



ANALYSIS AND EVALUATION OF INEQUALITY EFFECTS OF FORMAL AGRICULTURAL MICROCREDIT IN NORTH SUDAN

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ABSTRACT

The formal agricultural financial system in Sudan is considered as one of the main pillar for agricultural development. It contributes in reducing level of incomes inequality in rural areas. This paper addresses the farmer income distribution and its impacts on poverty incident in the rural area of the River Nile State of

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North Sudan. The inequality and low returns among the poor households might attribute to the inadequate formal microcredit and lack of agricultural policies. This research aims to explore the impacts of formal microcredit upon the farm income distributions of formal agricultural financial institutions in area of the study. To achieve the aim of the study, this research applied the Gini-coefficient technique and descriptive analysis. Both primary and secondary data collected and used to attain the aims of the study. The primary data were collected using structured questionnaires on 100 randomly selected respondents through the multi-stage stratified random method. The findings indicate that the income of formal agricultural microcredit resources have equalizing positive effects upon income inequality. Assume *ceteris paribus*, an improvement in income share from formal agricultural microcredit resources will generate a reduction in total income inequality of household.

Keywords: Inequality effects; formal microcredit and income inequality

INTRODUCTION

Global concern is rising about the performance of the agricultural sector in view of its integral role in poverty alleviation, economic development and meeting an ever-increasing nutritional demand (Onoja, 2017). Agricultural finance is the provision of multiple types of services dedicated to supporting both on and off-farm agricultural activities and businesses including input provision, production, and distribution, wholesale, processing and marketing. The market demand for smallholder agriculture finance is US\$450 billion, most of which is unmet. Without access to credit, most smallholders are restricted to farming practices that result in low levels of productivity (FAO, 2015). Income inequality is a large problem in the world, the need to find methods in order to minimize income inequality between areas in countries and increase the living standard for the population is great (Ellertsson, 2012). Although access to microfinance does seem to improve the relative income position of the poor, this improvement is modest, which is probably because the use of microfinance is generally small as compared to the size of the economy of the countries in our sample. Microfinance should, therefore, not be seen as a panacea for bringing down income inequality in a significant way (Hermes, 2014). Sudan has endowed vast geographic area and varied natural resources, but unfortunately it is still classified as a low-income country, with income per capita of less than US\$ 400. The country holds great economic potential. So far, however, it has been a land of missed opportunity. It is also a land of great diversity: ethnically, geographically and ecologically, and it faces the challenge of utilising/capitalising on such diversity to achieve development and eradicate poverty (UNDP, 2006). Since the performance of the agricultural sector has a direct affect on the living standard particularly poverty rates, but in Sudan the development of agriculture and the high growth rates of the Sudanese economy during the last two decades didn't combated poverty incident which has dramatically increased. The potential of agricultural development is manifest in the large mass of productive areas and land still virgin and in the favourable land/man ratio. UNDP (2004) reported that an overwhelming proportion of the nearly two-thirds of the Sudanese who live in rural areas depend on agriculture for their livelihood. About 70% of the labor force is principally employed in agricultural sector. It is evident that in the foreseeable future the welfare of Sudan's population, especially of the poor who are largely located in rural areas, will to a substantial degree depend on the performance of the agricultural sector.

Agricultural finance is still considered as one of the main sources to enhance agricultural production in Sudan. It aims to invest and optimize the available resources use properly

to maximize farmer's income. Although recently the awareness regarding the importance of agriculture finance for agricultural investment as effective generator of farm income, employment, exported products and taxes as well as poverty combat and the natural resources sustainability, there is still crucial need for raising awareness about the role of agricultural finance for agricultural development. Ruben (2009) mentioned that the great potential of agricultural finance in issues of food security, poverty reduction, and preservation of natural resources must be emphasized in order to overcome the perpetual under-investment in public agricultural production in developing countries.

The formal agricultural financial system in the country is essential factors that pushing food crop production, but recently it faced numerous constraints in term of the provisions of both short and long-term agricultural finance that enforced the majority to depend on their own resources. Thus, the dominant agricultural financial policies reflected in large segment of tenants among the irrigated and semi-mechanized rain-fed sectors are not satisfied with formal agricultural finance system. Faki et al. (2003) stated that, despite the government stressed to solve credit constraints by devoting high percentage macro-finance for the agricultural sector, the majority of the farmers are suffered of shortage or/and limited of credit resources, that is the total amount of finance provided for this sector only 5% of the total cost of production and that led to a high percentage 53% of defaulters failed to repay about 77% of the total agricultural finance.

