

Agricultural Productivity and Poverty in Rural Sudan

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Executive Summary

While agriculture remains the mainstay for a large share of the population in Sudan, and rural poverty has seen a dramatic decrease (between 2009 and 2014/15), poverty remains relatively high among those engaged in agriculture. Households engaged in agriculture—either crop farming or raising livestock—see among the highest rates of poverty among households classified by their main livelihoods in Sudan. As these households form a major bulk of the total population, understanding why these households remain poor and identifying strategies for lifting them out of poverty is a key concern for researchers and policy makers. This concern occupies the primary motivation for this study.

Using data from the 2009 National Baseline Household Survey (NBHS) and 2014/15 National Household Budget and Poverty Survey (NHBPS), this study sheds light on the rural landscape in Sudan. This is done using measures of rural welfare, such as poverty, asset ownership, and consumption. The focus is on the relationship between poverty and the agricultural livelihoods of rural households, and the geographic variation in these relationships. Empirically investigating the constraints to improving agrarian livelihoods, specifically by improving agricultural productivity and profitability, may guide policy toward increasing incomes and welfare in rural Sudan. By examining regional variation in agricultural practices, region-specific recommendations are made to guide potential policy interventions.

Though rural Sudan has fared much better than urban Sudan between survey rounds, the number of poor remains higher in rural than in urban areas. In 2014/15, an estimated 36.1 percent of Sudan's population had per capita expenditure below the national poverty line. When measured against the international poverty line of US\$3.20 per person per day (moderate poverty, a standard typical for lower-middle-income countries), 46.1 percent of the population was deemed poor in 2014/15 (World Bank 2019). About two-thirds of the population of Sudan lives in rural areas while one-third lives in urban areas. The later survey shows an almost equal rate of poverty in the urban and rural areas, implying that approximately the same ratio of poor resides in urban and rural Sudan. However, rural areas tend to have a higher poverty gap, the ratio by which the mean level of measured welfare falls below the poverty line, reflecting a higher severity of poverty in rural areas.

Sudan severely lags other African countries in terms of agricultural productivity. Sorghum, Sudan's most commonly produced crop—grown by close to half the agrarian households—has seen yields increase from below 500 kg per ha in 1995 to almost 700 kg per ha in 2017. However, other African countries that are major producers of sorghum, with comparable average incomes, have significantly higher levels of productivity. Sudan's neighbor, Ethiopia, has achieved far higher rates of productivity growth of both sorghum and millet, Sudan's other staple crop. Sustaining gains in poverty reduction, particularly in rural Sudan, will require lifting income levels of agrarian households by increasing farm productivity and profitability. Given the low starting point for productivity in Sudan, this is an achievable policy goal.

A major constraint to improving crop productivity in Sudan is the low use of productivity-enhancing inputs, particularly fertilizers and pesticides and low-yield seed varieties. Increasing fertilizer and pesticide use and adopting high-yield seed varieties, often in conjunction, is perhaps the most direct way to increase household-level farm productivity, without requiring large-scale public investments in infrastructure. Differences in productivity exist between households that use such inputs and those that do not. Furthermore, the poor are far less likely to use these inputs, perpetuating a cycle of poverty.

Increasing the rate at which these inputs are used, especially by the poor, can go a long way in increasing productivity, thus reducing rural poverty. Such gains can be especially large in regions primarily engaged in subsistence agriculture, as the marginal returns from low usage rates can have substantial positive welfare impacts on the poorest communities in Sudan.

Increasing input use can be achieved by investing in rural markets. Improving input markets so that every rural farmer has market access to purchasing such inputs is the first step in ensuring that public policies that promote such input use, such as subsidizing the price of these inputs or promoting these products through public extension services, achieve their desired effect. It is vital that the gains from any such programs are directed toward the small-scale agrarian households that make up the bulk of Sudan's rural population; the universal presence of agrarian input markets in rural Sudan is necessary for such an outcome.

Market participation of agrarian households in Sudan is low, constraining farmers' ability to raise their income levels and escape poverty. Improved access to output markets is just as important as improved access to input markets. The current state of rural infrastructure imposes significant transaction costs and risks on farmers who grow and sell their farm produce in markets. In addition to low productivity levels, many Sudanese farmers, particularly the poorest, produce crops at close to subsistence levels of production and hence, consume most of their harvest rather than use it for market exchange. Improving these households' ability to market their produce profitably can motivate them to either grow above subsistence levels or to switch to production of commercial crops.

Improving rural transportation and telecommunications networks, providing access to rural credit and financial services, and increasing the ease of doing business for input providers and output marketers can increase the geographic penetration of agrarian input and output markets. Such investments will need to cater to the diversity of economic, social, and cultural norms of agrarian communities throughout Sudan. A thriving nonagricultural economy that services the agricultural economy is seen as an essential means of transforming low-productivity, subsistence agriculture to high-productivity, commercial agriculture.

Though sorghum and millet remain the dominant crops grown in Sudan, the recent increase in the number of households growing sesame is a welcome development. The growth of sesame as a commercial crop has seemingly improved the livelihoods of many Sudanese agrarian households. With a significant increase in the cultivation of sesame, the region of Kordofan has seen drastic reduction in poverty (except for the conflict-ridden state of South Kordofan). Further improvements in welfare can be achieved by increasing the potential of households to profit from the growth of this commercial crop, either by boosting productivity or by improving marketing channels to sell this crop.

Deteriorations in the irrigation infrastructure need to be reversed to ensure Sudan remains competitive in the export of commercial crops. Sudan's vast irrigation network requires increased investments to ensure continued productivity of the commercial crops grown on these lands, such as sugarcane, sesame, cotton, groundnut, wheat, vegetables, fruits, and green fodder. Export of these crops brings vital foreign exchange into the country. Increasing productivity by investing in agriculture and irrigation will ensure that this sector continues to not only provide for the livelihoods of agrarian households but also provides vital employment for agrarian laborers working on commercial-size farms.

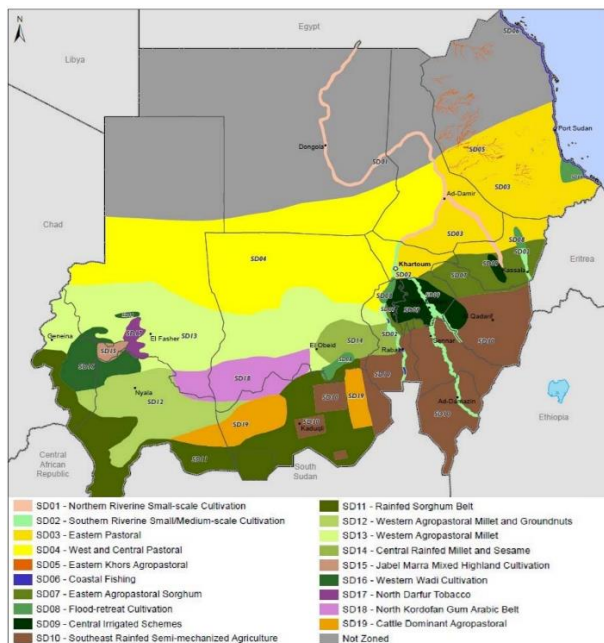
Access to cell phones has significantly increased channels of communication for the rural poor. Leveraging such channels to provide information on best practices, including in agriculture, can aid these households in making more productive decisions. Improved coverage can serve not only as a communication tool but also as a platform for service delivery in rural areas, especially for financial services. Like other countries in the region, the use of mobile-based money transfer networks can vastly increase financial transfers and transactions in rural communities, and may one day provide a means of accessing credit for credit-starved small-scale agrarian households.

I. Introduction

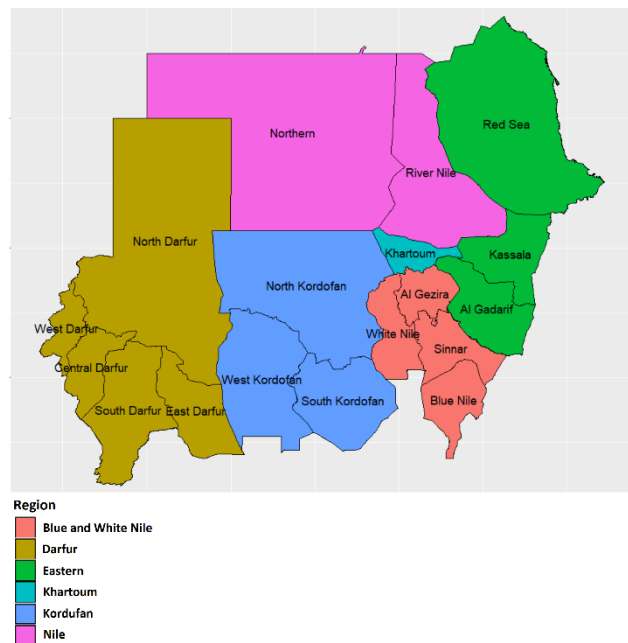
As one of Africa's largest countries, Sudan has immense ethnic, cultural, geographic, and ecological diversity. There are 19 major ethnic groups and more than 100 spoken languages and dialects, showcasing the combination of the original inhabitants of the Nile valley and migrants from the Arab peninsula. At the intersection of the Sahel and the East Sudanian Savannas, while possessing the longest flow path of the world's longest river, the Nile, Sudan's agro-ecological diversity mirrors its ethnic and cultural diversity, with 19 distinct agricultural livelihood zones defined within its boundaries (Figure a). Administratively, Sudan is divided over 18 states. This report uses six regions for classifying these 18 states, as seen in Figure b.

Figure 1: Agricultural Livelihood Zones

(a) Agricultural Livelihood Zones



(b) States and Regions of Sudan



Source: FEWS NET 2015.

Agriculture is the backbone of the Sudanese economy, generating one-third of gross domestic product (GDP) and a labor share of more than 50 percent (Figure 2). In 2000, agriculture's contribution to the GDP of Sudan was estimated at 40 percent (expressed as a percentage of value added) with a labor share of about 60 percent. With the discovery and production of oil, the economic importance of agriculture decreased significantly. However, since the secession of South Sudan in 2011 and with it three-quarters of the oil output and two-thirds of foreign exchange earnings, agriculture has reemerged in economic prominence. Agriculture's share of GDP, which was estimated at 24 percent in 2011, increased to 33 percent in 2012. Similarly, labor's share in agriculture, which stood at 50 percent at the time of South Sudan's secession in 2011, increased to 54 percent in 2012. The reemergence of agriculture in economic importance after the secession of South Sudan necessitates an investigation of the strengths and weaknesses of the sector.

Figure 2: Agriculture's Contribution to Sudanese Economy



Source: 'Agriculture Value Added' from World Development Indicators (WDI 2018).¹

'Agriculture Labor Share' from ILO (International Labour Organization) (ILOSTAT 2018).²

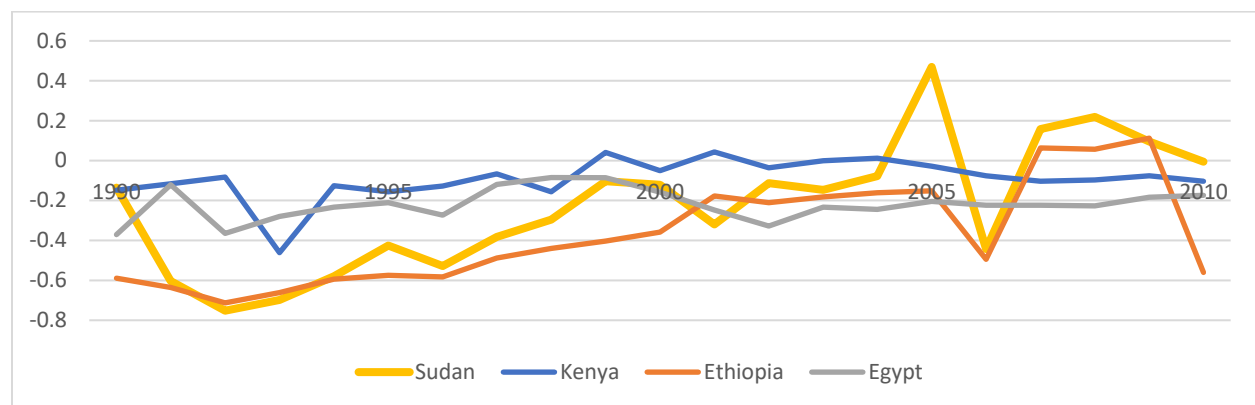
Since the early 1990s, the relative rate of assistance (RRA)³ (a measure of pro-agricultural policies), has been increasing for Sudan (Kym and Signe 2013). This measure has increased from being negative (indicating an anti-agricultural bias) to being slightly positive (indicating a pro-agricultural bias). Policies that restrict the export of agricultural commodities and promote the industrial sector by taxing the agricultural sector contribute to negative values for the RRA, as was observed in the early 1990s. As Sudan has reversed these policies, much like other African and developing countries, this indicator has steadily increased. However, since the 2007–08 world food price crisis, the increasing trend in this measure has reversed slightly. The increase in the RRA since the early 1990s, indicating an improving policy environment for the agricultural sector, may be a reason for the significant declines in rural poverty (as shown in Section II).

¹ <https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=SD>.

² <https://www.ilo.org/ilostat/>.

³ The relative rate of assistance (RRA) is calculated using the nominal rate of assistance (NRA) for the agricultural sector and the NRA for the nonagricultural sector, by calculating $RRA = 100 \times \left[\frac{100 + NRA_{ag}}{100 + NRA_{nonag}} - 1 \right]$. The nominal rate of assistance for each sector is computed as the percentage by which government policies have raised gross returns for farmers above what they would be without the government's intervention (or lowered them if $NRA < 0$). The RRA being below (above) 0, "provides a useful internationally comparable indication of the extent to which a country's sectoral policy regime has an anti- (pro-) agricultural bias (Kym 2010)."

Figure 3: Relative Rate of Assistance for Sudan and Neighboring Countries 1990–2010



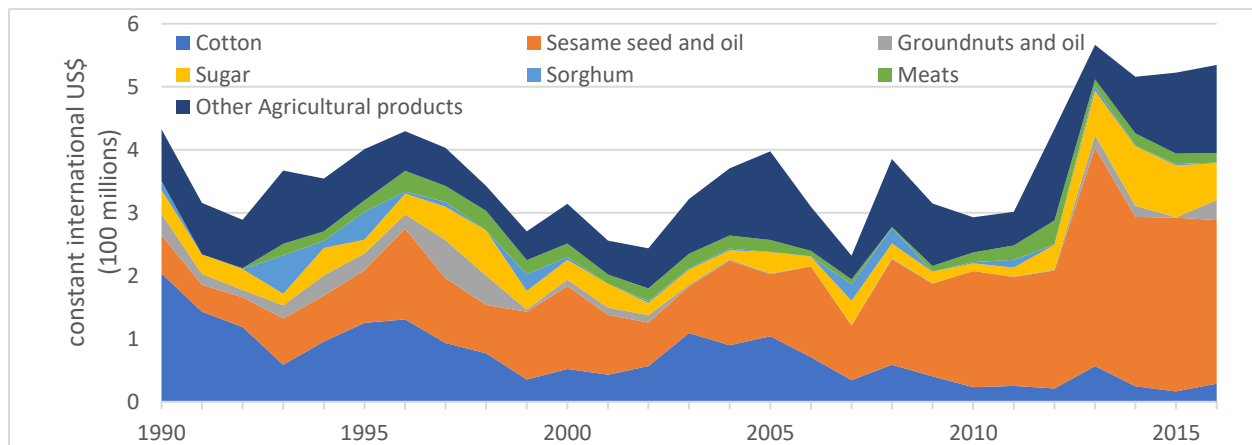
Source: Kym and Signe 2013.

A sharp increase in agricultural exports since the independence of South Sudan has been driven largely by an increase in the sale of sesame and sugar (Figure 4a). Though these are only a share of the value of the lost oil exports, the rapid increase in agricultural output demonstrates Sudan's tremendous agricultural productive capacity. These developments are also indicative of agriculture's ability to serve as a vital source of foreign exchange (Figure 4b) and to provide raw materials to the country's nascent food industry (World Bank 2018). More recent reports (FAO 2019) suggest that Sudan has been able to further capture the international market for sesame seeds, due to favorable weather, and reduced exports from other major producers.

