Vol. 13(44), pp. 2542-2550, 1 November, 2018
DOI: 10.5897/AJAR2018.13525
Article Number: 1776D2559124
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

ACADEMIC JOURNALS
African Journal of Agricultural Research

Full Length Research Paper

Farmers' perceptions, practices and proposals for improving agricultural productivity in South Sudan

Asad Sarwar Qureshi[1*], Adam Juma Abdallah[2] and Lona Aggrey Tombe[2]

[1]Senior Scientist - Irrigation, International Center for Biosaline Agriculture, Dubai, UAE.
[2]Directorate of Agriculture and Rural Development, Juba, South Sudan.

Received 5 September, 2018; Accepted 16 October, 2018

This study was carried out to establish farmers' perceptions regarding low agricultural productivity and to document their proposals for improving the performance of agriculture sector in South Sudan. The results reveal that the major challenges related to low agricultural productivity as perceived by farmers include poor leveling of fields, poor irrigation management, low water availability, loss of land due to salinity and low water use efficiency due to seepage and runoff losses. Low water availability is considered as the biggest challenge for improving agricultural productivity because dependence on seasonal rain results in low crop yields and serious food shortages during most part of a year. Therefore, installation of public wells to increase groundwater availability for irrigation and establishment of rainwater harvesting structures are proposed as the potential solutions to solve irrigation water problems and overcome food shortages. Strengthening of extension services and training of vegetable growers on drip and sprinkler irrigation system along with the provision of irrigation equipment can help a great deal in increasing agricultural productivity. The state and national governments should provide high quality seeds and loans to the vegetable growers to enable them improve their crop production and cultivation of crops during the dry periods.

Key words: Agricultural productivity, irrigation management, food security, livelihood, poverty.

INTRODUCTION

In South Sudan, agriculture account for 36% of the non-oil GDP with 80% of the population living in rural areas largely dependent on subsistence farming (FAO, 2015). Despite abundant water supplies, only 5% of the total 30 million ha arable land is cultivated. Crop yields are extremely low, which negatively affects incomes and livelihood of poor farmers. Lack of agricultural inputs such as seed and fertilizer, poor advisory services and inefficient irrigation management are considered as the major barriers (USAID, 2012). The salt-affected lands in South Sudan are in the White Nile irrigation schemes. The agricultural potential of these areas has hardly been utilized despite having fresh water availability from the Nile River.

About 95% of the land in South Sudan is suitable for agriculture, out of which about 50% is prime land with

*Corresponding author. E-mail: a.qureshi@biosaline.org.ae

high production potential (FAO, 2015). South-Sudan has highest per capita livestock holding in Africa, with 23 million herd of cattle, sheep, and goats. Livestock sector accounts for 15% of the total GDP. Therefore, to improve livestock productivity, there is a strong need for improved forage varieties that are resistant to common diseases (AfDB, 2013). Although agricultural lands in South Sudan are suitable for growing all sorts of crops, land productivity is generally low due to lack of agricultural inputs such as seeds, fertilizer, pesticides, agricultural machinery and higher labor costs (Tully et al., 2015). Farmers in South Sudan rely on traditional methods for seed and grain storage, which increases post-harvest losses as well as nutritional value of the produce (IFPRI, 2012). Availability of labor at reasonable costs and the time when it is most needed is another major issue limiting the crop production (Hanjra et al., 2009). There are critical environmental concerns in South Sudan related to water resources and their management. Water levels in rivers are decreasing due to increased erosion and siltation caused by land use changes and over-exploitation: forest clearing, over-grazing and fires (USAID, 2012).

Irrigation applications by farmers in South Sudan are not related to actual crop water requirements. Most of the farmers do not have access to modern irrigation technologies and irrigation is mainly done using traditional basin or flooding methods resulting in irrigation application efficiencies of 30 to 35% (Kadigi et al., 2012; GoSS, 2013). The studies done in South-Sudan have shown that there is a great potential to boost agricultural productivity if suitable irrigation infrastructure is provided (GoSS, 2013). Poor irrigation and agronomic practices, lack of inputs such as seed and fertilizer, and irrigation and farm machinery are generally considered as the major reasons for low agricultural productivity in South Sudan (World Bank, 2013).