River Nile State is enjoying comparative advantages with agricultural production (i.e. wheat, faba bean, chickpea, dry beans, onions, vegetables, spices, sorghum, maize, potatoes and fodder beside some perennial crops). Crop production depends mainly on household members where farmers using low level of commercial physical agricultural inputs to decrease operation cost of production. In North Sudan the farmers deal with both formal and informal types of finance. The formal agricultural microcredit are provided by governmental financial institutions and commercial banks (i.e. agricultural ministries, ABS, Farmer's Bank), while the informal agricultural microcredit sources include relatives, friends, merchants and others beside some tenants depend on their own resources. It became impressive to trace the route of how to increase farm revenue and how income inequality gap can be controlled. Numerous researches have proof of the vital role of micro-finance in increasing income and alleviate poverty. Some of these studies are mentioned by Mohd Saifoul et al. (2013) such as Copestake et al. (2001), Rahman et al. (2009), Dunn (2005), Bernd Balkenhol (2005), Coleman (2006) and David S. Gibbons and Sukor Kasim (1990), Roslan et al. (2007) and Shaw (2004) all found that micro-credit is one of the effective tools for revenue improvement as well as poverty reduction.

METHODOLOGY

The farming system of the River Nile State can be described as not full-mechanized system as well as conventional in some areas. Winter season is regarded as the main season for producing food legume, cereal, and vegetable crops; recently, the RNS stretched investment in livestock and oil crops. The winter season crops are commonly produced under pump

irrigation from the River Nile to some extent as well as irrigated from underground water. This research depends on primary data as well as secondary data. The primary data was collected through field survey in RNS of North Sudan by using structured questionnaires through direct personal interviewing in season 2010/2011. The secondary data was collected from different relevant sources. It has been managed by a researcher. A total of 100 respondents determined through probability proportional method using random stratified sampling survey in the State. Selection of RNS compatible with dominant of agricultural activities implies poverty incident. The research also employed a descriptive statistical analysis through the computer software program SPSS by using frequency, distribution, and graphical analysis to achieve the objectives of the study.

For measuring inequality of income and decomposition, a decomposable measure of inequality namely Gini coefficient (Adams, 1994; Yao, 1997) is used where the total income earned by households can separate according to certain sources. Gini coefficient technique is an efficient tool to calculate the mean monthly household incomes collated from Household Income Surveys (HIS) which were conducted every two or three years as well as it can examine the contribution of the different sources of income to total inequality. Based on this context a spatio-temporal dimension of poverty has been possible to expose exhibiting the poverty incident dynamics in North Sudan. Descriptive statistical analysis also applied to attain stated aims. In this part of the analysis frequency distribution, statistical analysis and graphs was used. Yao (1997) has presented the Gini coefficient approach in a new partition, it seems more easy to use regardless the population is categorized or not. In this new approach that referred to Yao, households are divided into n groups. Suppose m_i denote the average income of group i ($i=1,2, \dots, n$), m the average income of total population, p_i the population share of group i , and w_i , where $w_i = p_i m_i / m$, is the income share of group i in total income. Yao (1997) mentioned that Gini index measures total income inequality as follows:

$$G = 1 - \sum_{i=1}^n p_i (2Q_i - w_i), \quad i = 1, 2, \dots, n, \quad (1)$$

Where

$$\sum_{i=1} p_i = 1, \quad \sum_{i=1} w_i = 1, \quad w_i = \frac{p_i m_i}{m}$$

and

$$Q_i = \sum_{k=1}^i w_k, \quad k = 1, 2, \dots, n$$

Q_i is the product of income share from group 1 to group i and p_i and w_i follow descending order of m_i ($m_1 \geq m_2 \geq \dots \geq m_n$). Thus, assume that the amount of income earned from F sources. Let $w_{fi} = p_i m_{fi} / m_f$ represents the portion of the income for group i in the total income