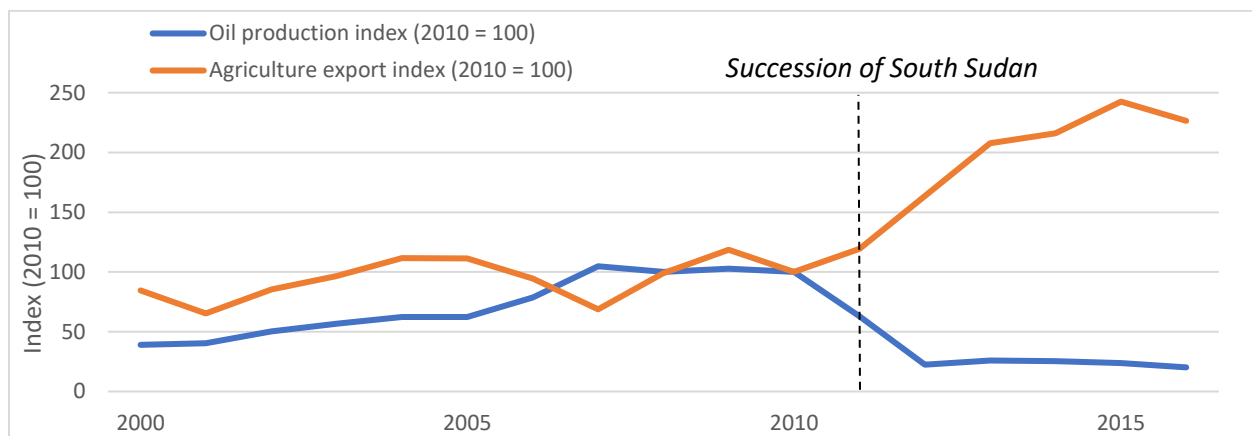
This increased prominence of agriculture in the Sudanese economy has been interpreted as evidence of a reverse 'Dutch Disease'. This term describes the apparent causal relationship between the sudden increase in the energy sector and the decline in other sectors of the economy, such as agriculture and manufacturing. Sudan has experienced a reversal of this phenomenon due to the sudden decline in oil production. How Sudan copes with this change in economic fortunes will be vital in ensuring the prosperity of the Sudanese economy and its people, especially the most economically vulnerable, such as the rural poor. Agriculture has an important role to play in this economic transition. This report shows that investing in agriculturally productive Sudanese households can lead to significant improvement in their welfare and the prosperity of the nation.

Figure 4: Value of Agriculture in the Sudanese Economy

(a) Agricultural Exports since 1990



(b) Agricultural Exports and Oil Production since 1990



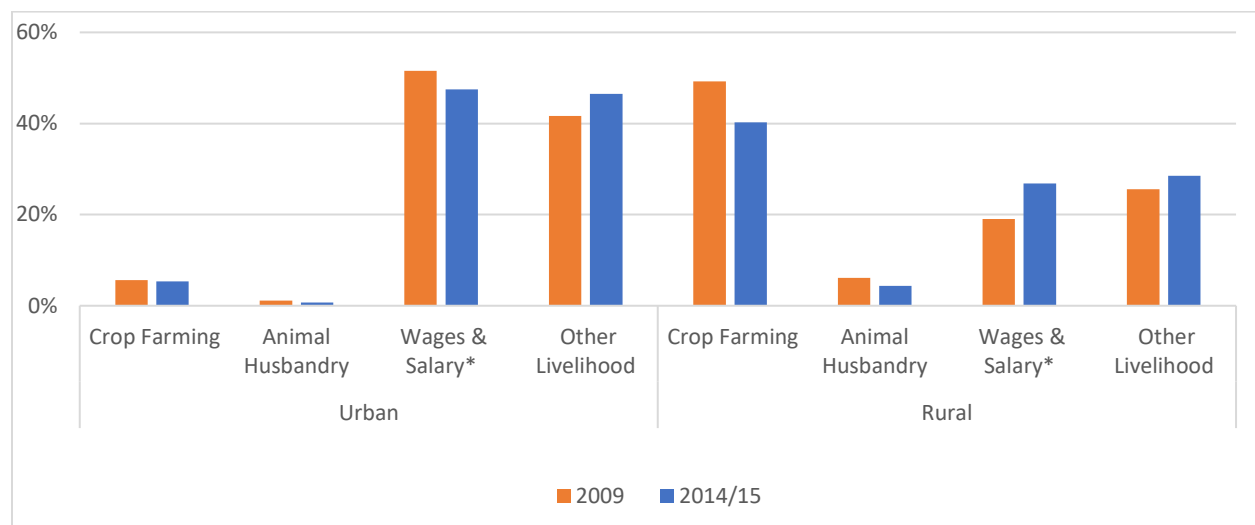
Source: FAOSTAT 2019⁴ and IMF 2018.⁵

Agriculture, particularly crop farming, is an important source of livelihood for Sudanese households, particularly in rural areas (Figure 5). In 2014, 40 percent of rural households identified crop farming as their main livelihood. Despite the decrease from 50 percent in 2009, crop farming still represents the most common source of livelihood in rural Sudan. In urban areas, only around 5 percent of households engage in crop farming (which is likely to be peri-urban farming). Around 5 percent of rural households identified animal husbandry as their main source of livelihood. Agriculture's importance to households in rural Sudan links the study of the rural economy with understanding the agricultural decisions and outcomes of these agrarian households.

⁴ <http://www.fao.org/faostat/en/#data>.

⁵ <https://www.imf.org/en/Data>.

Figure 5: Main Livelihoods of Sudanese Households, 2009 and 2014/15



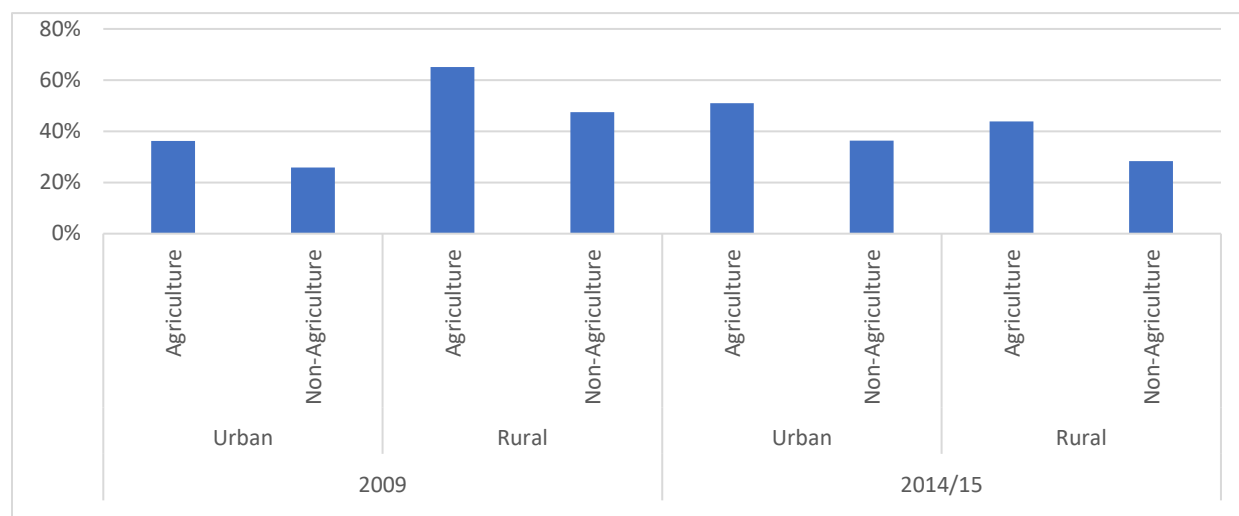
Source: Authors' calculations using 2014/15 NHBPS and 2009 NBHS.

Note: * 'Wages and salary' may include some households that are employed in agrarian work but are paid in wages. The individual survey, as opposed to the household survey, suggests that around 20 and 30 percent of such individuals in rural Sudan were in fact farming crops or raising livestock in 2009 and 2014/15, respectively.

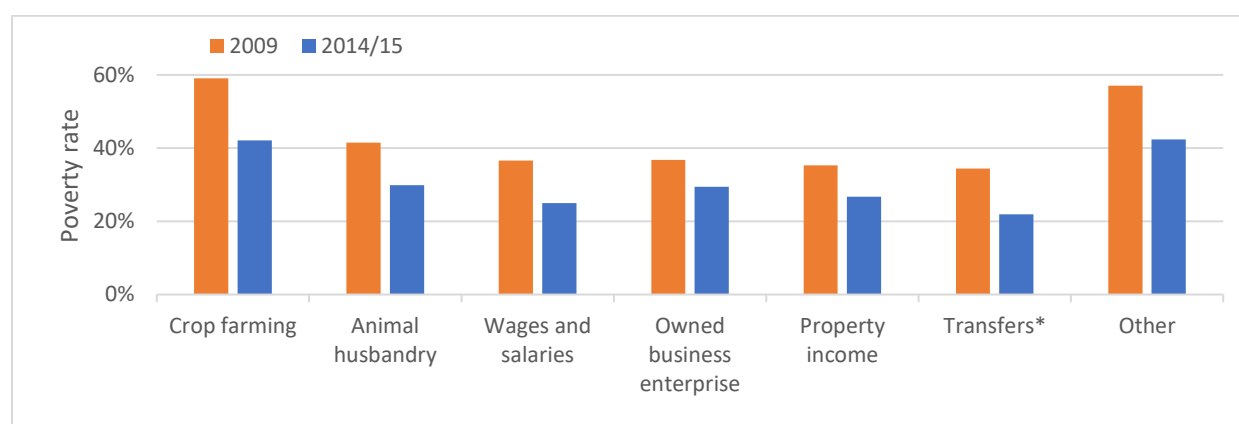
Poverty rates among agricultural households are significantly higher than the poverty rates of nonagricultural households (Figure 6a). This disparity is observed both in the rural and urban population and holds true for both 2009 and 2014/15. Though overall rural poverty has reduced significantly between 2009 and 2014/15, this disparity has stayed almost constant. Within rural Sudan, poverty is especially high for those engaged in crop farming, as opposed to those engaged in animal husbandry (Figure 6b). The higher rates of poverty for agrarian households further motivate this study to examine agricultural production in Sudan and its impacts on household welfare.

Figure 6: Poverty Rate by Agricultural/Nonagricultural Household and Livelihood Type, 2009 and 2014/15

(a) Poverty Rate for Agricultural/Nonagricultural Households



(b) Poverty Rate by Main Livelihood Type in Rural Sudan



Source: Authors' calculations using NHBPS 2014/15 and NBHS 2009.

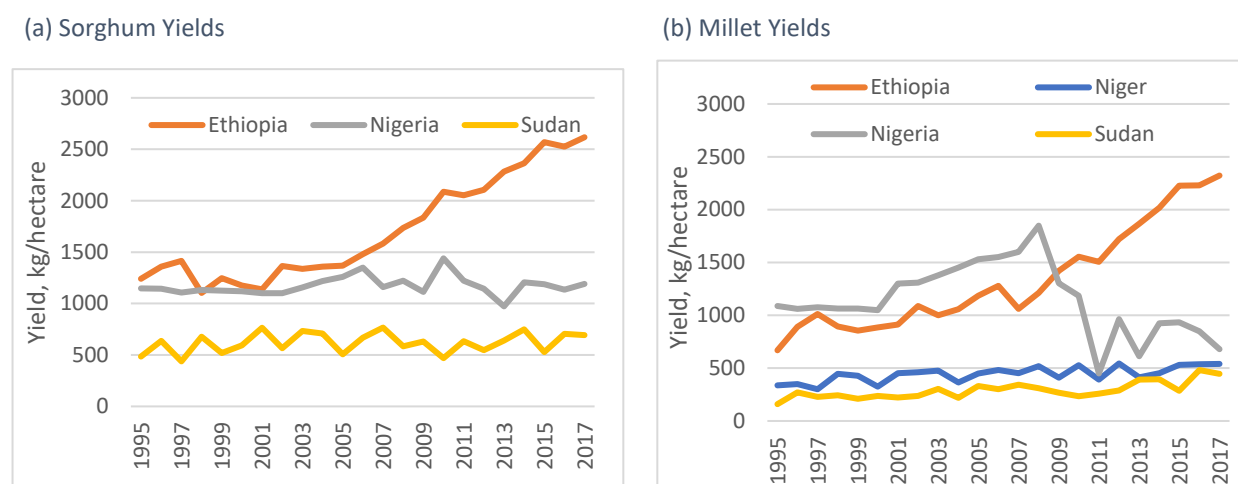
Note: *Transfers include main livelihoods from remittances, pensions, aid, and transfers from family members.

Reducing poverty, particularly for agricultural households, requires reforms that will boost incomes from agricultural activities. This paper aims to examine the relationship between agriculture and household welfare. With the significant loss of government revenue following the secession of South Sudan, agricultural growth has the potential to improve the welfare of Sudanese households. This entails not only increasing the agricultural productivity of Sudanese farmers but also improving access to markets, thereby allowing farmers to cheaply obtain productivity-enhancing inputs and get better prices for their marketable agricultural surplus.

Compared to other African countries that produce the same main crops as Sudan produces, Sudan has lagged in productivity growth (Figure 7). For instance, sorghum, Sudan's most commonly produced crop, has seen yields increase from below 500 kg per ha in 1995 to almost 700 kg per ha in 2017. However, this is lower than yields in Nigeria (1,200 kg per ha) or Ethiopia (2,600 kg per ha), the latter of which has seen a dramatic increase in yields over the past couple of decades, up from 1,200 kg per ha in the mid-1990s. Similarly, among the major producers of millet in Africa, Sudan has the lowest yields

despite recent improvements. Like sorghum, millet yields have grown dramatically in neighboring Ethiopia. These comparisons suggest that, by imitating successful policies implemented in countries that have seen rapid improvements in yield, Sudan too can increase agricultural productivity for all its farmers, from small-scale household farming to large-scale commercial enterprises.

Figure 7: Sorghum and Millet Yields in Top Producing African Countries



Source: FAOSTAT 2018.

Agriculture remains the mainstay of most of Sudan's poor though agricultural productivity is low. Hence, increases in agricultural productivity are expected to reduce poverty. Little is known about household-level constraints to productivity gains. By examining the decisions agrarian households make, we hope to shed some light on why these yields are low and how to foster productivity growth for Sudan's agrarian population. Understanding factors driving and hampering agricultural productivity is crucial for efforts to improve growth and reduce poverty.

This study will primarily use data from the Sudan 2009 NBHS and the 2014/15 NHBPS to provide insights into constraints to agricultural productivity to inform policy reform. This study explores the complexity of rural livelihoods in Sudan, with a focus on agrarian livelihoods, by highlighting regional variations in welfare, agricultural practices and productivity. This study also empirically investigates variation in household-level crop yields and relates this measure of agrarian productivity to household welfare as well as to key inputs and production variables. Factors contributing to variations in yield are identified by using household-level regressions. Focusing policy on easing these constraints to productivity (such as fertilizer/pesticide use, irrigation, crop choice, land title, and so on) can lead to improvements in productivity for the average agrarian rural households and welfare for all of Sudan.

Though the focus of this report is on rural and agrarian households, it is important to note that urban and rural welfare are closely related in developing nations such as Sudan. For example, rural livelihoods can improve by increasing agricultural productivity. Increased agricultural productivity has a direct positive effect on food producers—they can increase their own household consumption of the food they grow or they can sell some of their surplus in the market. In turn, the increased supply of food in the market could lead to a reduction in the price of food. This would increase the purchasing power and thereby the welfare of net food consumers, such as the urban poor. Just as increased productivity in the industrial sector can draw people away from rural areas, increased productivity in the rural economy

can drive people away from the urban sector or perhaps slow the migration out of rural areas. Increasing agricultural productivity can therefore “serve as a social buffer for the urban poor in periods of economic crisis or social urban unrest” (Anríquez and Stamoulis 2007). As Sudan has recently experienced both an economic crisis due to a drastic fall in oil revenues and urban unrest that has led to regime change, the importance of the rural economy cannot yet be discounted.