Increasing agricultural productivity at the farm level depends on the farmer's knowledge of the causes of low crop production and the farming practices they should use to overcome this problem. Understanding farmers' perceptions and adaptive strategies to cope with low productivity problems could help in suggesting interventions to tackle this problem (Wickham et al., 2006). Farmers' response strategies are usually based on the timing and severity of the problem perceived and their ability to interpret available information to develop the right response for a given situation (Meze-Hausken, 2000; Kassa et al., 2013). Based on the available information, farmers might decide to employ local mitigation and adaptation practices such as improved land and water management practices, diversify cropping patterns and change their investment decisions (Mamba et al*.,* 2015).

This study was conducted to understand farmers' responses regarding low crop yields and water use efficiencies at their farms. Farmers were asked to describe major constraints faced by them in improving overall agricultural productivity. An analysis of farmers' suggestions for improving the performance of agriculture sector and reducing household poverty in South Sudan was also part of this study. It is anticipated that findings of this study will be used as an entry point for policy makers and other stakeholders to devise effective strategies to enhance agricultural productivity and improve food security and livelihood of millions of poor living in rural areas.

DESCRIPTION OF THE STUDY AREAS

South Sudan is in East Africa bordering Sudan frontier with Ethiopia, Kenya and Uganda; and to the water divide which represents the southern boundary with Democratic Republic of Congo and Central African Republic in the west (Figure 1). The water resources of South Sudan consists of the Nile River, its tributaries, and groundwater. The Blue Nile and its tributaries flow down from the highlands of Ethiopia, while the White Nile and its tributaries flows from Uganda and Central African Republic into the largest contiguous swamp on their way to Sudan and Egypt (The Sudd Region). The low lands of White Nile Valley have great potential for irrigation due to fresh water availability from the Nile River but hardly been utilized for agricultural production (FAO, 2015).

South Sudan has a tropical climate with wet and dry seasons. The temperature typically ranges between 25 and 35°C. During the dry months (January to April), annual temperatures are in the range of 20-25°C, while the highest temperatures can go up to 35°C just before the rainy season (May to September). The annual rainfall pattern is zone dependent ranging from 500 to 2000 mm, which provides 130 to 300 days of growing season. The average annual precipitation in the western parts of the country is between 1000 and 2000 mm, while north-eastern and south-eastern parts of the country receive 500 to 750 mm. Considering these variations, 5 districts from different states of the country were selected to conduct socio-economic survey to establish farmers' perceptions. The selected districts include Aweil, Bentiu, Bor, Torit and Juba districts as shown in Figure 1. The performance of agriculture sector varies in accordance with the zone and the year. The selected areas represent lands with low fertility, poor quality groundwater, and large number of resource poor farmers. The general characteristics of the selected sites are shown in Table 1.

Data collection and analysis

The survey data was collected from a total of 200 respondents from five districts of South Sudan, which were selected using multistage random sampling technique. The selected districts Aweil, Bentiu, Bor, Torit and Juba) have mixed crop-livestock system, therefore, the livelihood of most of the respondents is based on both farming and livestock rearing. In addition to survey data, data from secondary sources regarding groundwater quality and levels, soil maps and information on the status of irrigation water availability and its quality was also collected. Secondary data is essential to get baseline information of the selected areas.

Data were collected using a semi-structured questionnaire, which was developed in consultation with irrigation and agriculture experts of the targeted districts. This strategy was considered better to understand farmers' insights about the causes of low agricultural productivity and document their propositions for improving the performance of irrigated agriculture in the country. The questionnaire was pre-tested in the field by trained enumerators