arising from factors $f(f = 1, 2, \dots, F)$, where p_i is defined as above, m_f the mean income of the population for factor f , and m_{fi} is the mean income of the group i . If p_i 's and w_{fi} 's arranged so they automatically follow descending order of group average income m_{fi} (or $m_{f1} \leq m_{f2} \leq \dots \leq m_{fn} \dots \leq m_{fn}$), The Gini coefficient for income source f is defined as follows:

$$G_f = 1 - \sum_{i=1}^n p_i(2Q_i - w_{fi}), \quad (2)$$

Where

$$\sum_{i=1}^n p_i = 1, \text{ and } Q_{fi} = \sum_{k=1}^i w_{fk}$$

This is the cumulative income share of group 1 to i with p_i 's and w_{fi} 's following $m_{f1} \leq m_{f2} \leq \dots \leq m_{fn} \dots \leq m_{fn}$. If p_i 's and w_{fi} 's follow descending order of group average total income, m_{fi} 's, and instead of group average factor income, p_i 's, the same equation can be applied to compute the factor concentration ratio (concentration ratio), C_f , as underneath:

$$C_f = 1 - \sum_{i=1}^n p_i(2Q_{fi} - w_{fi}), \quad (3)$$

$$G = \sum_{f=1}^F w_f C_f \quad (4)$$

Where:

$$\sum_{f=1}^F w_f = \sum_{f=1}^F \frac{m_f}{m} = 1.$$

It is clear that Gini coefficient or Gini index of total income is the weighted average of the concentration ratio. Therefore, the decomposition of the Gini index involves only factor concentration ratio, C_f 's, and factor income shares in total income w_f . It doesn't involve the computation of factors Gini index C_f 's. By dividing C_f (factor concentration ratio), with G (total Gini index), It will produce g_f (relative concentration coefficient), that can be defined as:

$$g_f = \frac{C_f}{G}, \text{ and } \sum_{f=1}^F w_f g_f = 1 \quad (5)$$

The relative concentration ratio, g_f , indicates the effect of income source f on total inequality. If the g_f value for an income factor is greater than unity, that means the income factor is the inequality-increasing factor, which indicates, *ceteris paribus*, an enlarged share of that total income factor will leads to an increase inequality of total income. Conversely, if the g_f value for an income factor is less than unity, that means the income factor is be inequality-decreasing factor. The contribution percentage of an income source can be determined multiplying $w_f g_f$ value of income source by 100.

RESULTS AND DISCUSSION

The socioeconomic profile of the tenants in an area of study may show the interaction between the community and development process. No doubt, high crop productivity and household returns are linked directly to farm sustainability and thus contribute significantly to rural development and living standard of household. Socio-demographic profile of the surveyed tenants in River Nile State were represented that: the mean age of surveyed tenants in the State was 40 years old, while the average family's size of surveyed tenants ranged as 1 to 15 persons. The research unveiled that all surveyed tenants were educated. Farming experience of surveyed respondents estimated at 20 years on the average, while 65% of the household's farm size in the State was less than 20 feddan (see Table 1).

TABLE 1 Household farm size in river Nile state

<i>Item</i>	<i>Frequency</i>	<i>Percent</i>
1–5 fed	18	18
5–10 fed	25	25
11–15 fed	10	10
16–20 fed	12	12
21 and above	35	35
Total	100	100

One feddan equal 0.42 hectare

The average distance from tenant's residential area to their farms location estimated at 2.7 km. The study revealed that the farming system in the State is mainly occupied by potatoes which cover about 20% of the total cultivated land (see Figure 1).

Figure 1 shows that the majority of the cultivated land (44%) occupied by numerous vegetables (tomatoes, potatoes, onions, carrot and others) followed by cereals (wheat and maize) and food legumes crops with similar area of (23%), while alfalfa and fodder occupy small areas (10%). This combination changes from one season to another according to price levels.