The remainder of this paper is organized as follows. Section II describes the state of the rural population in Sudan, by first discussing the spatial distribution of poverty across the states as well as changes in poverty levels between 2009 and 2014/15. It also describes the profile of poor rural households using characteristics such as their incomes, consumption, and assets.

Section III focuses on the practice of agriculture in Sudan. It documents the agriculture-specific characteristics of households, such as choice of crops, use of inputs, irrigation, plot size, and credit access. We use these characteristics to illustrate the profile of rural farmers in Sudan and identify differences between poor and non-poor farmers.

Section IV describes agricultural yields across Sudan and relates these measures of farm productivity to the previously described farm characteristics to identify constraints to agricultural productivity.

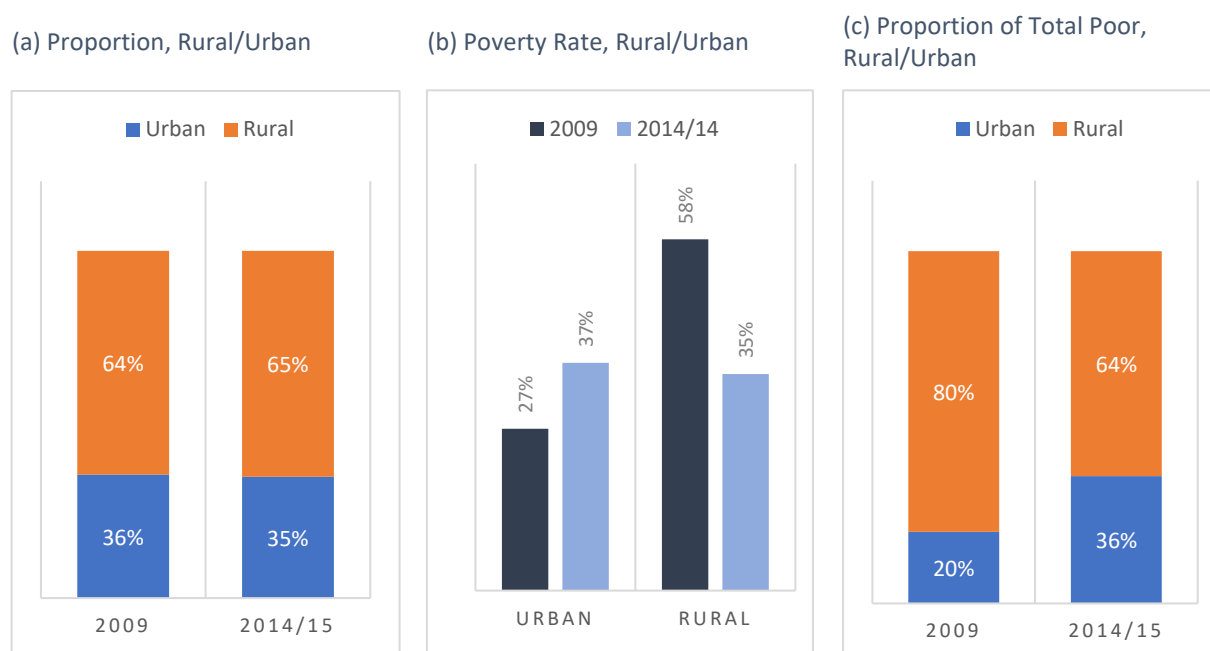
Section V concludes with a summary of the main findings and policy recommendations.

II. Description of Sudan's Rural Population

A. Rural Population and Poverty

The majority of Sudan's population is rural. There has been little change in the rural/urban composition of Sudan since 2009 (Figure 8a). Unlike most other developing countries in the development stage of their economic transition, the share of the rural population has increased, though only slightly, from 64 percent to 65 percent. While the poverty rates in urban areas have increased, the poverty rate in rural Sudan has decreased dramatically from 58 percent to 35 percent, and is now comparable to poverty rates in urban areas (Figure 8b). As the majority of Sudan's population is still rural, almost twice as many poor people reside in rural areas compared to urban areas (Figure 8c). By focusing on the welfare of these households, Sudan can achieve further substantial reductions in national poverty.

Figure 8: Rural/Urban Composition of Sudan's Population and Poverty, 2009 and 2014/15

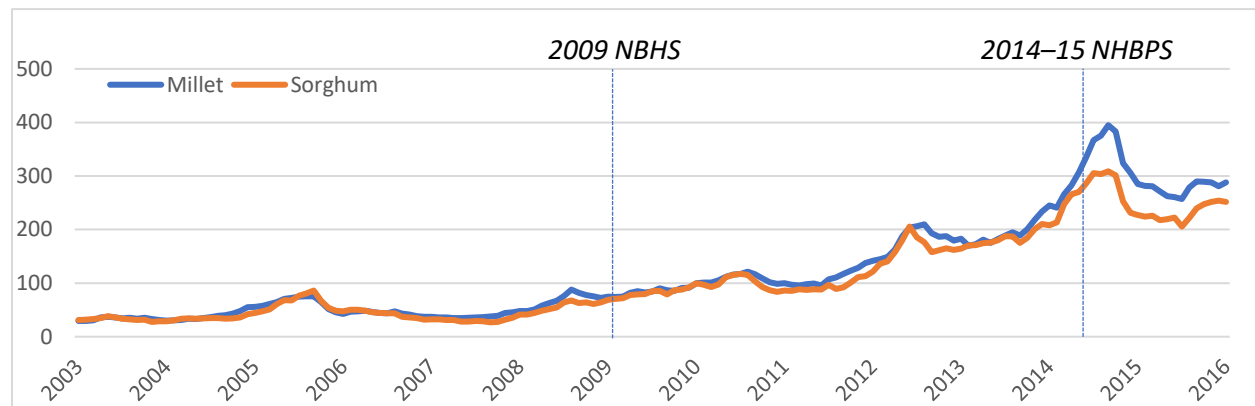


Source: Authors' calculations using NHBPS 2014/15 and NBHS 2009.

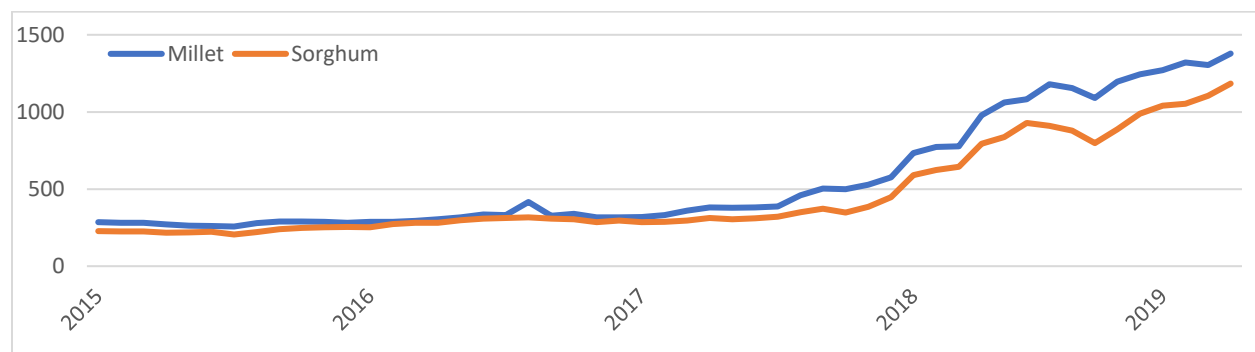
The increase in urban poverty and decrease in rural poverty might be explained by the relatively high prices of staples (Figure 9a). At the time NHBPS 2014/15 was conducted, both sorghum and millet prices had risen significantly, though they have since reduced. As the urban population is a net consumer of food and the rural population is a net producer of food, this increase in food prices may have had an adverse effect on urban households while having a beneficial effect on rural households. These price increases might have exacerbated the already prevailing negative effect on urban areas from the reduction in oil revenues. As noted in the introduction, increasing agricultural production can bring down food prices, thereby benefitting urban consumers. Food prices have been a contributing factor to the recent political instability, as prices have increased rapidly since 2018 (Figure 9b). Increasing Sudan's food production is therefore as vital for meeting Sudan's domestic consumption needs as it is as a source of foreign revenue.

Figure 9: Average Sorghum and Millet Prices across Sudan

(a) Average Sorghum and Millet Prices in Markets across Sudan 2003–2016 (2010 = 100)



(b) Average Sorghum and Millet Prices in Markets across Sudan, 2015–2019 (2010 = 100)

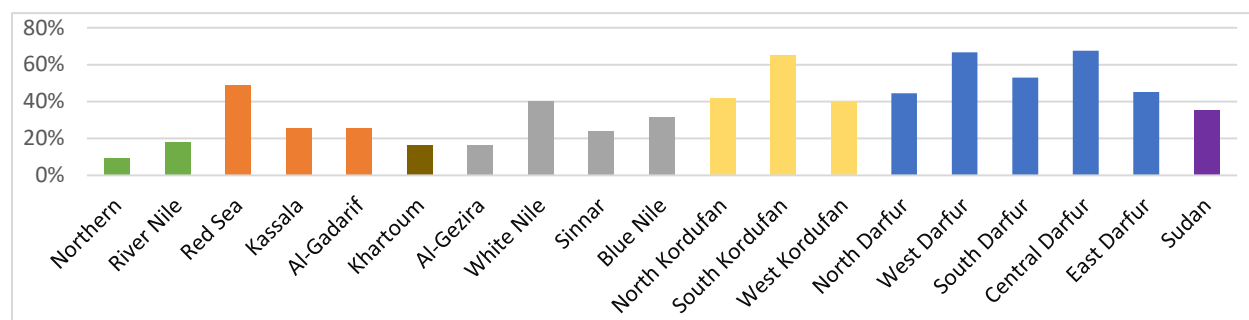


Source: Global Food Prices Database World Food Programme.

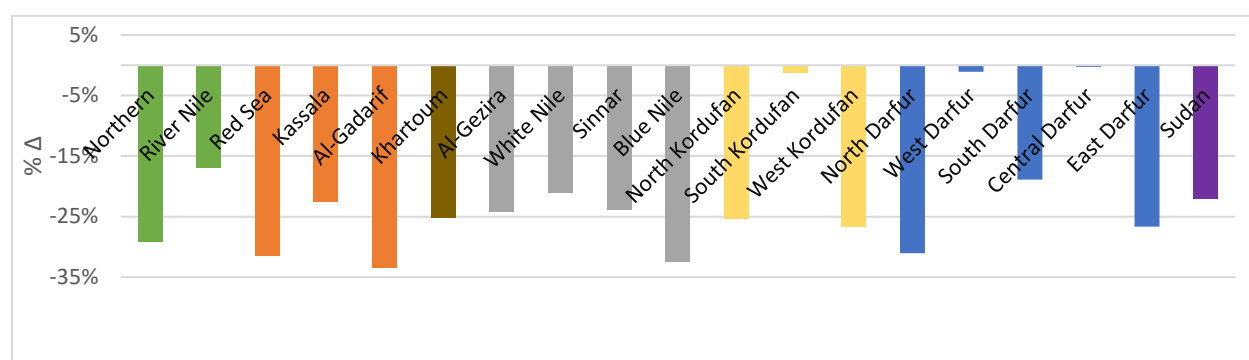
Rural poverty has reduced across regions of Sudan, although states experiencing civil conflict have not seen reductions (Figure 10). South Kordofan, West, and Central Darfur are the only states where rural poverty has not reduced. These states witnessed conflict due to separatist movements, which have led to greater disparities in poverty rates between these regions and the rest of Sudan. In 2014/15, these states had the highest rates of rural poverty. More recently, due to armed conflicts subsiding in Darfur, there has been a steady trend of internally displaced persons (IDPs) returning over the past few years (FAO 2019). As these households return to engaging in agriculture, the Darfur region’s agricultural production has also seen significant gains.

Figure 10: Rural Poverty in Sudan by State, 2009 and 2014/15

(a) Rural Poverty in Sudan, 2014/15



(b) Rural Poverty Change by State, 2009 to 2014/15



Source: Authors' calculations using NBHS 2009 and NHBPS 2014/15.

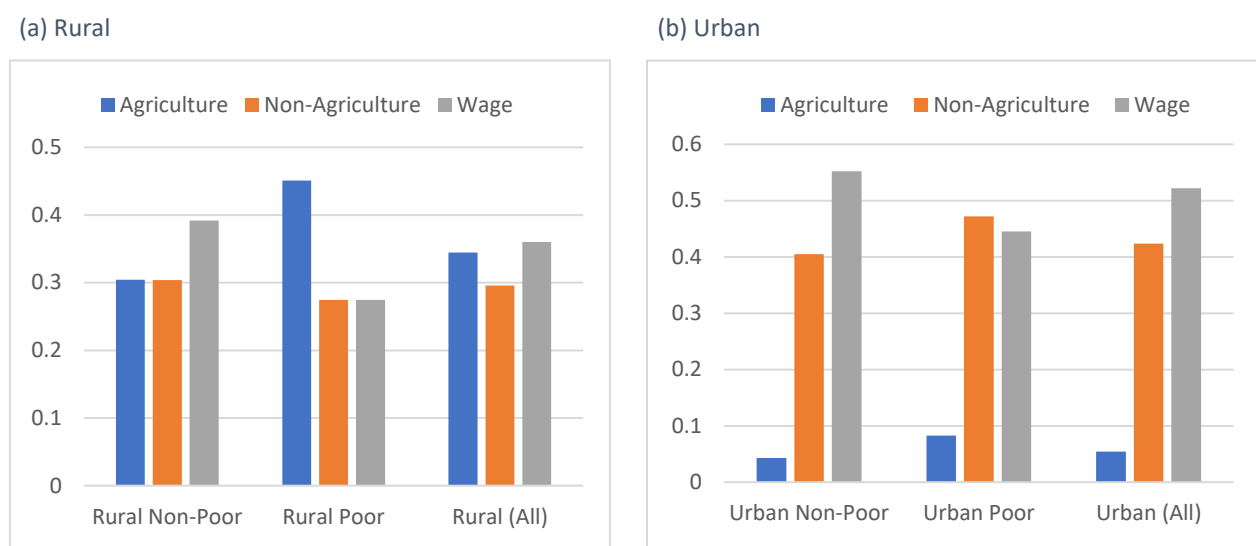
Note: Because the states in Kordofan and Darfur were split from larger states in 2014/15, we use the poverty rate corresponding to the parent state for the initial poverty statistic for those states.

B. Incomes, Consumption, and Assets in Rural Sudan

Incomes

The average rural household earns at least one-third of its total income from agriculture, while this is only 5 percent in urban Sudan (Figure 11). This is not surprising given that the majority of rural households depend on agriculture as a source of livelihood with little diversification into the nonagricultural sector. The dependence on agriculture is predominant among the rural poor, with at least 39 percent of the total income of the rural poor accruing from agriculture compared to 31 percent for the rural non-poor. Importantly, the actual reliance on agriculture is likely to be higher than these numbers suggest, as income from wages is often tied to agricultural employment. The surveys do not make it possible to accurately differentiate the source of wage employment.

Figure 11: Rural and Urban Incomes in Sudan, 2014/15



Source: Authors' calculations using NHBPS 2014/15 and NBHS 2009.

Across states, there is significant variation in the dependence on agriculture (Figure 12a). In the Darfur and Kordofan regions, agriculture is the main source of income for most households. In Khartoum, the Red Sea, and Al-Gadarif, nonagricultural activities and income from wages and salaries are the main sources of household income. In states such as Al-Gezira, Sinnar, Kassala, and the River Nile, wages and salaries are important sources of income for households, but due to the importance of irrigated agriculture in these states, such wages and salaries are mostly tied to agricultural employment.