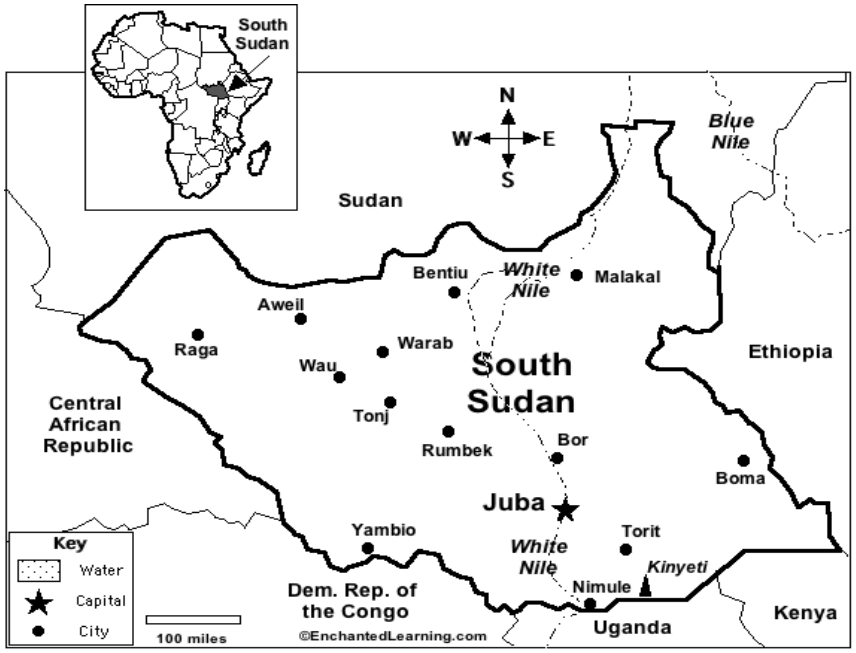

Figure 1. Location of South Sudan**.**

Table 1. General characterization of selected sites in South Sudan.

S/N	Site	Zone	Type of Crops
1	Aweil	Western Flood Plains	Agro-pastoralism: Livestock and agriculture predominant. Main crops are sorghum, pearl millet, vegetables, cow peas
2	Bentiu	Nile-Sobat Rivers	Agro-pastoralism and fishing: Prone to seasonal flooding. Major crops sorghum, beans and vegetables.
3	Bor	Nile-Sobat Rivers	Agro-pastoralism and fishing: Prone to seasonal flooding. Major crops include sorghum, beans and vegetables.
4	Torit	Hills and Mountains	Agriculture and livestock husbandry. Crops include cassava, sweet potatoes, sorghum, maize, finger, pearl millet.
5	Juba	Hills and Mountains	Agriculture and livestock husbandry. Crops include cassava, sweet potatoes, sorghum, maize, finger, pearl millet.

and necessary corrections were made based on the obtained feedback. Focus Group Discussions were also conducted with farmers in each district to record their collective views on the reasons of low agricultural productivity, its impacts on their well-being and their suggestions for improvement.

The selected districts have mixed crop-livestock system; therefore, the livelihood of most of the respondents is based on both farming and livestock rearing. During the survey, farmers were asked about the limitations and constraints faced by them in the adoption of innovative technologies and approaches for improving agricultural productivity. The data collected through household survey, interviews and focus group discussions was used to perform descriptive and econometric analyses using mean, percentage, frequency and analysis of variance (ANOVA). SPSS Version 20 software was used to carry out statistical analysis. The Chi square test was conducted to verify the

Table 2. Demographic characteristics of selected sites.

Parameter	No. of respondents	%
Age range (years)		
20- 30	55	27.5
31- 40	65	32.5
41- 60	76	38.0
>61	4	2.0
Marital status of respondents		
Single	37	18.5
Married	110	55.0
Widowed/Divorced	53	26.5
Education level of respondents		
No Education	47	23.5
Primary education	56	28.0
SSC education	103	51.5
Employment status of respondents		
Unemployed	90	45.0
Private employment	80	40.0
Public employment	30	15.0

significance level of association between farmer's perceptions and their determinants.

RESULTS AND DISCUSSION

Socio-economic characterization of the respondents

The demographic and socio-economic characteristics of respondents include gender, family size, marital status, education level, landholding and livestock ownership. Table 2 shows that 80% of the respondents aged between 20 and 50 years whereas the age of the remaining 20% respondents was above 50 years. This shows that majority of the respondents in this survey were active farmers and represents a good mixture of experienced and young emerging farmers. Out of the total sample of 200 respondents, 135 (67.5%) were male and 65 (32.5%) were female. This disproportion was due to the fact that the male respondents were readily and easily accessible whereas access to female respondents was limited due to their busy schedules at home. The survey results indicate that 55% respondents were married and they practice irrigated farming to earn food and other necessities of life such as health and education for their families and children. Single emerging young and widowed/divorced farmers are mainly involved in subsistence farming. The challenges of food security and livelihood are more significant in divorced/widows.