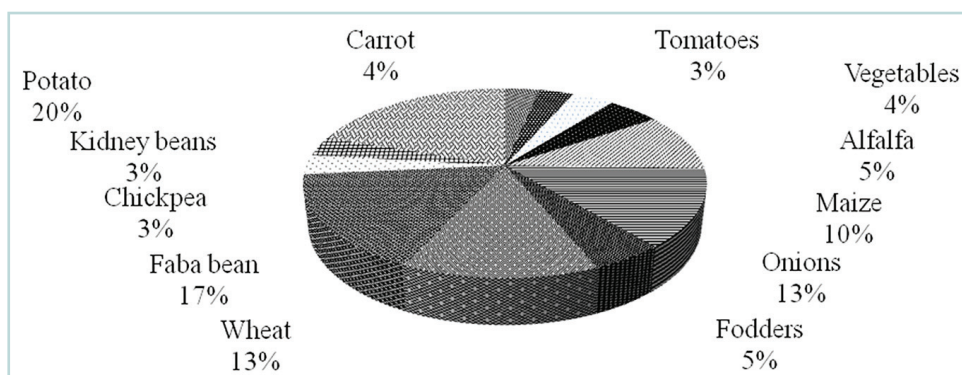


FIGURE 1 Prevalent crop combination at surveyed tenancies

Cost of Crop Production

Production costs play a unique role in producing annual crops where material-input costs largely influence earned profits (Doll and Orzem, 1984). Cost of crop production in the State usually covers the essential inputs of production (i.e. labour, seeds, Fertilisers, irrigation), services, and farming management. The important fact that producers always try to avoid the high cost of production because it may lead to low profit. In northern Sudan, the high cost of crop production is attributed to high cost of some of production inputs. The study revealed that a one third (1/3) of surveyed tenants are rented land, while 25% of respondents are shared land with others under a particular production relationship and the rest of the farmers (42%) considered as land owners. This result indicates the high percentage (60%) of tenants in the State are poor farmers and susceptible for poverty incident. The RNS tenants suffer from the high cost of crop production and they spend high amount of their resources to finance their field crops by about 3,647 SDG/fed.

Figure 2 shows that about 15 cost components constitute the bulk of production where land rent cost component is absolutely considered as the most agricultural constraint facing field crop production, having the highest cost item at 17% of total production cost. This might refer to the scarcity of fertile land and the high demand for agricultural land particularly in winter season. This is ranked by seeds component, which is also regarded as one of the most important agricultural hindrances that is caused by the high cost of seed production or/and high importation cost; and justifies the need to improve local seed industry and devote more efforts for research and breeding. The underneath elaboration of the survey results in Figure 2 illustrates the 15 cost components in terms of field crop production operations.

Land rent component is formed the highest expensive resource due to the limitation of arable land which led to high demand for land particularly in winter season. The majority of surveyed tenants complained about the high cost of inputs particularly land rent and seeds.