Households in states in the irrigation belt rely heavily on wages and salaries as their main source of income (Figure 12a). These are in the Blue and White Nile regions of Sudan, including the states of Al-Gezira, the White Nile, Sinnar, and the Blue Nile, and in the rural areas of the states of Khartoum and the River Nile. Households that earn incomes from wages and salaries are often employed in agrarian work in the rural regions of these agrarian states with their easy access to irrigation. Such agrarian work is often done on large commercial farms, including those in the large agricultural schemes. The major irrigation schemes include Al-Gezira in Al-Gezira state, the New Haifa Scheme in Kassala, and the Rahad Scheme in the Blue Nile. Pump irrigation schemes also exist in the Northern, River Nile, Blue Nile, and White Nile and in the Suki Scheme in Sinnar state (FAO 2015).

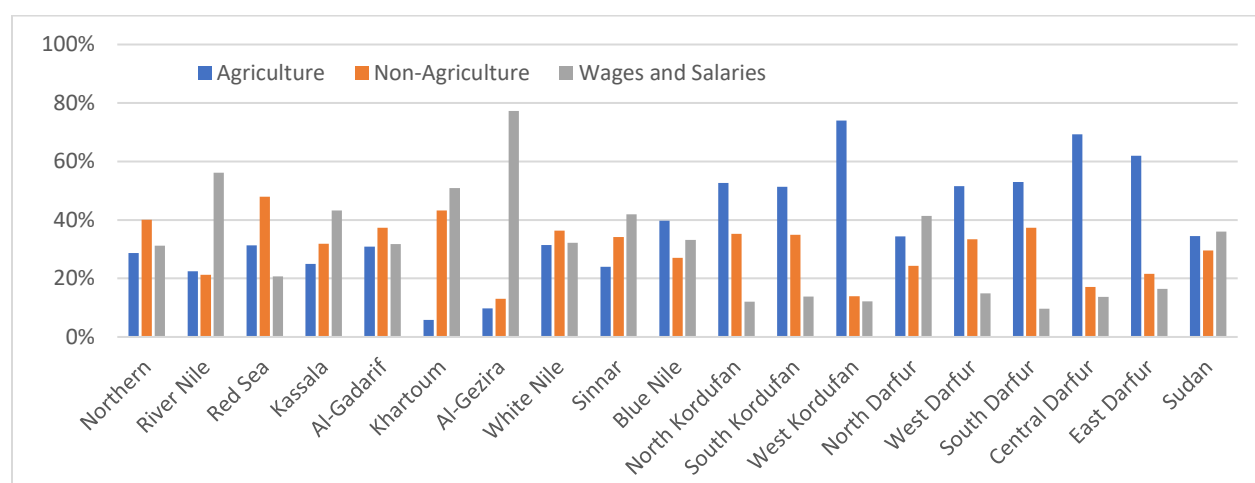
Households in Darfur and Kordofan rely more on direct incomes from agriculture, through sales of crop and livestock produce, as opposed to incomes from wages and salaries (Figure 12a). Agricultural production in these states is much less reliant on large irrigated farms and hired labor than in the irrigation belt. The disparity in poverty rates between households whose main livelihood is agriculture and those whose main livelihood is from wages and salaries therefore stems primarily from geographic differences. As shown in Section III.A, agrarian households in these regions cultivate millet primarily for subsistence needs, with increasing cultivation of sesame for sale in Kordofan.

Wages and salaries have increased as an important share of total income, at the expense of agricultural and nonagricultural incomes (Figure 12b). A vast majority of households in Al-Gezira, a state known for its large-scale irrigation scheme, earn wages and salaries primarily from agrarian work.

Most states have seen some increase in the proportion of total income earned from wages and salaries. This suggests the increasing importance of large and commercial farms in these regions of Sudan. As seen earlier (Figure 6b), due to the lower rates of poverty for households earning incomes from wages and salaries, their increasing share in the population has contributed to a reduction in rural poverty.

Figure 12: Proportion of Income Earned from Agricultural, Nonagricultural Wages in Rural Sudan, 2009 and 2014/15

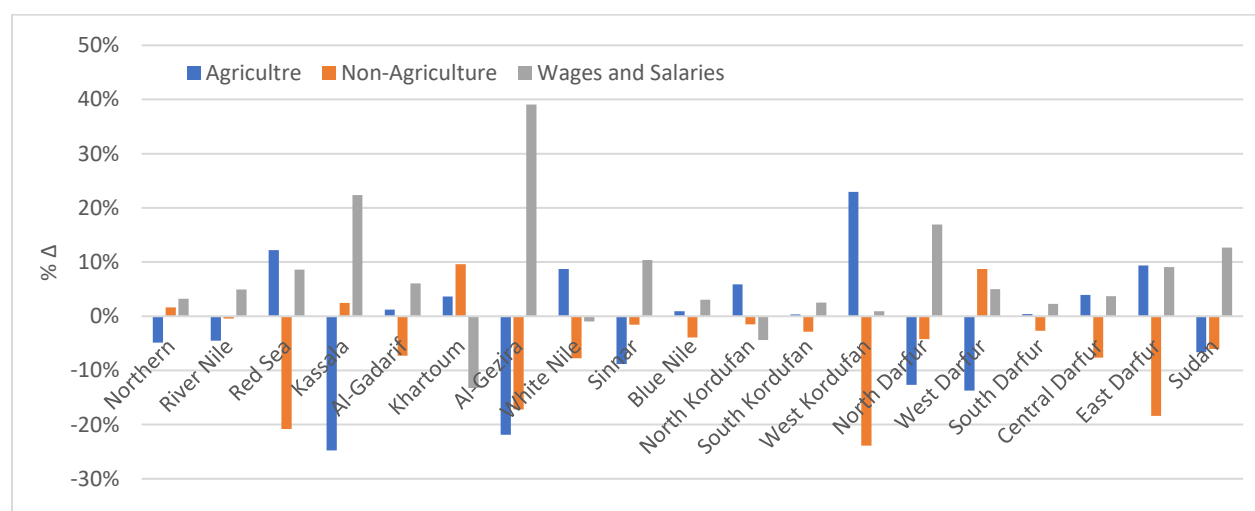
(a) Proportion of Income by Source, 2014/15



Note: Agricultural income comes from crops, horticulture products, livestock, livestock products, poultry and poultry products, fish and fish products, forest products, and other agricultural activities.

Nonagricultural income comes from wages and salaries, industrial activities, commerce, rented estates, other rents, transport and communication, transfers from abroad, domestic transfers, supports, and other sources.

(b) Change in Proportional Income by Source, 2009 to 2014/15



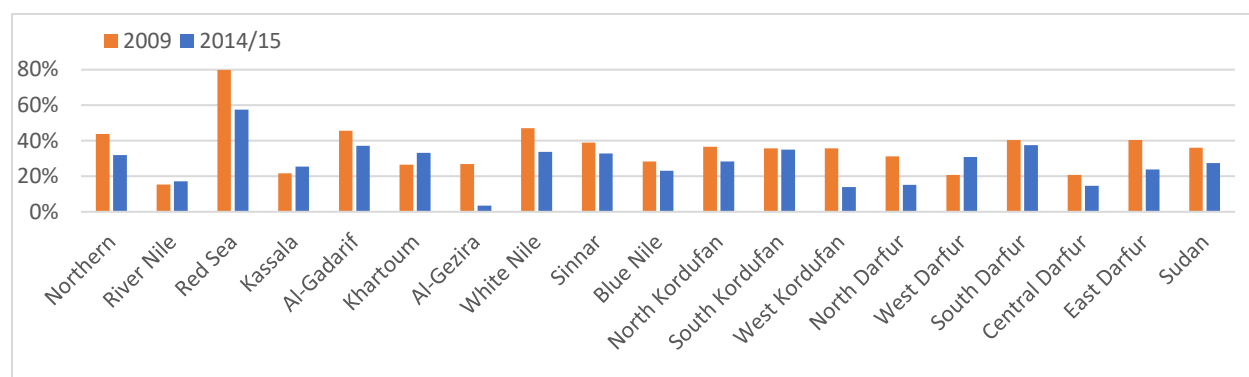
Source: Authors' calculations using NBHS 2009 and NHBPS 2014/15.

The contribution of nonagricultural income to total household income has not increased, either for the poor or the non-poor (Figure 13). In fact, on average, households were slightly less reliant on nonagricultural incomes in 2014 than in 2009. Rural Sudan has therefore become more reliant on agricultural wage incomes (possibly a form of tenant farming) and less reliant on nonagricultural

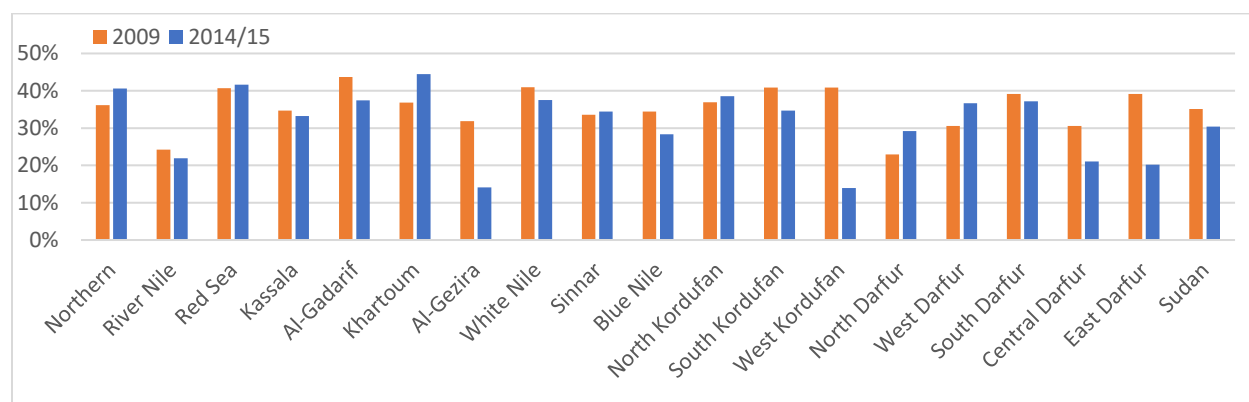
incomes. Given that households with nonagricultural incomes have lower poverty rates (Figure 6b), the stagnation in rural income diversification is probably holding back further welfare improvements in rural Sudan. Poor households earn a significantly smaller proportion of their income from nonagricultural sources.

Figure 13: Nonagricultural Income for the Poor and Non-poor, 2009 and 2014/15

(a) Nonagricultural Income as a Proportion of Total Income for Rural **Poor** Households



(b) Nonagricultural Income as a Proportion of Total Income for Rural **Non-poor** Households

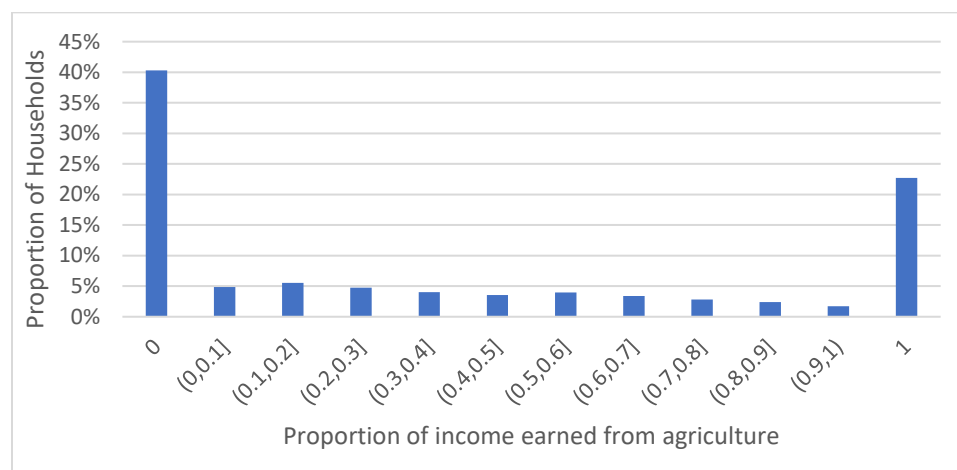


Source: Authors' calculations using NHBPS 2014/15.

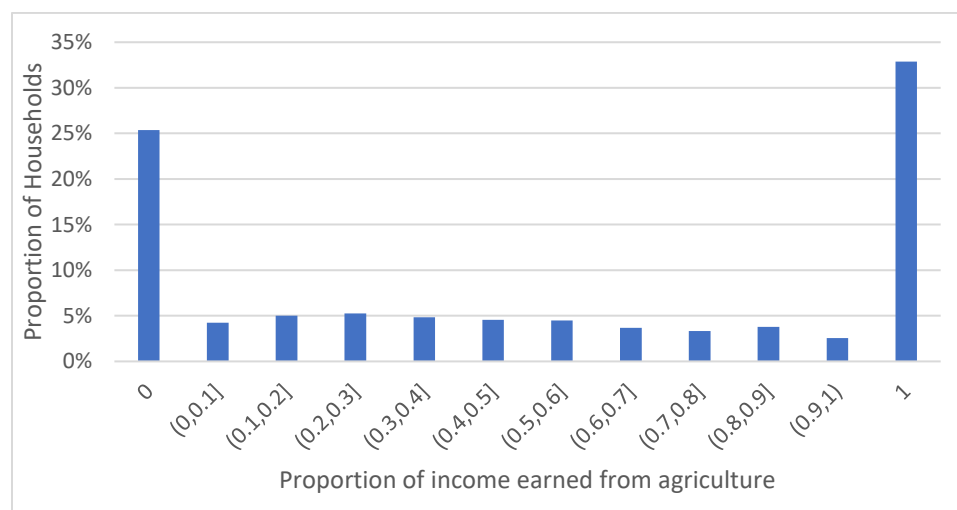
Incomes are fairly specialized in rural Sudan, for both the poor and the non-poor (Figure 14). Almost one-fourth of non-poor households identify earning all their income from agricultural sources, while almost one-third of poor households identify earning all their income from agricultural sources. Around 40 percent of non-poor households earn all their income only from nonagricultural sources, while about 25 percent of poor households can claim the same. The non-poor are therefore observed to be less reliant on agriculture than the poor. It is hard to establish whether poverty leads to a greater reliance on incomes earned solely from agriculture or whether finding a way to diversify incomes away from agriculture leads to reduced poverty. If it is the latter, then policies that wean households away from complete reliance of agricultural incomes may reduce poverty.