The education level of respondents was high as about 50% have high school education followed by 27% with primary educated and 23.5% with no formal education. The unemployment rate in the selected areas was very high; 45% of the respondents are without jobs, about 40% rely on part time jobs with private companies and only 15% have secured public sector jobs. The earnings of these farmers are far below their daily needs, which force them to look for additional income generation activities. The low income and higher unemployment rate are reported as the major causes of poverty in these areas.

The *t-test* analysis showed that there is a significant difference ($P < 0.01$) in farm size among households. The average landholding per household was 1.8 ha with a standard deviation (SD) of 0.8 ha. The number of land parcels per household differ significantly ($P < 0.1$) between respondents with a combined mean of 1.25 and a standard deviation of 1.2.

The livestock ownership is considered a proxy for wealth in rural areas of South Sudan. In the survey areas, livestock is a major source of food, income and security in times of hardship for the communities. In this study, the livestock asset of separate households was estimated by tropical livestock unit (TLU) (Storck et al., 1991). The TLU provides a common unit for comparison because households own different livestock species (cattle, goat, sheep etc.). The average livestock holding per household was found to be 8.5 TLU with SD of 1.8 TLU.

Although agricultural production system of the selected districts is a mixed farming system (crops and livestock), farmers prefer to grow crops to secure food supply and satisfy cash needs of their families. The different sources of income reported by the respondents include livestock

Table 3. Types of irrigation and pumping methods used by farmers.

Types of irrigation	No. of respondents	%
Irrigation methods		
Surface irrigation	146	73
Drip irrigation	18	9
Sprinkler irrigation	0	0
None	36	18
Pumping methods		
Lift pump	174	87
Flow pump	26	13
Access to irrigation equipment	152	76

herding, crop cultivation, off-farm wage employment, permanent employment and food aid. The survey results indicate that more than 80% farmers earn their living through crop selling and off-farm jobs whereas permanent employment also contribute significantly to the incomes of the respondents.

The survey results indicate that farmers try to reduce production costs and increase farm income by performing most of the farm activities using family labor. Farm labor activities such as land clearing, ploughing and irrigating are mainly performed by men whereas women contribute more in winnowing and harvesting activities. Other activities such as sowing weeding, bagging, and transporting are largely shared among male and female members of the household.

Household poverty is very pervasive in the selected areas because low crop productivity has direct impact on the income and livelihood of households. The household income of more than 60% of the respondents is less than one US$ per day. Declining farm incomes has forced households to do extra work to earn cash to meet their daily needs resulting in serious health problems especially for women and children. Farmers occasionally lose their livestock due to drought and diseases. This situation made them entirely dependent on food aid programs of national and international organizations for more than 6 months in a year.

The land fertility status in the five districts differs significantly due to various reasons. The respondents were asked to categorize their lands using three fertility indicators, that is, poor (infertile), average and good (fertile). The consolidated results of the survey revealed that the majority of the lands owned by respondents are poor in fertility. About 43% of the respondents consider their land infertile, 51% rated their land as average and about 6% termed the fertility of their land as good (fertile).

Farmers' perceptions about the importance of irrigation

The land holdings in South Sudan are generally small and not all land is cultivated at the same time due to shortage of water and other agricultural inputs. According to survey results, 70% of the farmers have less than 1 ha of land whereas 16% own less than 3 ha and 14% have more than 4 ha of land. Table 3 shows that 42% farmers cultivate vegetables and 28% legume crops to meet their household needs and to earn small money by selling the excess produce in local markets. Cereals and oil crops are grown by 17.5 and 12.5% farmers, respectively. Other crops are grown in small quantities and include groundnuts, vegetables and cassava (Figure 2).