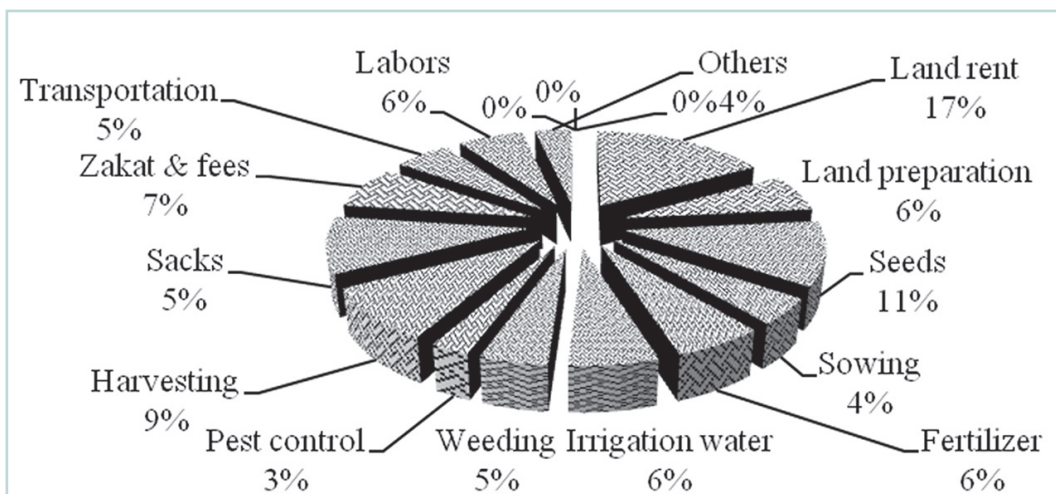


FIGURE 2 Share percentages of variable cost components for RNS field crops

Formal Agricultural Microcredit Sources in the State

The results of the study revealed that formal agricultural microcredit in the River Nile State usually receive from Agricultural Ministry of the State and Agricultural Bank of Sudan (ABS). ABS finances farmers either in kind such as inputs or amount of cash regarded in most time as a proportion of total production cost with a particular interest rate. Thus, a formal agricultural microcredit resource is considered as insufficient to cover the real farm operation costs. The farmers usually receive physical inputs of production such as seeds, land preparation, fuel, pesticides, harvesting, and others. Unfortunately, the process to receive these inputs is inconsistent with the proper time of beginning the season, and this delay always leads to a reduction in crop productivity. Because of this inconvenient process of formal agricultural microcredit, some famers seek to informal finance to avoid financial risks during the winter season. Formal agricultural microcredit is regarded as fundamental alternative sources of finance for the farmers in the state and it is known without interest rate. The main sources of informal finance are local merchants and relatives (see Figure 3).

The study revealed that both of the formal agricultural microcredit and informal agricultural microcredit mentioned above contributed to the farm finance with close percentages as 51% and 49% respectively. The Figure 3 also shows the main components of informal agricultural microcredit where 80% of respondents seek informal finance from village merchants, while 17% of them have to use their own, and 3% have to depend on their relatives.

MAJOR FINDINGS OF INEQUALITY IN RIVER NILE STATE

There are numerous sources for farm and off-income in the State, but the most common source of farm income is the sale of produced field crops and livestock. Off-farm income is still essential sources for State tenants to improve their living standard as well as to avoid farm production risk. Table 2 and Table 3 illustrate the distribution of total household income from differenet sources in the State. Table 2 shows that 30% of the tenants obtain SDG 2000 or less per season which is relatively low. About 39% of respondents earn more than SDG 6000 per season, and 24% of the surveyed tenants earn between SDG 2001 to SDG 4000. While 7% receive income ranging between SDG 4001 to SDG 6000 per season. The average amount of income received by the household is SDG 7,392 per season.

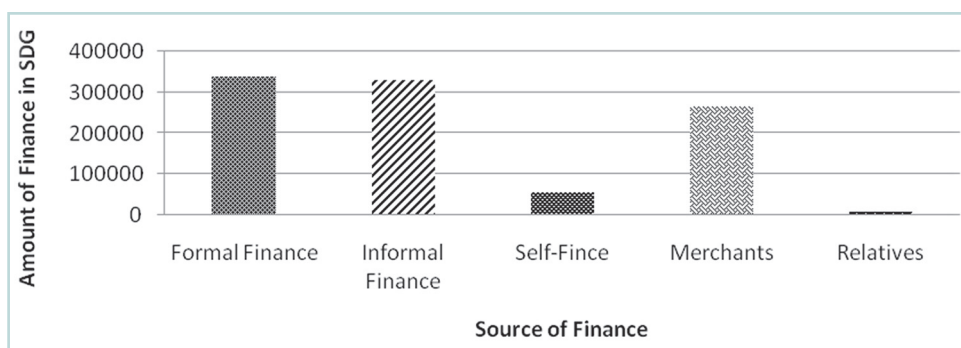


FIGURE 3 Average value provided by the main financial sources

TABLE 2 Distribution of total household income (SDG/Season)

<i>Income range (SDG/Season)</i>	<i>Number of tenants - formal financed farm</i>	<i>Percent</i>
2000 or less	30	30
2001–4000	24	24
4001–6000	7	7
More than 6000	39	39
Total	100	100

TABLE 3 Descriptive statistics of total household income (SDG/Season)

Mean	6685
Minimum	600
Maximum	25000
N	100

Structure and Distribution of Household Income

Contribution of microcredit to agriculture is tremendous, it can be consider as an efficient generator of income, employment, state revenues (tax) as well as its ability to combat poverty and natural resources conservation. It is a challenge to increase awareness and knowledge regarding the importance of agricultural finance for developing agricultural sector. The research revealed that income sources derived from formal and in formal agricultural microcredit in River Nile State. These sources of farm finance consider the main contribute directly to farm production, thence to farm income. As shown in Table 4, the income derived from activities financed by formal agricultural microcredit contributes 51% of the total farm income. While, about 49% come from other informal agricultural microcredit or without any contribution of formal microcredit. This explains clearly the essential role of formal agricultural microcredit in raising farm income and improving living standard of tenants in the State. Furthermore it would enable farmers to sustain their farm investment, thus could achieve food security and poverty reduction.