Figure 14: Distribution of Rural **Poor** and Non-poor Households

(a) Distribution of Rural **Non-poor** Households by Proportion of Income Earned from Agriculture, 2014/15



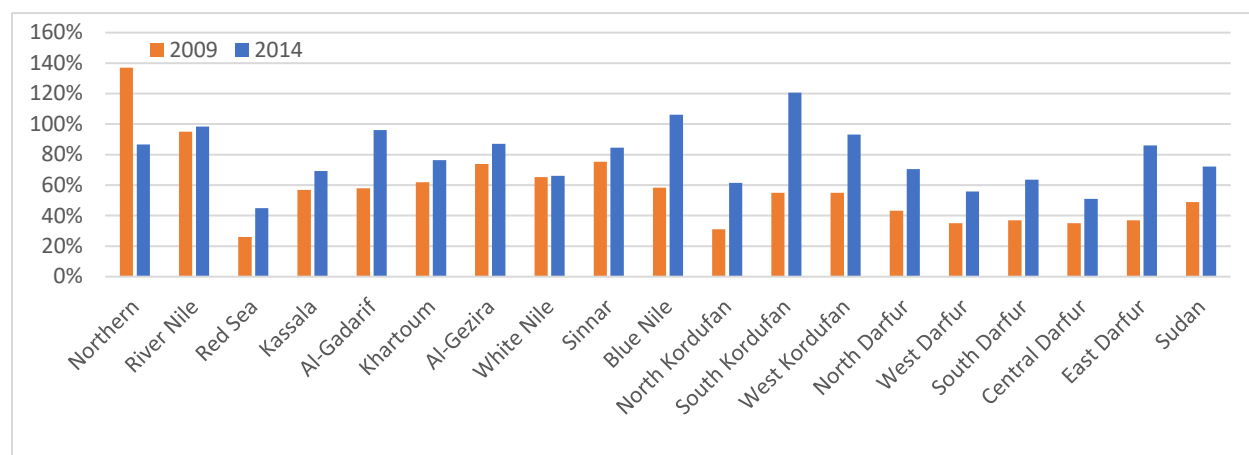
(b) Distribution of Rural **Poor** Households by Proportion of Income Earned from Agriculture, 2014/15



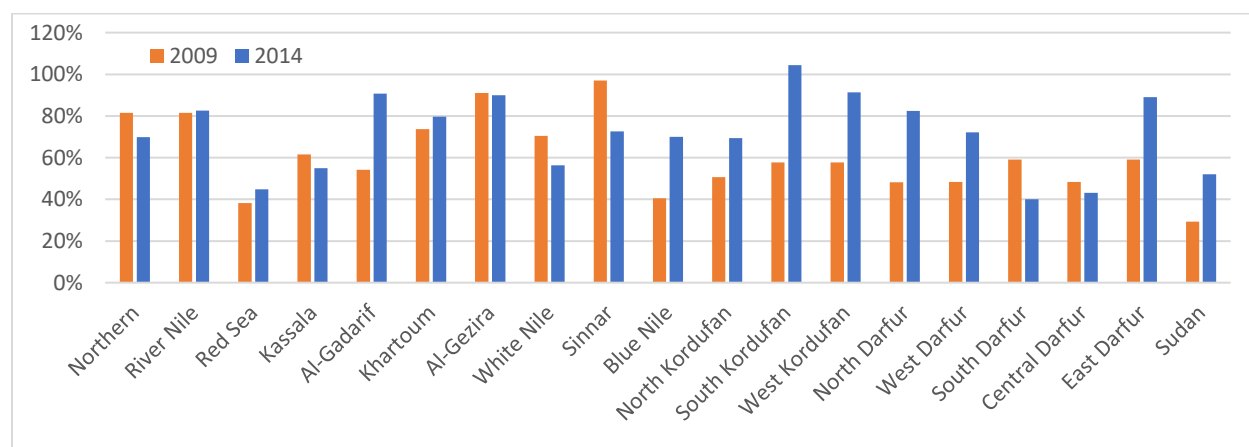
The gap between incomes and wages in rural and urban Sudan has significantly reduced since 2009 (Figure 15). The ratio of total rural income to total urban income has increased throughout the country, and the ratio for wages and salaries has increased in most states. This again shows that rural Sudan has fared better than urban Sudan. As there has been no increase in nonagricultural incomes, most of this increase has come from increased agricultural incomes, either through own crop production and sales, or through agrarian employment, as reflected in the increased share of income from wages and salaries.

Figure 15: Ratio of Incomes and Wages between Rural and Urban Households, 2009 and 2014/15

(a) Income Ratio



(b) Wage Ratio

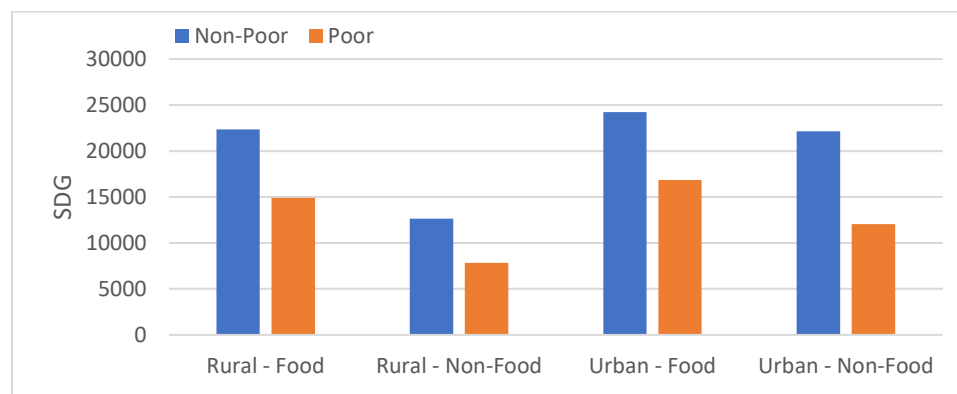


Source: Authors' calculations using NBHS 2009 and NHBPS 2014/15.

Consumption

Both food and non-food consumption are significantly lower for the poor compared to the non-poor, in both rural and urban areas (Figure 16). Lower rates of food consumption by the poor in rural Sudan are of special concern, because lower food consumption can trap households in cycles of poverty. Insufficient energy needs can result in greater difficulties maintaining employment, especially in labor-intensive agricultural work. Lower energy and nutrient intake can lead to greater incidence of disease and poor growth in children. Addressing this inequality, so that all Sudanese citizens have a healthy and sustainable diet of food, is vital for creating a prosperous Sudanese economy.

Figure 16: Household Food and Non-food Consumption, 2014/15

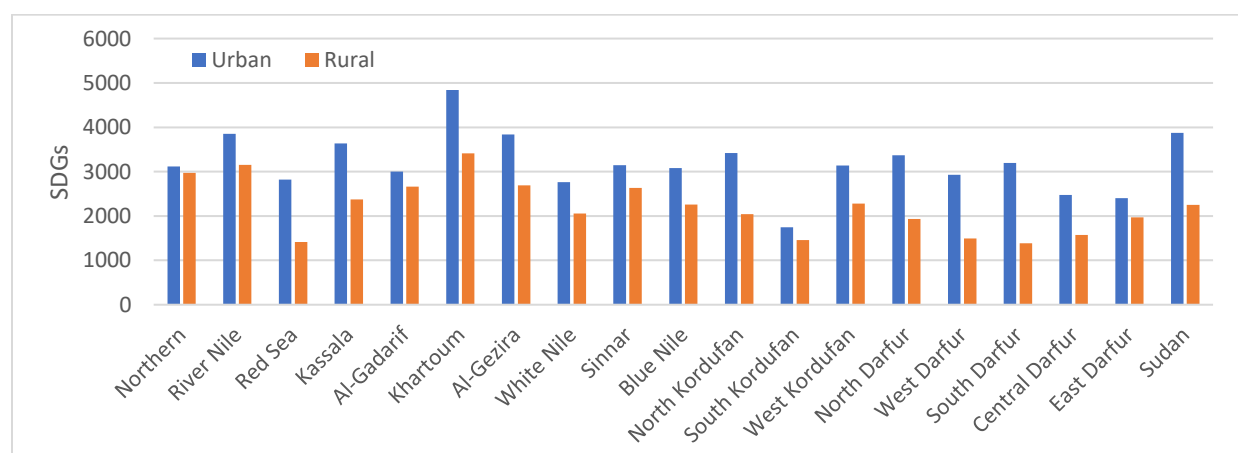


Source: Authors' calculations using NBHS 2009 and NHBPS 2014/15.

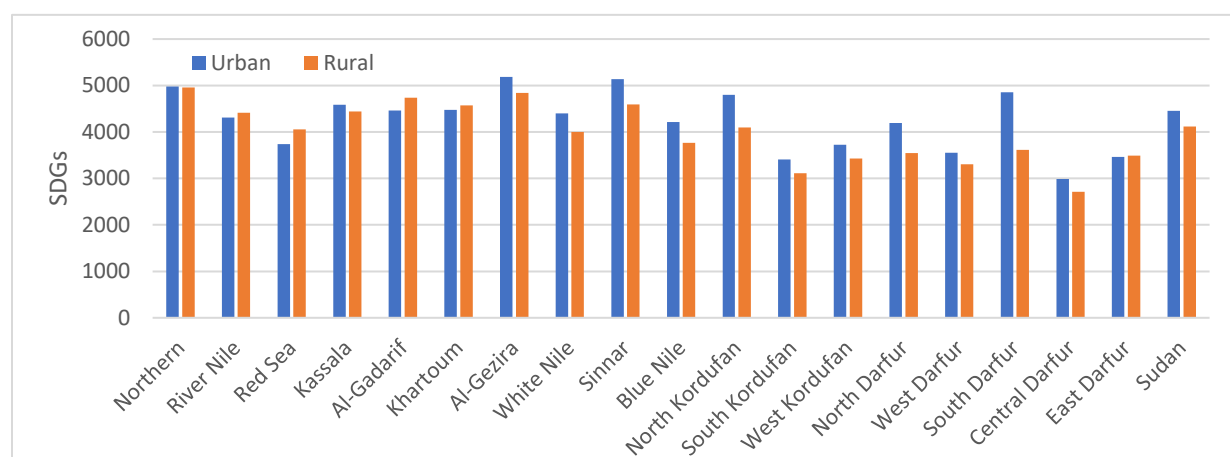
Both food and non-food expenditures remain lower in rural Sudan compared to urban Sudan (Figure 17). These differences are significantly higher for non-food expenditure, whereas only small differences exist for food expenditure. However, as there are differences in prices between the rural and urban areas, food consumption is likely higher in rural areas, something which is to be expected, due to the increased physical demands of agrarian work. Differences in non-food consumption, where the urban population on average consumes almost twice the monetary amount as the rural sector, are unlikely to be due to different prices. As we note in the next subsection, such non-food expenditure may account for differences in asset ownership between urban and rural Sudan. Some assets, such as those that aid in communication and transport, can improve the productive capacity of farmers. Therefore, improving market infrastructure, to increase the opportunity for both food and non-food consumption in rural Sudan, is vital for improving rural livelihoods and alleviating poverty.

Figure 17: Per Capita Food and Non-food Consumption, 2014/15

(a) Per Capita Non-food Consumption



(b) Per Capita Food Consumption



Source: Authors' calculations using NHBPS 2014/15.

Note: Calculations use yearly equivalents based on consumption in the last 10 days.

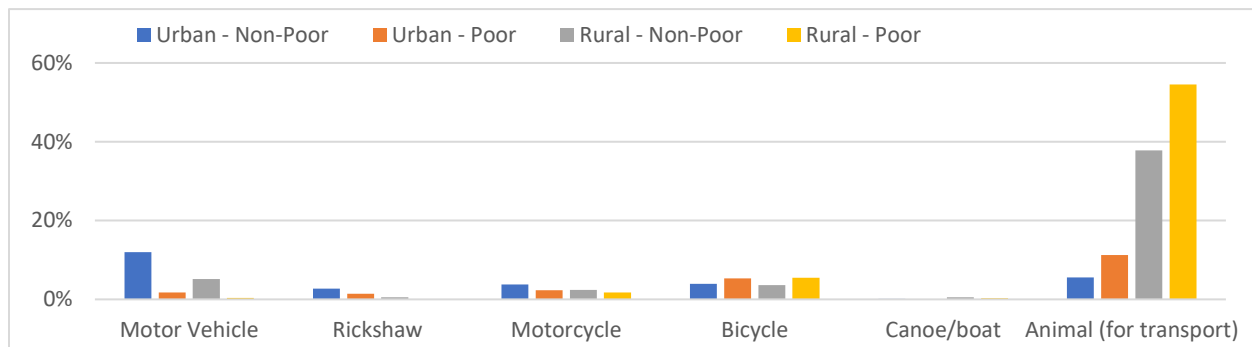
Assets

Asset ownership is generally lower for the poor than the non-poor, and lower for rural households than urban households (Figure 18). Assets that improve connectivity and increase access to information, such as televisions, satellite dishes, radios, mobile phones, phones, and computers, are more common in urban areas than in rural areas, while the poor have very little access to these resources. This means that sharing agricultural information with farmers, especially poorer farmers, can be a challenge. However, cell phones are now common in rural areas, with 70 percent of rural households owning one. Cell phone coverage is only 60 percent for the rural poor.

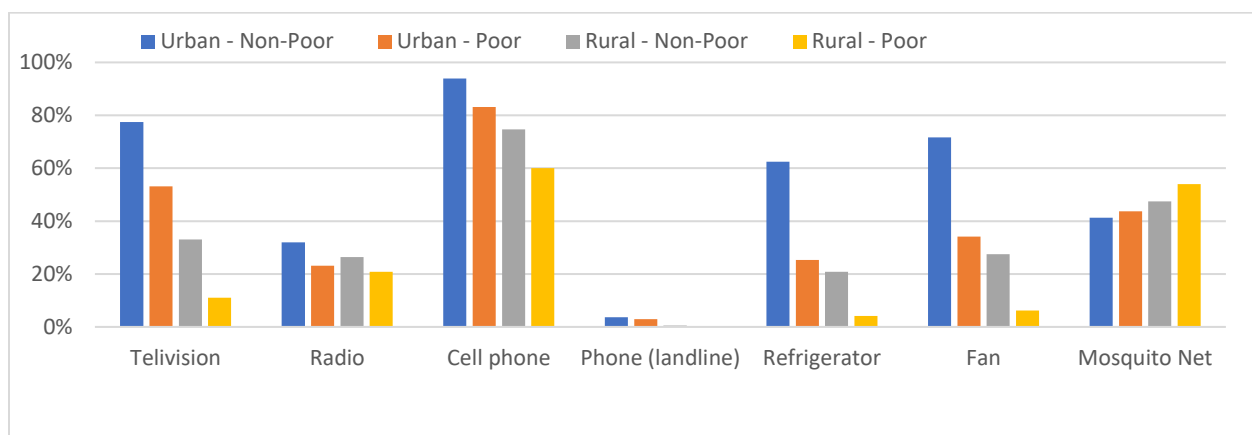
Motorized transport assets, such as motor vehicles, rickshaws, and motorcycles, remain low throughout Sudan but are more common in urban areas and are almost nonexistent among the rural poor. Rural areas have significantly higher rates of asset ownership of animals used for transportation; this is especially true for the rural poor. Limited ownership of transportation assets and an inadequate transportation network can impede access to productive inputs, such as fertilizers and pesticides, and reduce the opportunity to market surplus agricultural produce.

Figure 18: Ownership of Non-transport- and Transport-related Assets, 2014/15

(a) Transport-related Assets



(b) Non-transport-related Assets



Source: Authors' calculations using NHBPS 2014/15.

III. Agriculture in Sudan

Sudan has a diversified crop portfolio, grown in diverse agro-climatic conditions. This includes cereals (such as sorghum, millet, wheat, rice and maize), oilseeds (mainly sesame, groundnut and sunflower), industrial crops (cotton and sugarcane), fodder crops (alfalfa, fodder sorghum and Rhodes grass), pulses (broad beans and pigeon peas), and horticulture crops (okra, onions, tomatoes, citrus, mango, and so on). Rural households are also extensively engaged in animal husbandry, with an estimated livestock population of 109 million heads of cattle, sheep, goats, camels, and others across the country in 2018 (FAO 2019).

Crop production in Sudan is practiced under three main patterns, which influence the type of crop grown (FAO 2019).

- (a) Irrigated agriculture includes large-scale irrigation schemes using the Nile and its tributaries (such as the world's largest, the Al Gezira Scheme), large-scale irrigation schemes using seasonal floods, and small-scale irrigation practiced by individual households along the banks of the Nile and its tributaries. The principal crops of the irrigated sector include sugarcane, cotton, sorghum, groundnut, wheat, vegetables, fruits, and green fodder.
- (b) Semi-mechanized rain-fed agriculture is practiced across approximately 6.7 million ha and receives 500 mm average rainfall annually. It is practiced in the states of Kassala, Gadarif, Blue Nile, Sinnar, White Nile and South Kordofan. In this region, Sudan's staple sorghum accounts for 80 percent of the cultivated land and produces around 45 percent of the country's requirement. Other crops include sesame, sunflower, millet, and cotton.
- (c) The traditional rain-fed agriculture covers 9 million ha. This is the combined acreage of irrigated and semi-mechanized rain-fed agriculture. Due to the small scale of household-managed traditional rain-fed agriculture, it employs the greatest share of the population. Though such farming is found throughout the country, it is predominant in the west of the country, in the regions of Darfur and much of Kordofan. Subsistence crops such as sorghum and millet are the norm, but commercial crops, such as groundnut, and increasingly, sesame, are also grown on a small scale.