Farmers" knowledge about irrigation management is very limited and majority of them is totally unaware of salinity problems. They usually relate low crop productivity to water shortage and the attacks of insects and diseases. In general, farmers (87%) are aware of the importance of irrigation for sustainable crop production as the rainfall is neither reliable nor sufficient. More than 85% of the respondents believe that the irrigation systems need further development whereas 15% think that first priority should be given to the rehabilitation of the existing irrigation systems.

The survey results reveal that 73% farmers use surface irrigation methods and 9% have installed drip system, whereas the rest 18% rely on traditional flooding method (Table 3). Farmers consider surface irrigation as an income source because it improves their livelihoods through increased crop yield and cultivation of cash crops such as vegetables and fruits both during rainy and dry seasons for the local markets.

More than 87% of the farmers prefer lift irrigation because it is reliable and easy to pump water from surface canals and groundwater wells. In addition, they are less expensive and have minimum operational and maintenance requirements. Many respondents use mechanical pump engines, hand pumps and water-cans to lift water from river and small dug wells for irrigating their fields.

Table 3 shows that 76% of the surveyed farmers have access to one or more irrigation equipment such as pipes, pumps, diesel generators and watering cans. The remaining 24% of the farmers do not own any of these

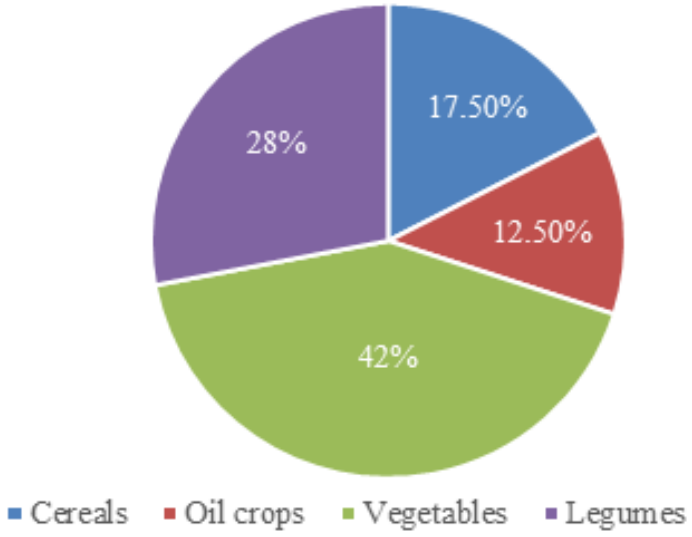

Figure 2. Commonly grown crops in South Sudan.

equipments because of low purchasing power. These farmers either rent or borrow these equipments from their fellow farmers. Most farmers (36%) use 'rotodynamic" type of pumps due to their low cost, high efficiency and ease of installation. However, the drawback of these pumps is that they need skilled labor to ensure regular maintenance and better operation. The poor farmers look to government and donor agencies for financial assistance to buy these pumps.

The farmers were found to have very limited knowledge of crop water demands. In the absence of scientific irrigation scheduling information, farmers' irrigation applications largely depend on the availability of water and visual plant stress indicators. Most of the farmers apply irrigation when the soil surface becomes dry and the crops start showing signs of stress (e.g., dry leaves, changed color of leaves, etc). Resultantly, their irrigation applications are much higher than the actual crop demand. The water applied in excess of crop demand is wasted through surface runoff that damages neighboring fields. During the survey, 80% of the respondents admit that irrigation applications generate surface runoff whereas the remaining 20% do not consider it a big issue. To prevent runoff, farmers use different methods such as land leveling, widening of channels and raising the bunds of their fields.

The survey results indicate that farmers having access to sufficient irrigation water and own pumps tend to apply irrigation twice a day to save their crops from extra water stress. This is an important irrigation practice because discharges are low and temperatures are high, which make the soil dry due to fast depletion of applied water. Farmers having no access to pumps and irrigation water, apply random irrigations depending on the access to water (Figure 3). The results show that 17% farmers irrigate daily, 11% twice a week whereas 19% can only afford irrigation three times a week. These unscheduled irrigation applications produce low water use efficiency and crop yields. This demonstrates that timely access to irrigation water is the biggest constraint in improving agricultural productivity in South Sudan. Mamba et al. (2015) have also stressed the need to match irrigation applications to cover vagaries of climate changes.

