical planter	01	01	01	0.43	01	0.464	01	0.126
Broadcast planter	01	01	01		01		01	
Wide level disk	94	94	01		01		01	
Total	100	100						

Significance level 0.05 or less

3.6. Type of weeding used

Table (6) revealed that the majority of farmers (96%) reported that they used semi-mechanical weeding. (03%) of them reported that they used mechanical weeding with fertilizer. (0.1%) of them reported that they used mechanical weeding. The result of this study is not in line with the results obtained by Mustafa, (2006) who mentioned that in the Gedarif area, weeding with chemical herbicides using a sprayer attached to the tractor was recently introduced.

Chi-squares test showed that there was no significant association between the adoption of the type of weeding and farmers': Age group, education level, and farm size.

Table 6: Percentage distribution of farmers according to type of weeding

Type of weeding	Frequency	Percentage	Age groups	Sig.	Education level	Sig.	Farm size	Sig.
Semi mechanical	96	00	50		38		45	
Mechanical	01		01	0.469	01	0.130	01	0.894
Mechanical with fertilizer	03		01		01		01	
Total	100	100						

Significance level 0.05 or less

3.7. Harvest type

Table (7) indicates that (58%) of farmers reported that they used the manual harvest. (40%) of them reported that they used the manual thresher. (02%) of them reported that they used the mechanical harvest. Similarly, Mustafa, (2006) reported that harvesting of sesame is entirely carried out manually while sorghum harvesting includes three operations; head cutting heads piling, and threshing. The first two operations are done manually while threshing is done by mechanical harvesters (Semi mechanical).

Chi-squares test revealed that there was no significant association between the adoption of harvest type and farmers': Age group, education level, and farm size.

Table 7: Percentage distribution of famers according to harvest type

Harvest type	Frequency	Percentage	Age groups	Sig.	Education level	Sig.	Farm size	Sig.
Manual	58	58	50		38		45	
Manual thresher	40	40	01	0.758	01	0.124	01	0.426
Mechanical	02	02	01		01		01	
Total	100	100						

Significance level 0.05 or less

Kind of machine ownership

Table (8) revealed that the majority of farmers (77%) reported that they rent the machines from other farmers. (10%) of them reported that they rent the machines from other sources. (08%) of them reported that they rent the machines from companies. (05%) of them reported that they used their own machines. The result of the present study is not in line with the result reported by Craig (1991) who found that in Gedarif and other areas of mechanized rainfed agriculture in Sudan most of the tractors were owned by individual farmers, the remainder was hired. This result also agreed with FAO (1995) and Turk's (1999) results in the same area.

Chi-squares test indicates that there was no significant association between the adoption of kind of machine ownership and farmers': Age group, education level, and farm size

Table 8: Percentage distribution of farmers according to kind of machine ownership

Kind of machine ownership	Frequency	Percentage	Age groups	Sig.	Education level	Sig.	Farm size	Sig.
Personal ownership	05	05	50		38		45	
Renting from companies	08	08	01		01		01	
Renting from other farmers	77	77	01	0.422	01	0.137	01	0.094
Renting from other sources	10	10	01					
Total	100	100						

Significance level 0.05 or less

To explain the lack of significant associations between some socioeconomic characteristics of farmers and their use of agricultural mechanization, we asked the farmers about their use of agricultural mechanization in their agriculture practices and they answered that this use did not result from the work of agricultural extension officers with them, but resulted mainly from the financial ability that enables them either to buy or rent agricultural machinery. In addition to that, there are no agricultural extension

services. This result agrees with results obtained by Yahya *et al.,* (2016) who mentioned that no extension or awareness services concerning best practices in agricultural production were provided to farmers in mechanized scheme areas, farmers and investors were left to rely on their own experience and the professional services were only provided upon request, according to the financial capacity of the investor. Also, a similar result was reported by Mustafa (2006) who mentioned that a lack of extension services was reported by farmers in the Gedarif mechanized rainfed area.

4. Conclusion and Recommendation

From this study, it can be concluded that the farmers are not adopting the complete package of the recommended agricultural mechanization in the stud area. The study recommends that determinants facing farmers in this subsector should be solved.

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