A. Crops and Livestock

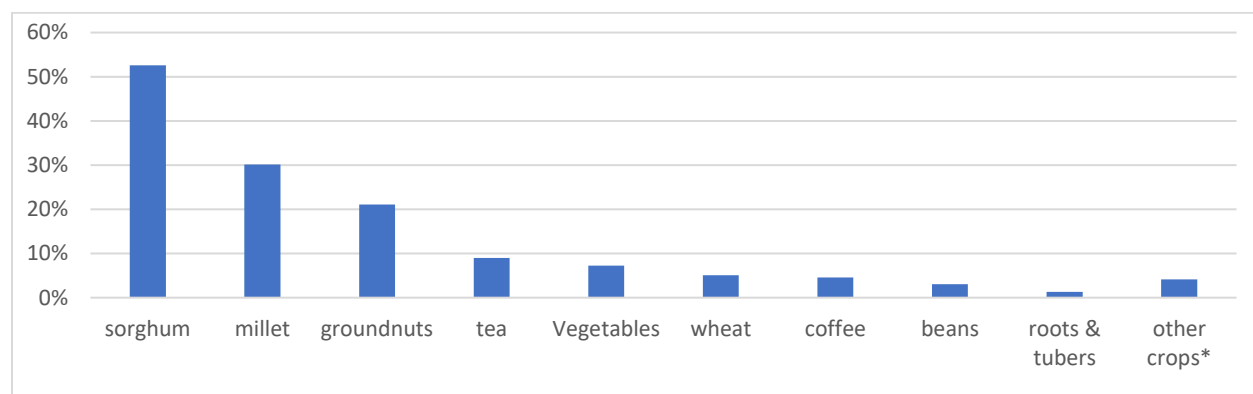
Crops Grown

Sorghum is the most common crop grown by crop-producing households in Sudan, followed by millet (Figure 19Error! Reference source not found.). According to the 2014/15 survey, close to half the households engaged in crop farming grow sorghum. This has changed little since 2009, when slightly more than half of all households grew sorghum (note the list of crops in 2009 is different from those in 2014/15). Approximately one-third of crop-producing households grow millet. This proportion has increased slightly since 2009. Other common crops grown are sesame, groundnut, and tea (mainly hibiscus in Kordofan). These statistics represent households that identify a crop cultivated for their own consumption. Households that work the land with laborers and identify their income as 'wages and salaries' do not report which crop they grow. These statistics do not represent the proportion of crops

grown at the national level; being a household-level survey, large-scale farming operations which grow commercial crops are not included.

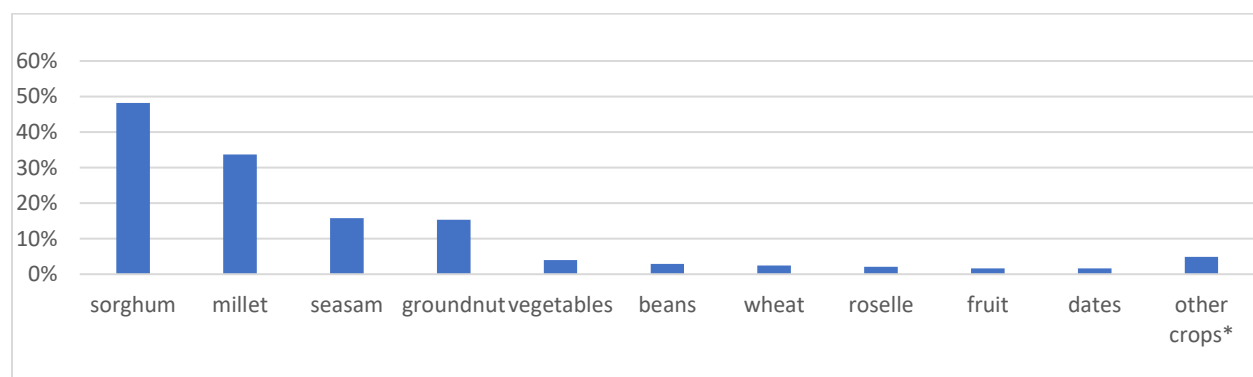
Figure 19: Popularity of Crops Grown in Sudan, 2009 and 2014/15

(a) Crop Grown as a Proportion of Total Agricultural Households, 2009



Note: * Other crops include cotton, maize, and rice.

(b) Crop Grown as a Proportion of Total Agricultural Households, 2014/15



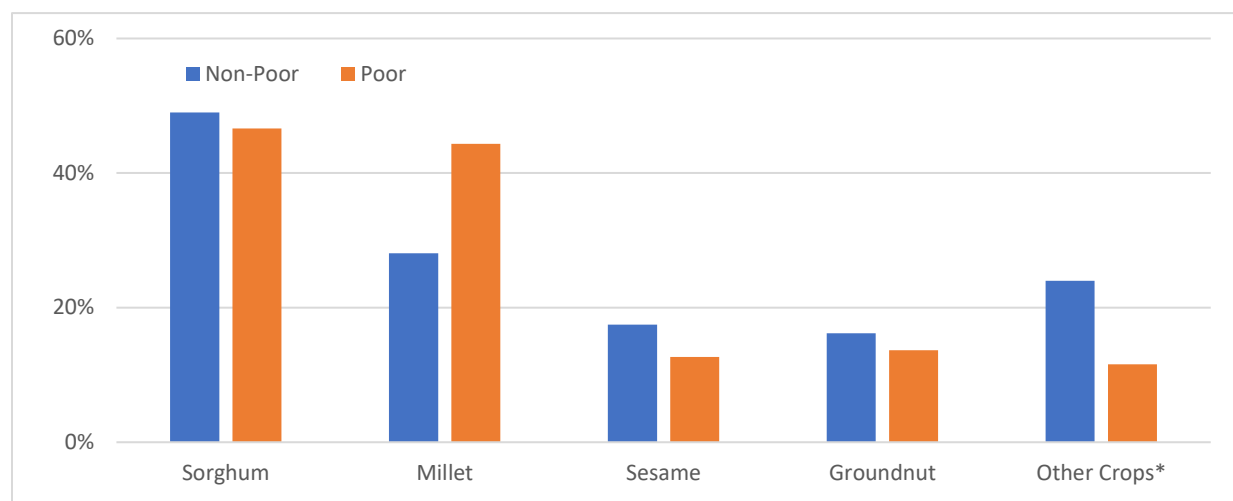
Source: Authors' calculations using NBHS 2009 and NHBPS 2014/15.

Note: * Other crops include cotton, maize, sunflower, potato, gum arabic, and spices.

There are key differences between crops grown by poor and non-poor households, with subsistence crops more likely to be grown by the poor (Figure 20). While sorghum is grown almost equally by poor and non-poor households, millet is grown more predominantly by the poor; sesame and groundnut are grown more predominantly by the non-poor. Apart from roselle, non-poor households predominantly grow almost all the cash crops listed in the survey. This is driven by the extent to which production constraints, such as access to land, input and output markets, and credit and insurance markets, are binding for poor and non-poor households. As a result, poor households resort to low-risk, low-return subsistence crops such as millet. Increasing the diversity of crops grown by the poor, by creating opportunities to market profitable crops is vital to increase the farm revenues of poor agrarian households.

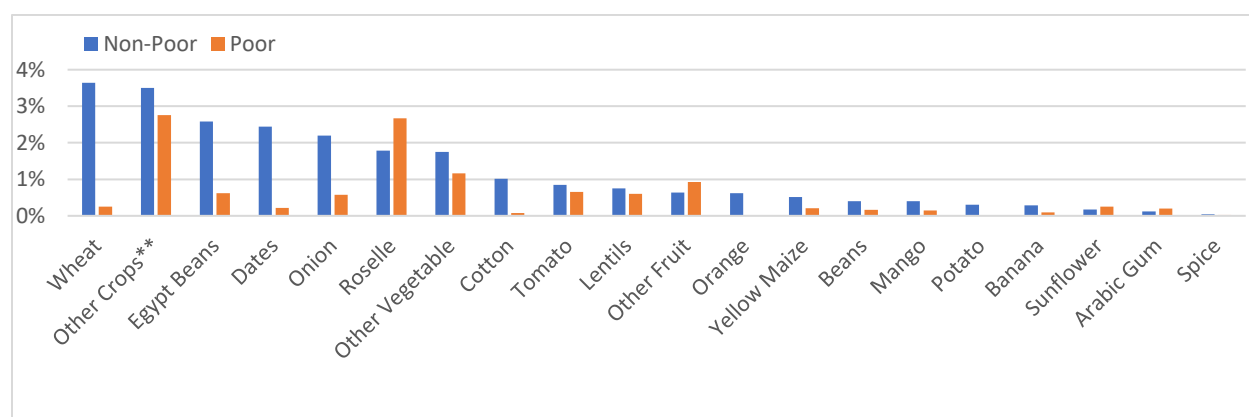
Figure 20: Main and Other Crops Grown by the Poor/Non-poor, 2014/15

(a) Main Crops



Note: * Other crops include those listed in Figure 19b.

(b) Other Crops



Source: Authors' calculations using NHBPS 2014/15.

Note: * Other crops besides those listed in Figure 19a.

** Other crops besides those already listed in Figure 19b.

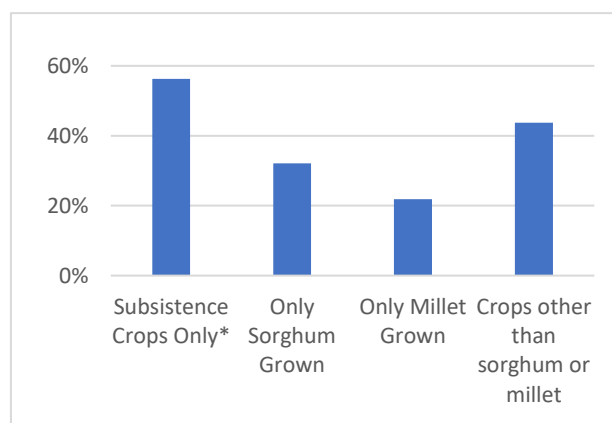
Most of the households engaged in crop production grow only the subsistence crops of sorghum and millet (Figure 21a). More than half the households, 56 percent, that engage in crop production grow only these two crops and nothing else. Most of these households grow either millet or sorghum exclusively, 32 percent of households grow only sorghum, 22 percent grow only millet, and only 2 percent grow both. This means there is very little geographic overlap between these two crops.

Households growing only sorghum or only millet have higher rates of poverty than households growing other crops (Figure 21b). Those engaged in millet production have especially high rates of poverty. These households are concentrated in Darfur and Kordofan. Households engaged in growing the other two common crops—sesame and groundnut—have significantly lower rates of poverty, while households engaged in all other types of crop production have the lowest rates of poverty. These other crops are primarily cash crops. This strong positive correlation between poverty and growing

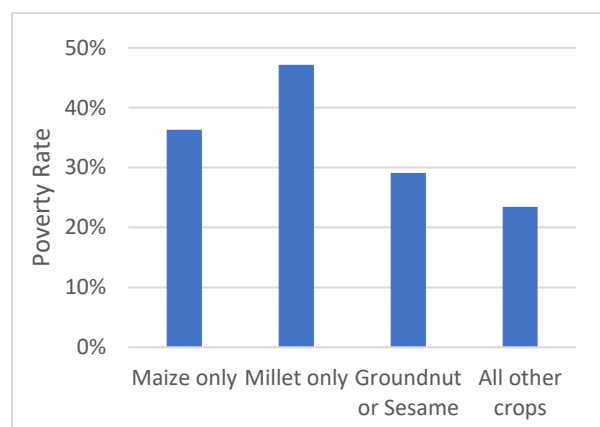
subsistence crops suggests that growing subsistence crops traps households in a cycle of poverty. Poverty imposes constraints that prevent households from diversifying into income-generating cash crops. Additionally, growing low-income-generating subsistence crops prevents households from making the investments required to grow cash crops. These constraints might be regional, as some regions in Sudan have greater access to the infrastructure, such as irrigation, that sustains commercial crop cultivation.

Figure 21: Crop Production and Poverty, 2014/15

(a) Crop Cultivation by Households as a Proportion of Total Agrarian Households



(b) Crop Cultivation and Poverty

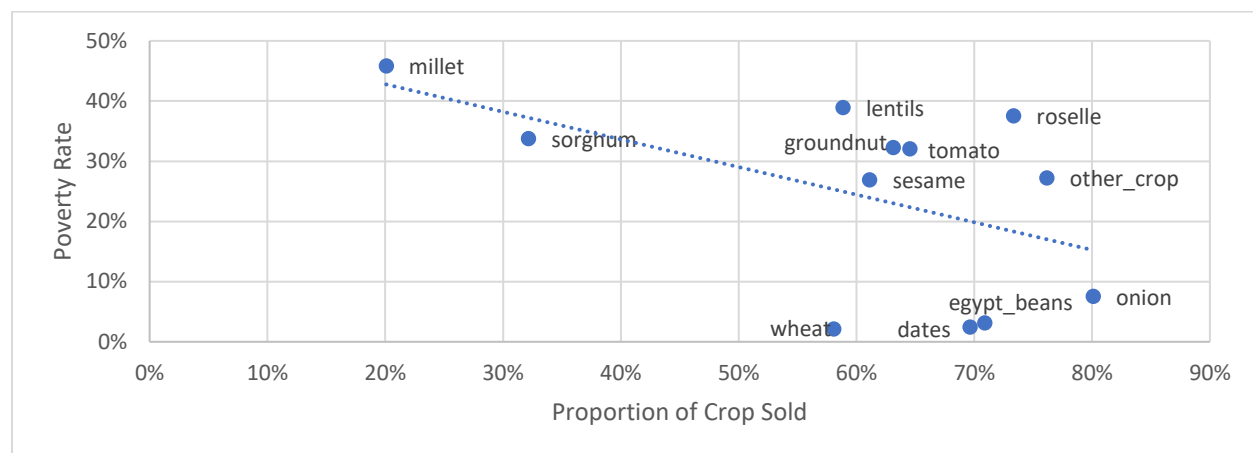


Source: Authors' calculations using NHBPS 2014/15.

Note: * The household grows only sorghum or millet.

Households that sell a higher proportion of their produce in the market have lower rates of poverty (Figure 22). Crops such as millet, sorghum, and lentils are grown predominantly to be consumed within the household. Average rates of poverty in households that produce these crops are higher than the average rates of poverty in households that produce crops that are predominantly sold in the market, such as wheat, dates, and Egyptian beans. This again suggests the nexus between subsistence crop production, lower household incomes, and poverty. However, a causal relationship is hard to establish as regions with better market infrastructure are likely to be better-off in general. Such regions will tend to sell more of their crop in the market and have a reduced likelihood of poverty, irrespective of market engagement by agrarian households.

Figure 22: Proportion of Crop Produce Sold and Poverty, 2014/15



Source: Authors' calculations using NHBPS 2014/15.

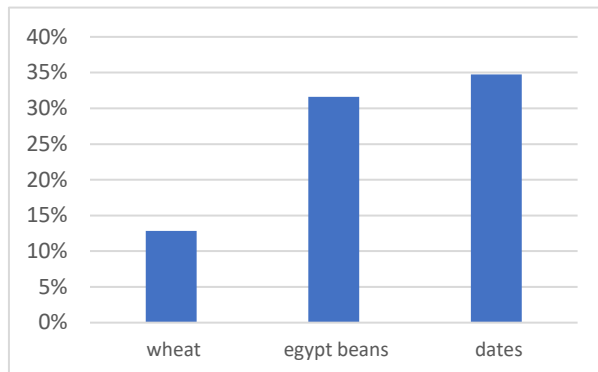
There are important regional differences in which crops are grown (Figure 23). Dates are the most common crop grown in the Nile region (Figure 23a). Sorghum is the most common crop grown in the Eastern region, Khartoum, and the White and Blue Nile region (Figure 23b–d). It is also the second most important crop grown in Darfur and Kordofan (Figure 23e–f). Millet is most common in Darfur and is important in Kordofan but is not grown extensively elsewhere. The most important crop in Kordofan is sesame.