Farmers prefer basin method of irrigation because they consider it better to control surface runoff. However, excessive irrigation applications through this method cause depletion of soil nutrients, which exacerbate existing poor soil fertility problems. Farmers complain that they do not get any information from the extension workers or irrigation technicians regarding timing and amount of irrigation water application for different crops.

Farmers' perceptions about the production and market constraints

The information collected from secondary sources revealed that average crop productivities in the selected districts were consistently low. During this survey, farmers were asked about the major production and marketing constraints faced by them for improving their agricultural productivity. The major challenges of irrigation management as perceived by farmers include poor land leveling of fields, lack of irrigation management, less irrigation time, loss of land due to salinity and low water use efficiency due to seepage and runoff losses. More than 95% of the respondents consider lack of agricultural inputs such as improved seed, fertilizer and farm machinery, shortage of arable land, lack of technical knowledge, shortage of irrigation water and increasing

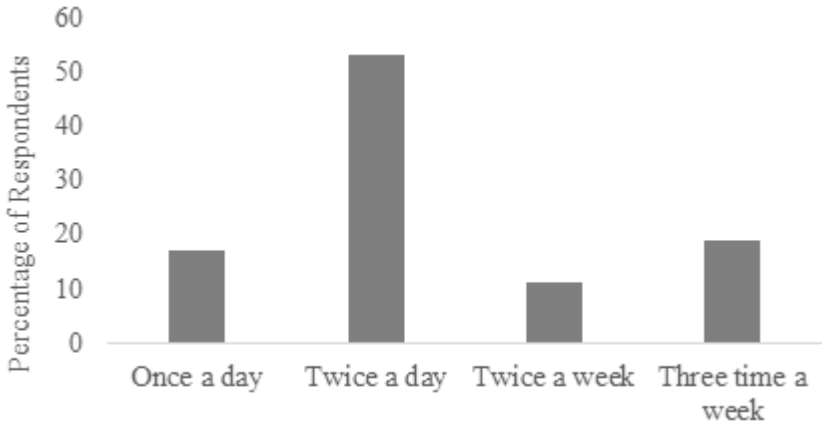

Figure 3. Irrigation schedules adopted by farmers.

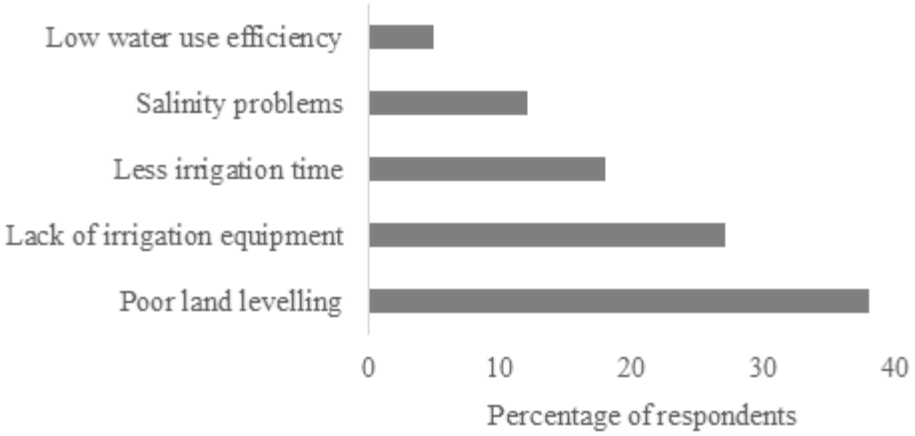

Figure 4. Challenges of irrigation management as perceived by farmers.

salinity as the major constraints for low productivity. In all districts, non-availability of pesticides is resulting in the expansion of invasive weeds.

Figure 4 shows that 38% farmers consider lack of irrigation equipment as the major challenge for improving crop production followed by less irrigation time (27%), low water use efficiency (18%), poor land leveling (12%) and salinity problems (5%). For the leveling of their fields, farmers have to hire the services of companies as they do not have skills and equipment to do it themselves. This makes this task difficult for them. Low water use efficiency is mainly caused by excessive seepage and surface runoff due to the use of flooding method of irrigation. Salinity problems are not widespread in the study areas except in the Bore district.