TABLE 4 Structure of total household income

<i>Income</i>	<i>Source of income</i>		<i>Total</i>
	<i>Formal Financed Farm</i>	<i>Informal Financed Farm</i>	
Total income (SDG)	339,270	329,220	66,8490
Share % in total household income	51%	49%	100.00%

1SDG=0.17 USD (2015)

This fact is consistent with the findings of the research conducted by Ruben (2009). He pointed that the great potential of agricultural credit in issues of farmer's living standard particularly food security, poverty alleviation, and efficiency of farmer sources use must be emphasized in order to overcome the perpetual under-investment in public agricultural production in developing countries. Furthermore, easy access to agricultural finance services will encourage farm production activities thereby increasing income and wealth. This conclusion of this part might lead to an important question regarding income inequality among tenants in the State. Does the obtained farm income under agricultural microcredit will create variation between the State tenants? Table 5 depicts Distribution of income among formal financed farm. The income inequality between the two mentioned segments is very clear.

TABLE 5 Frequency analysis of income among formal financed farm

<i>Income range (SDG/Season)</i>	<i>Number of tenants - formal financed farm</i>	<i>Percent</i>
2000 or less	52	52
2001–4000	25	34
4001–6000	10	10
More than 6000	13	13
Total	100	100

From Table 5, note that the majority 52% of financed household obtain SDG 2000 or less per season which is relatively low. Indeed 13% of financed household receive more than SDG 4500 per season. The average total household income gained by financed household is SDG 3390 per season (see Table 6).

TABLE 6 Descriptive of income received from financed farm (SDG/Season)

<i>Descriptive statistics</i>	<i>Income received among tenants/ financed farm</i>
Average	3,390
Minimum	600
Maximum	25,000
N	100

Interrelation between agricultural micro-credit and inequality

Table 6 shows the Gini coefficient for income from formal agricultural microcredit sources and income from informal agricultural microcredit resources sources and total household income. The Gini coefficient for the total household income is 0.221 which implies that the distribution of the total household incomes amongst the surveyed respondents intended to be equal. The estimated coefficient Gini income of farms financed by formal agricultural microcredit is high at 0.739, this shows that the income distribution is uneven in the category of resources. While the computed Coefficient Gini income of farms financed by formal agricultural micro-credit is 0.698. There search unveiled that the total inequality overall revenue decreased

when revenue from formal agricultural microcredit sources computed together with income from informal agricultural microcredit source as depicted by the Gini coefficient of 0.221 (see Table 5). Table 7 reflects that the opportunity household income derived from formal agricultural microcredit sources contribute to overall income inequality. Household's income other than income from farms that finance by informal agricultural microcredit which includes such as relatives, self-finance and merchants.

TABLE 7 Impact of micro-credit financing

<i>Sources of income</i>	<i>Gini coefficient</i>
Income from formal agricultural microcredit	0.739
Income from informal agricultural microcredit	0.698
Income from all sources (total income)	0.221

Income obtained from formal agricultural microcredit sources improves income equality among respondents under study (Gini coefficient 0.739) and increase the probability for income inequality (Gini coefficient of 0.221). Based on these finding an important question might unveils, that either income gained from formal agricultural microcredit sources contributed to equality or inequality?.

In other words, the study aims to examine how far the contribution of income inequality under formal agricultural microcredit sources on the total income inequality. Thus, in this case decomposition of total Gini coefficient is needed. The previous research question is quite interesting because it may leads to reveal the contribution proportion of income sources to inequality not only in term of inequality degree (magnitude for each source as shown in Table 7), but also in term of share or/and relative importance of income sources in total income of households. Thus, the results indicate that the income gained by formal agricultural micro-credit sources was highly unequally distributed when examined by Gini coefficient (0.739) as illustrated in Table 7.