Sesame is a common cash crop in the Kordofan region, where it was grown by almost half of all farmers in 2014/15 (Figure 23e). As the 2009 survey did not include sesame as a potential crop grown, it is difficult to confirm whether the current production of sesame is a recent trend or if it has been a common crop produced by Sudanese farmers. However, as shown in Figure 4b, the Food and Agriculture Organization of the United Nations (FAO) statistics show that sesame production and exports have grown significantly during this time. Substantial reduction in rural poverty (Figure 10b) in two of Kordofan's three states (the states not affected by conflict) may be partly explained by farmers growing this cash crop.

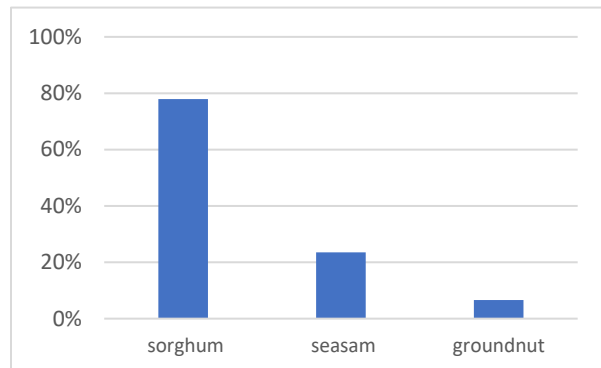
Households engaged in crop production in Sudan's most populous rural region, that is the Blue and White Nile (the states of Al-Gezira, White Nile, Sinnar, and Blue Nile), mostly grow sorghum (Figure 23d), but larger commercial farms in this region grow cash crops. This region is heavily irrigated. States such as Al-Gezira are known as the breadbasket of Sudan. Most households list income from wages and salaries as their main source of livelihood in these states. Information on what crops these farmers are growing is not provided in the survey. As seen in Figure 4b, Sudan has recently increased exports of sesame and sugar. This is largely due to increased production in this region. Given that individuals from these households are employed in larger, commercial farms, increasing the productivity and profitability of these farms will be vital to ensure the prosperity of the households of such employed farmers.

Figure 23: Top Three Cultivated Crops in Sudan by Region (Proportion of Households), 2014/15

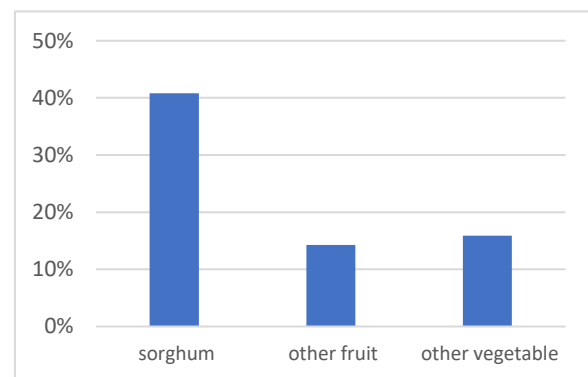
(a) Nile Region (Northern, River Nile)



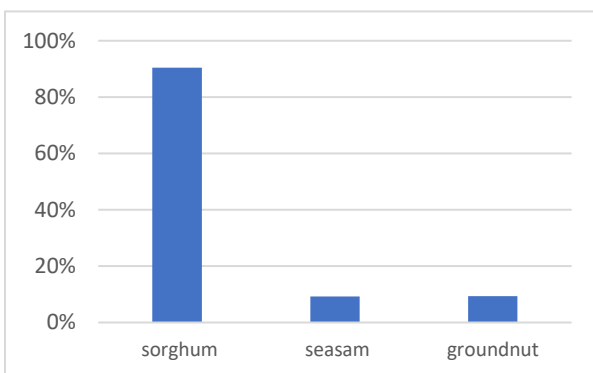
(b) Eastern Region (Red Sea, Kassala, Al-Gadarif)



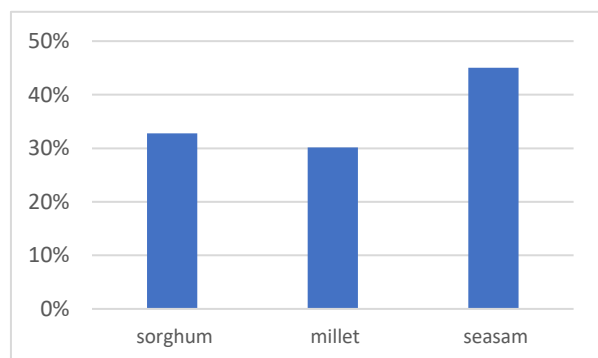
(c) Khartoum



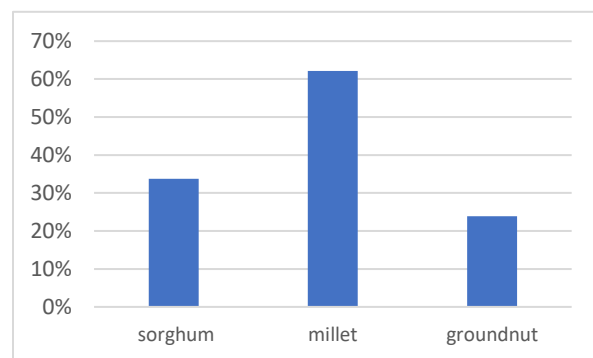
(d) Blue and White Nile Regions (Al-Gezira, White Nile, Sinnar, Blue Nile)



(e) Kordofan Region (North, South, and West Kordofan)



(f) Darfur Region (North, West, Central, and East Darfur)



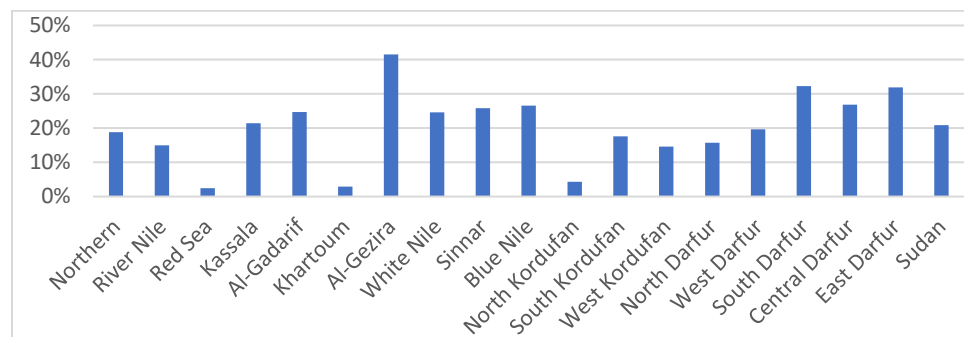
Source: Authors' calculations using NHBPS 2014/15.

Livestock Ownership

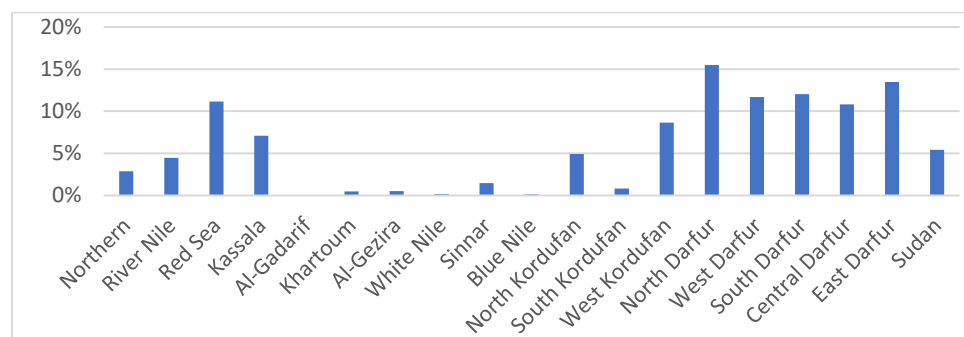
Ownership of livestock is widespread in rural Sudan, especially in the Darfur region (Figure 24). Cattle ownership is especially common in Al-Gezira, followed by South, Central, and East Darfur. Goat and sheep ownership is also concentrated in the Darfur region. Almost one-third of rural households own a camel; households in the Darfur region are more likely to own camels. Over half of all rural households own poultry, while almost all households in Darfur own poultry.

Figure 24: Livestock Ownership in Rural Sudan

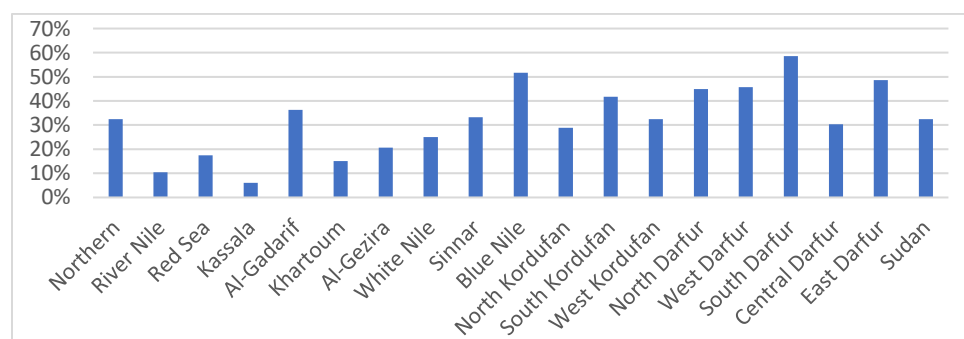
a) Cattle Ownership



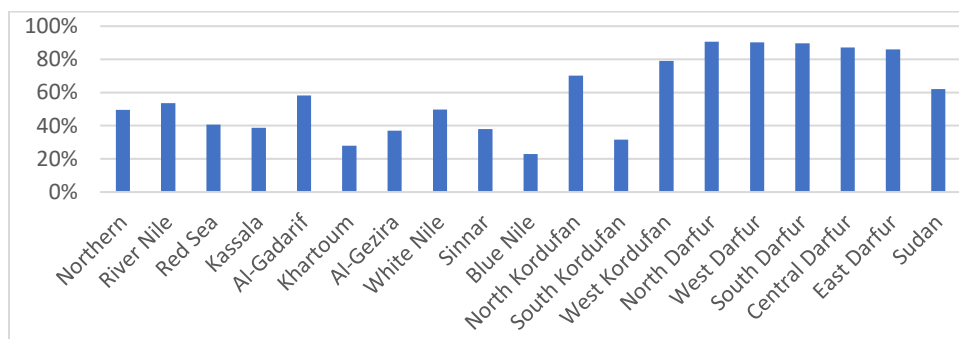
b) Goat/Sheep Ownership



c) Camel Ownership



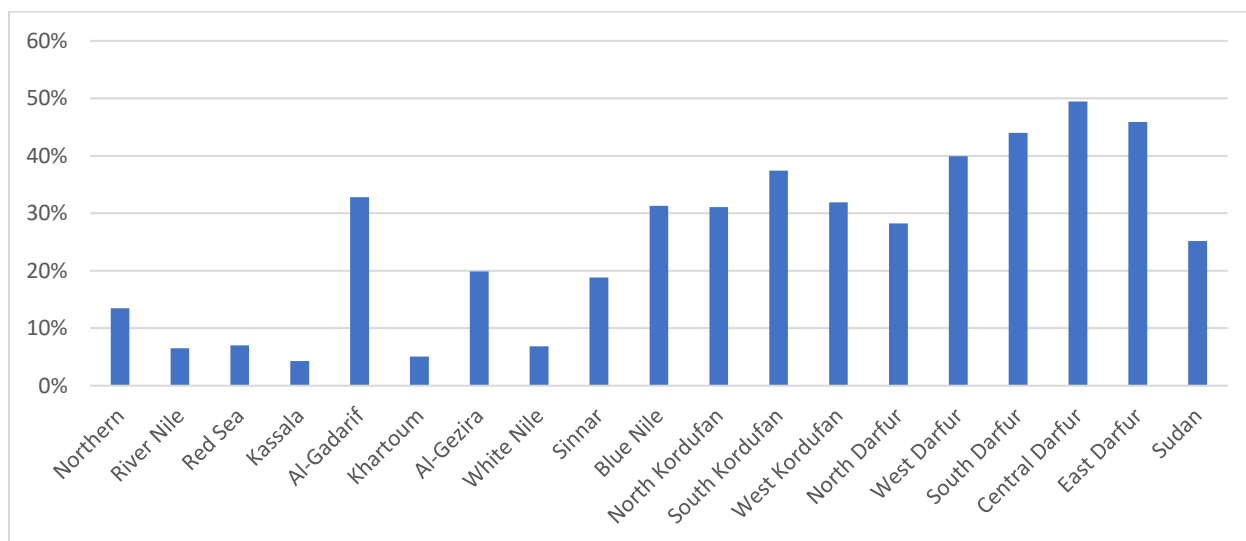
d) Poultry Ownership



Source: Authors' calculations using NHBPS 2014/15.

For households that own livestock, the death or theft of their livestock is a common occurrence (Figure 25). The questionnaires ask whether a household has been severely affected by such an event; around one-fourth of households that own livestock claim that such an event has affected them adversely. Higher rates are noted in Darfur, where reliance on livestock is greater than in the rest of Sudan. Such losses can cause hardships to households that rely on livestock for income, either through the sale of these assets, or through the sale of animal products. Programs that insure against the loss of livestock can help these households overcome such hardships without falling into poverty.

Figure 25: Shocks Affecting Households that Own Some Form of Livestock



Source: Authors' calculations using NHBPS 2014/15.

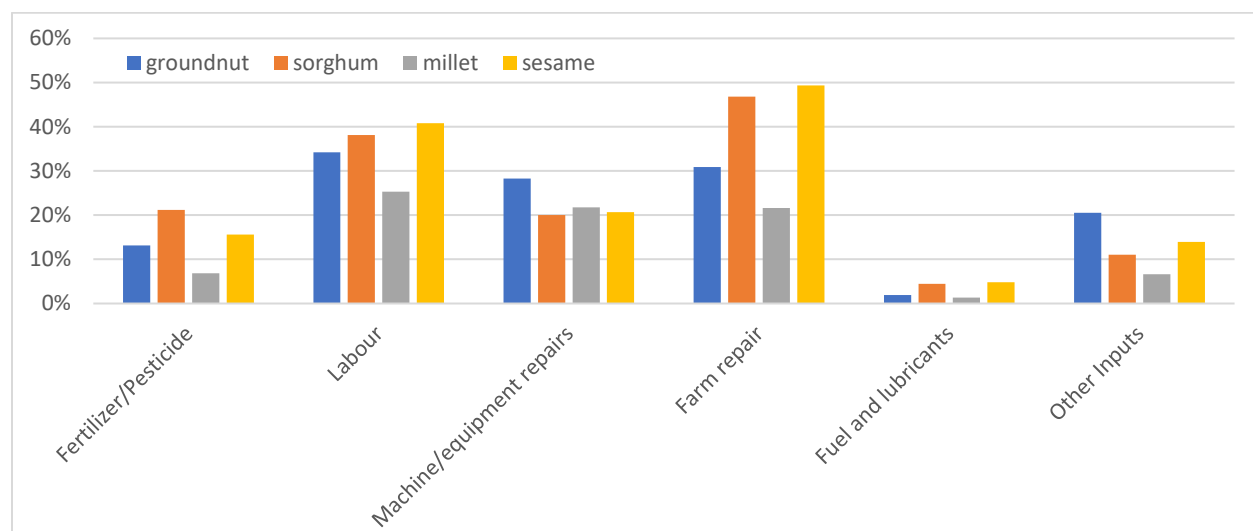
B. Farm Characteristics

Input Use

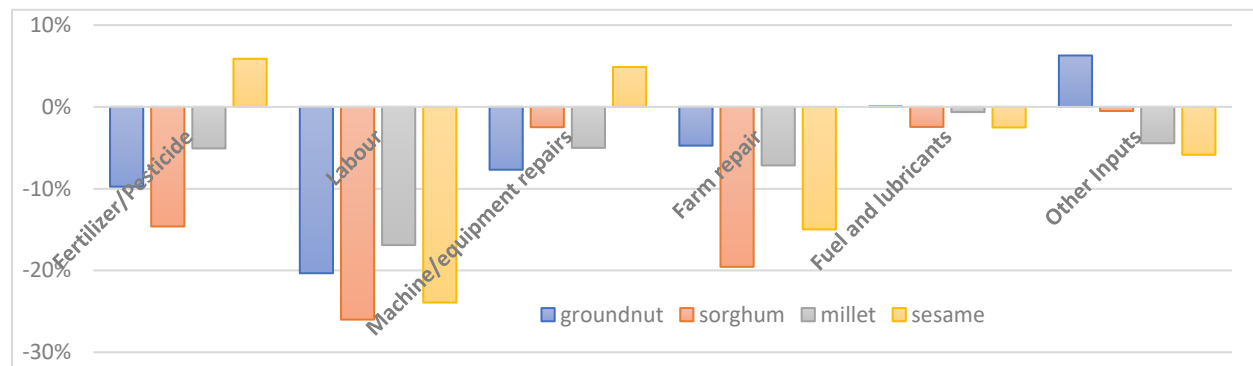
Very few households spend on agricultural inputs to increase the productivity of cultivation (Figure 26a). For the four major crops, only between 20 percent (for sesame) and 36 percent (for sorghum) of households spend any money on pesticides or fertilizers. An even lower proportion spends a significant amount on these inputs. The most common input expense for farmers is farm repairs (except for millet, for which it is machine/equipment repairs). Labor costs constitute the second most common input expense. Input use by the poor is generally markedly lower than that of the non-poor (Figure 26b). A notable exception is fertilizer/pesticide use for sesame, which is used at a higher rate by the poor.