In South Sudan, farmers hire annual labor for land preparation, planting, weeding and harvesting purposes. The cost of hiring labor ranges from 200 to 1000 South Sudanese Pound (ssp) per day (IUS$ = 130 ssp). Meanwhile, the daily income of the respondents from the sale of their farm products ranges from 1500 to 5000 ssp per day. This shows that farmers earn good income from irrigation farming to cover these costs. However, without irrigation, income levels are low and it becomes hard for them to cover these expenses. Farmers' first preference is to use surface water for irrigation because of its low cost and better quality. However, in the absence of surface water, their ultimate choice is groundwater for irrigation. Some farmers prefer to use groundwater because of its on-farm availability since surface water is far from their farming site.

During the survey, farmers demanded training to increase their level of awareness about irrigation management, crop water requirements and soil management. They suggest that government and/or other concerned agencies should arrange these trainings on regular basis. Farmers think that the government organizations and the NGOs should take appropriate steps for improving irrigation management in South Sudan.

Consistently lower land productivity in the study areas is resulting to reduced farm incomes, food insecurity and sway in poverty. Due to aforementioned constraints, crop yields are generally low and after meeting domestic needs, very little is left for sale in market to earn cash for other family needs. In addition to low produce, farmers are also facing many marketing constraints to get true market value of their produce. During the field survey, lack of market information (42%) and poor infrastructure to access regional markets (32%) were rated as the major marketing constraints by farmers. Farmers also consider involvement of brokers (18%) and high transaction costs (8%) as the main constraint for marketing their products. Due to poor quality of produce and lack of storage facilities, farmers prefer to sell their produce soon after harvesting. The brokers take advantage of the situation and farmers have to compromise on the price.

CONCLUSIONS AND RECOMMENDATIONS FOR IMPROVING AGRICULTURAL PRODUCTIVITY

Results of this study show that household poverty is very pervasive in the selected areas of South Sudan. The land holdings are generally small and not all land is cultivated at the same time due to shortage of water and other agricultural inputs. Farmers were unanimous in declaring low availability of irrigation water as the biggest challenge for improving agricultural productivity in South Sudan. In the absence of irrigation water, farmers depend on seasonal rain, which results in serious food shortages during most part of a year. Therefore, installation of public wells to increase groundwater availability and establishment of rainwater harvesting structures to store rain water needs to be introduced to solve irrigation water problems and overcome food shortages.

Farmers mostly use locally produced seed for growing crops. These seeds are of poor quality and mostly infected which results in low crop productivity. Therefore, farmers should be provided with the quality seed to improve crop yields. Lack of agricultural machinery is also one of the major causes of low crop productivity. Farmers suggest that government should take necessary steps in providing machinery such as tillage equipment, planters, sprayers, levelers, harvesters, threshers and transport trailers to farmers on subsidized rates. Farmers commonly use wide disc planters for land preparation, which uses lots of fuel and damage the soil structure due to excessive moment of tractor and other machinery. The maintenance and availability of spare parts for these machines is a major problem in South Sudan.

The locally produced drip and furrow irrigation systems are useful for smallholder farmers for increasing water use efficiency by minimizing non-beneficial use of water. The benefits of these systems can be maximized if they are properly designed, managed, and maintained. Therefore, farmers should be provided consultancy services to properly design drip irrigation systems. The easy access to manuals and guidelines developed by different manufacturers on different design factors may help farmers improve their skills for properly designing drip irrigation system.

Establishment of agriculture extension services to the farmers should be one of the priorities for the government and stakeholders. Training of vegetable growers on modern irrigation methods such as drip and sprinkler irrigation system as well as provision of irrigation equipment to the farmers can help a great deal in increasing water use efficiency and agricultural productivity. The state and national governments should provide high quality seeds and loans to the vegetable growers to enable them improve their crop production and cultivation of crops during the dry periods.