Although the results in Table 7 show that income from formal agricultural microcredit sources has a clear share in total households' income. These results can be clarified and confirmed through decomposition of Gini index. In other words, to assess the contribution of income sources on total income inequality of formal agricultural microcredit, we should to separate the inequality Gini index. Decomposition of Gini index as proposed by Yao (1997) that directly examine each of income sources increase or decrease inequality. This is because of income source that could be known by observing the relative concentration coefficient (g_f) yielded from the Gini inequality decomposition. As stated earlier, if the relative concentration coefficient (g_f) greater than one, that indicates an income source had a disequalising (negative) effect on total inequality, while a value less than one implies that the income source had an equalising (positive) effect on inequality. Table 8 Illustrates a summary of Gini decomposition. From Table 8, the share percentage of income from formal agricultural microcredit sources is 50.8%, while its contribution to the total inequality is about 46%.

TABLE 8 Summary results of Gini coefficient by income sources

<i>Income Sources</i>	m_f	w_f	G_f	C_f	$w_f C_f$	$g_f = C_f / G$	$w_f g_f$	<i>Contribution %</i>
FAM*	3392.7	0.51	0.739	0.377	0.155	0.897	0.46	46.00
IAM*	3292.2	0.49	0.698	0.306	0.186	1.106	0.54	54.00
Total	7391.9	1.00	0.341	0.341	0.341	1.000	1.00	100.00

*FAM=Formal agric microcredit

*IAM=Informal agric microcredit

This reflects that the income from formal agricultural microcredit sources has an equalising effect on inequality since its share in the total income is less than its share in the total inequality. This is already pointed by g_f or the relative concentration coefficient for formal agricultural microcredit sources since the value is less than one. Thence, assuming *ceteris paribus*, stretching income share from formal agricultural microcredit sources will create a reduction in total income inequality.

CONCLUSIONS

Development of agricultural financial sector within a country endowed with agricultural resources like Sudan is essential to realise a conducive macroeconomic environment. Moreover, drawing more attention by the State for formal agricultural microcredit sources is needed because of their importance in financing small scale farms particularly that characterised as poor or low-income farm.

The formal agricultural microcredit might extract numerous benefits to the agricultural sector and will enable the farmers to increase investment and update farm technologies, hence they can increase farm production, improve household returns, contribute to food security, combat poverty, improve their standard living and sustain their farm production. Furthermore, successful formal agricultural microcredit could bring tremendous benefits to economy such as decreasing country unemployment through generating new job opportunities especially in rural areas. Thus, it will contribute significantly to the issue of income inequality distribution. Many empirical studies illustrated that formal agricultural microcredit contribute either positively or negatively to total income inequality of households, depending on the context household socio-economic characteristics in district. This research looks to assess the impacts of formal agricultural microcredit to inequality income distribution among the tenants considering informal agricultural microcredit in the River Nile State of North Sudan.

This research unveils some findings of the field survey for RNS of North Sudan, and it explored the importance of formal agricultural microcredit for realising a successful winter season among the region's farms and its impacts inequality income distribution among the surveyed farmers. The study conclusion obtained from a set of analytical tools represented that: the opportunity household income derived from formal agricultural microcredit sources contribute to overall income inequality. Household's income other than income from farms that finance by informal agricultural microcredit which includes such as relatives, self-finance and merchants. Income obtained from formal agricultural microcredit sources improves income

equality among respondents under study (Gini coefficient 0.739) and increase the probability for income inequality (Gini coefficient of 0.221). Based to the study findings, it is clear that formal agricultural microcredit in the State contribute significantly to income equality among the surveyed respondents relatively to the informal agricultural microcredit. It bears in mind that the contributions of household income components and the share percentage of income from formal agricultural microcredit sources might result an inequality of total household income. It is importance to consider it as a route for improve farm income of poor household, and hence combat inequality among the poor farmer segment achieving socioeconomic stability and farm sustainability. This is confirmed by the relative concentration coefficient (g_f) for income source from the formal agricultural microcredit where its value is less than one. This reflects that increase in share of income sources of formal agricultural microcredit will drive a reduction in total income inequality, and might lead finally to squeeze the gap of income distribution.

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BIOGRAPHIES

ELGILANY A. AHMED holds a Ph.D. from the University of Khartoum with a thesis on 'Economic Aspects and Water Use Efficiency in Public Pump Irrigated Schemes – A Case Study of River Nile State of Sudan. The application of the PhD research was done in University of Giessen in Germany. A few topics of current research interest, Economics of agricultural resources use with emphasis on water management, value chain development, and socioeconomic research.

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