There is a need to develop a marketing mechanism for buying agricultural products of farmers at their true prices. This will encourage them to increase crop production and improve their incomes. Effective extension program should be initiated to disseminate information on soil, water and salinity management practices to farmers. Farmers should also be linked with national research and extension organizations so that they can benefit from their intervention programs of improving land and water management for increasing their agricultural productivity. Provision of easy credit facilities for farmers might also be a step in the right direction.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors are grateful for the financial support of the International Fund for Agricultural Development (IFAD) for the implementation of this project “Rehabilitation and Management of salt-affected soils to improve agricultural productivity in Ethiopia and South\Sudan”. They are also thankful to the members of the field team in South Sudan for conducting survey and collecting other relevant field data for this study. The help of Dr. Susan Robertson of ICBA in finalizing the questionnaire is also highly appreciated.

REFERENCES

AfDB (2013). South Sudan: An infrastructure action plan. A program for sustained strong economic growth. African Development Bank. Tunis.

Food and Agriculture Organization (FAO) (2013). Sudan productive capacity recovery program (SPCRP). South Sudan. Independent final evaluation. OSRO/SUD/623/MUL. Food and Agriculture Organization of the United Nations (FAO). Rome.

Food and Agriculture Organization (FAO) (2015). South Sudan Country

profile. Geography, Climate and Production. Food and Agriculture Organization of the United Nations (FAO). Rome.
GoSS (2013). The rapid water sector needs assessment and a way forward. Government of the Republic of South Sudan. http://documents.worldbank.org/curated/en/434701468302991568/Main-report
Hanjra MA, Ferede T, Gutta DG (2009). Reducing poverty in Sub-Saharan Africa through investments in water and other priorities. Agricultural Water Management 96:1062-1070.
International Food Policy Research Institute (IFPRI) (2012). Increasing Agricultural Productivity and Enhancing Food Security in Africa. International Food Policy Research Institute, Washington, D.C.
Kadigi RMJ, Tesfay G, Bizoza A, Zinabou G (2012). Irrigation and Water Use Efficiency in Sub-Saharan Africa Briefing Paper Number 4, GDN Agriculture Policy Series. The Global Development Network (GDN), Oxford.
Kassa Y, Beyene F, Haji J, Lejesse B (2013). Farmers perceptions of the impact of land degradation and soil and water conservation measures in west Hareghe zone of Oromia national regional state, Ethiopia. Journal of Biology, Agriculture and Healthcare 3(11):12-19.
Mamba SF, Salam A, Peter G (2015). Farmers' Perception of Climate Change a Case Study in Swaziland. Journal of Food Security 3(2):47-61.
Meze-Hausken E (2000). "Migration caused by climate change: how vulnerable are people in dryland areas? A case study in Northern Ethiopia." Mitigation and Adaptation Strategies for Global Change 5(4):379-406.
Storck H, Bezabih E, Birhanu A, Borowiecki A, Shimeles W (1991). Farming systems and farm management practices of smallholders in the Hararghe Highlands: Farming systems and resources economics in the tropics. Wissenshafts varlag vauk, Kiel, Germany 11:41-48.
Tully K, Sullivan C, Weil R, Sanchez P (2015). The state of soil degradation in Sub-Saharan Africa: Baselines, trajectories, and solutions. Sustainability 7:6523-6552.
United Nations Development Program (UNDP) (2012). Environmental impacts risks and Opportunities Assessment. Natural Resources Management and Climate Change in South Sudan. Government of the Republic of South Sudan and United Nations Development Program.
UN-Water (2015). The United Nations World Water Development Report: Water for a Sustainable World. United Nations Educational Scientific and Cultural Organization (UNESCO), Paris, France.
United States Agency for International Development (USAID) (2012). USAID Country Profile: Property rights and resource governance. South Sudan. United States Agency for International Development. Washington.
Wickham JD, Nash MS, Wade TG, Currey L (2006). Statewide empirical modeling of bacterial contamination of surface waters. American Journal of Water Resources 42:583-591.
World Bank (2013). The rapid water sector needs assessment and a way forward. Republic of South Sudan. World Bank. Washington. https://openknowledge.worldbank.org/handle/10986/2114