Figure 26: Agricultural Input Use in Sudan, 2014/15

(a) Proportion of Households Using Given Input (Greater than 100 Sudanese pounds) by Crop



(b) Percentage Difference in Input Use by the Poor compared to the Non-poor



Source: Authors' calculations using NHBPS 2014/15.

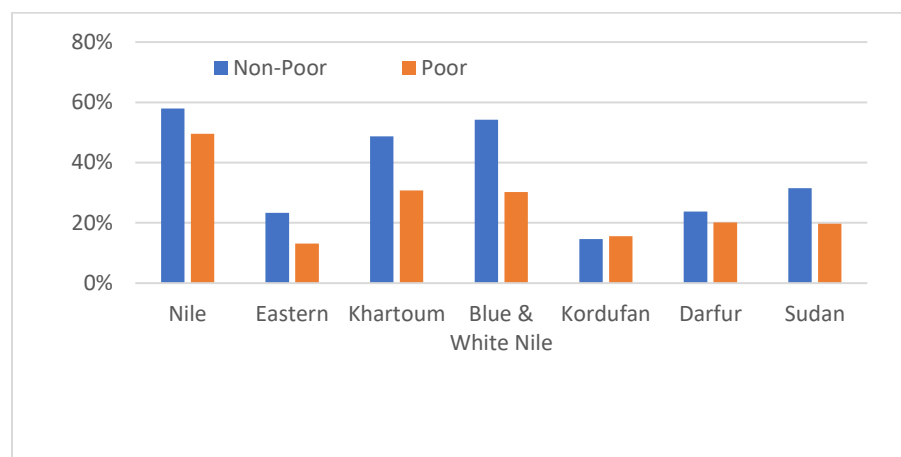
Note: SDG 100 = US\$2.2 (June 2019).

Fertilizer/pesticide use is significantly lower for the poor compared to the non-poor (Figure 27). This is seen in all regions of Sudan, except for Kordofan. For Sudan as a whole, the poor are one-third less likely

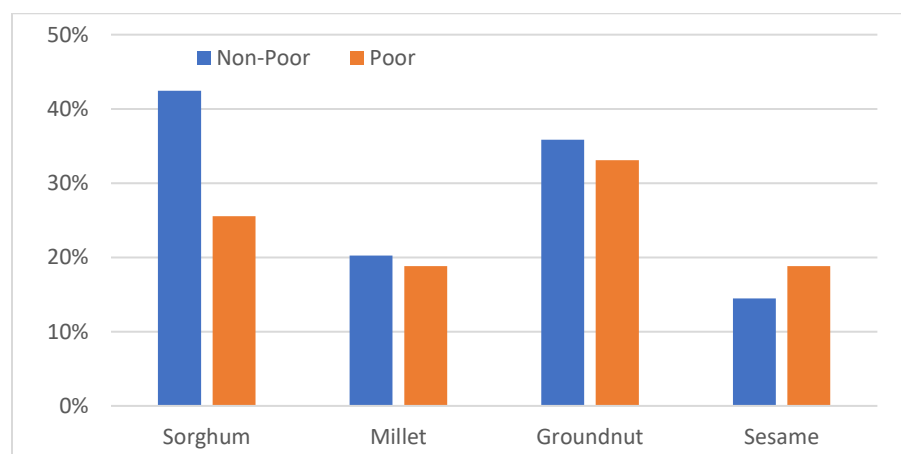
to use fertilizer/pesticides compared to the non-poor. By crops, the poor are far less likely to use fertilizer/pesticide for sorghum cultivation, which is the most commonly cultivated crop in Sudan.

Figure 27: Fertilizer/Pesticide Use by the Poor vs. Non-poor

a) Fertilizer/Pesticide Use by the Poor vs. Non-poor, by Region

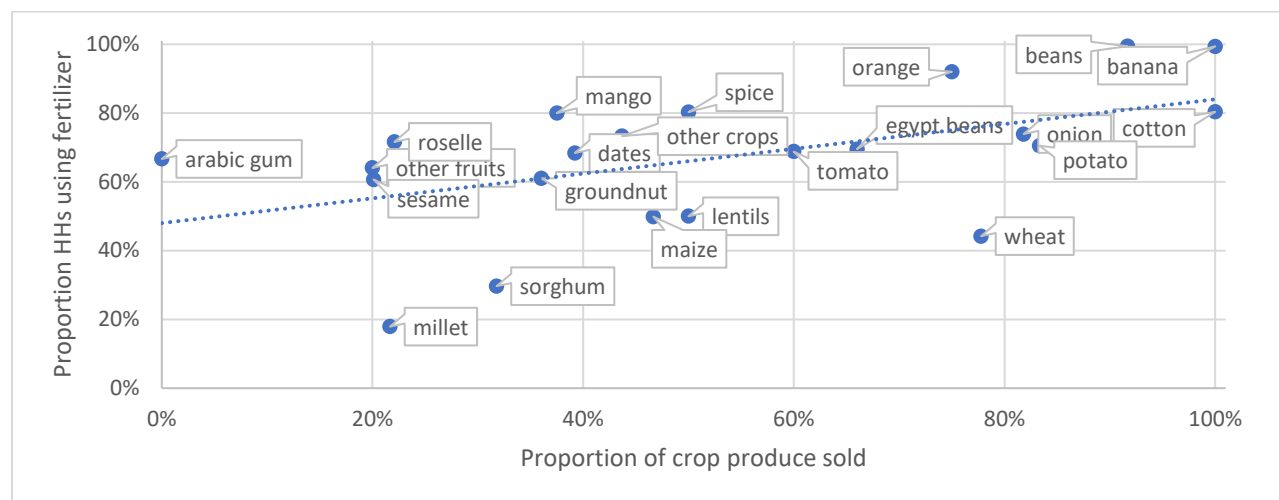


b) Fertilizer/Pesticide Use of the Poor vs. Non-poor, by Crop



Greater input use is associated with greater sales of a crop by agrarian households (Figure 28). Crops that are sold more on average have been treated more with fertilizers and pesticides. This suggests that the incentives to increase productivity are tied to a household's ability to sell its crop in the market. Another explanation for this relationship is that regions with adequate output markets, which allow farmers to profit from growing cash crops, also have better input markets giving them access to productivity-enhancing inputs, such as fertilizers and pesticides. Therefore, improving market infrastructure can lead to changes in the type of crop grown, from subsistence to cash crop cultivation, thereby increasing an agrarian household's income and welfare.

Figure 28: Relationship between Fertilizer Use and Crop Sales, 2014/15



Source: Authors' calculations using NHBPS 2014/15.

Note: HHs = Households.

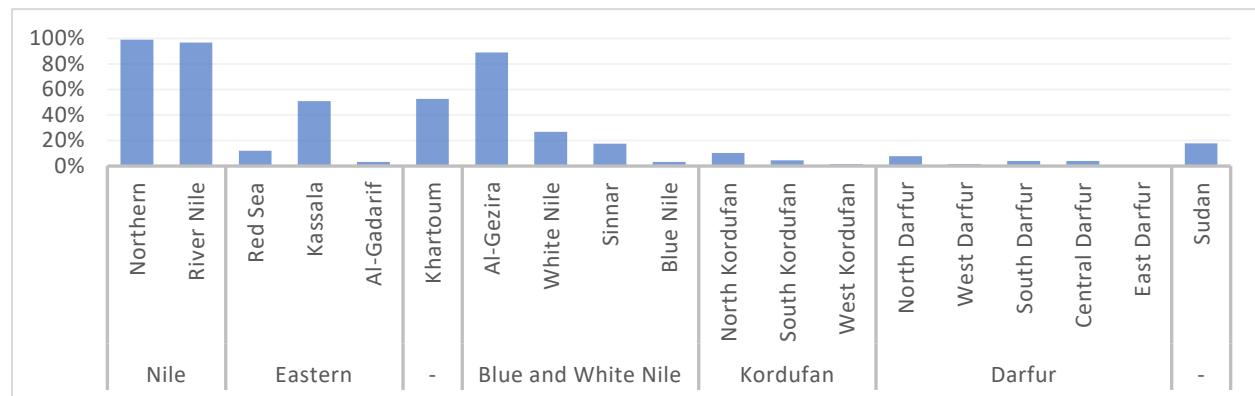
Irrigation

Less than one-fifth of households engaged in irrigated agriculture in Sudan (Figure 29a). States on the River Nile and its tributaries, the Blue and White Nile, have higher rates of irrigation. For example, the River Nile and Al-Gezira states have cultivated lands that are nearly 100 percent irrigated. States in regions where the poverty is highest, such as Kordofan and Darfur, have nearly no irrigation of cultivated lands. Irrigation use has decreased between 2009 and 2014/15, from 23 percent to 18 percent, with the largest reduction seen in the Darfur region, where irrigation was already at very low levels.

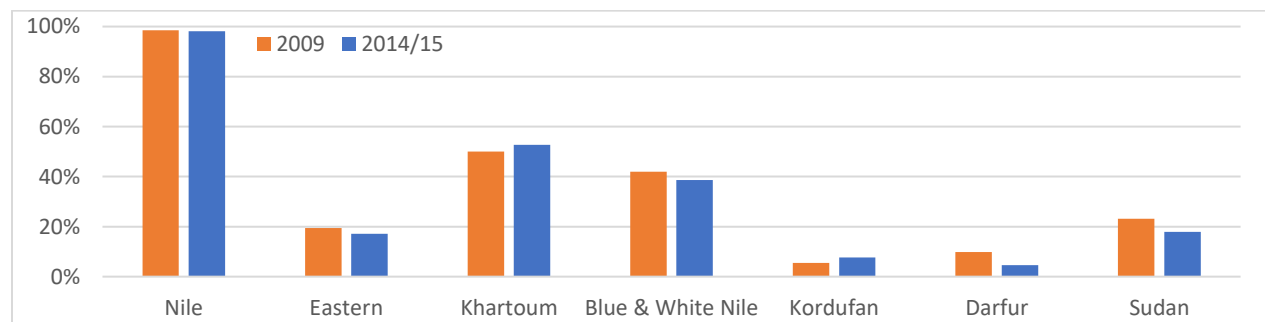
Within states where there are significant levels of irrigation, such as in the Eastern region, Blue and White Nile regions, and Khartoum state, poor agrarian households are generally less likely to have access to irrigation for farming (Figure 29a). In these regions, expanding irrigation to the poor may be more economical than doing so in regions with very little irrigation infrastructure, such as the regions of Kordofan and Darfur. In these regions, there is little difference between irrigation access between the poor and the non-poor, because none of the lands are irrigated. Expanding irrigation may be costly, because there are few riverways in these areas, though pumping water from underground aquifers may be feasible.

Figure 29: Irrigation Utilization for Agrarian Households

(a) Irrigation Utilization for Agrarian Households by State, 2014/15

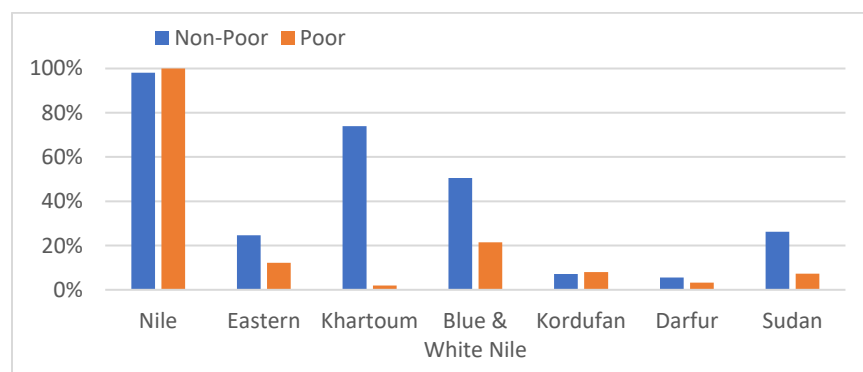


(b) Irrigation Utilization for Agrarian Households by Region, 2009 and 2014/15



Source: Authors' calculations using NHBPS 2014/15.

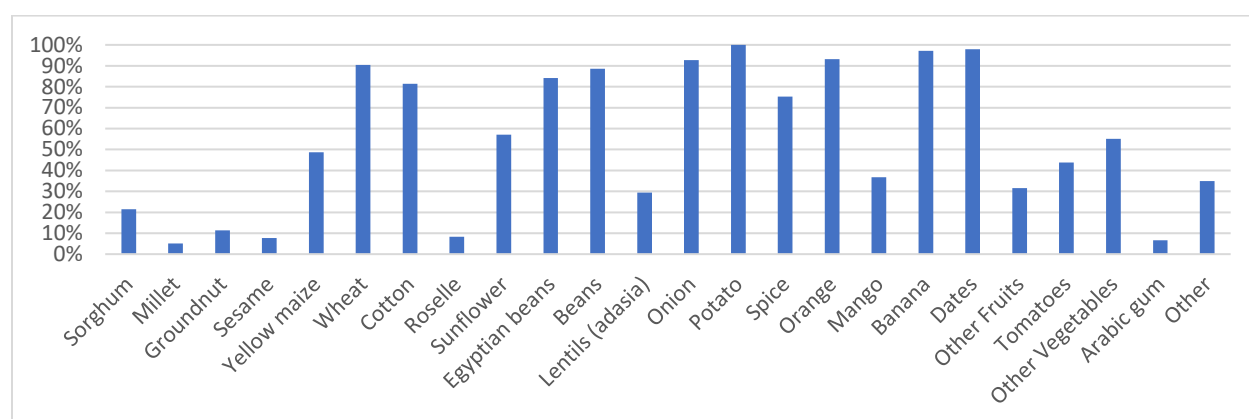
(c) Lower Irrigation Uptake of the Poor compared to the Non-poor (by Region), 2014/15



Source: Authors' calculations using NHBPS 2014/15.

Very little of the land cultivated for the four main crops—sorghum, millet, groundnut, and sesame—is irrigated (Figure 30). Of these four crops, sorghum has the highest rate of irrigation, at 21 percent, while millet has the lowest rate of irrigation, at only 5 percent. The low rate of irrigation for millet corresponds to where it is predominantly grown, in the regions of Kordofan and Darfur. Besides these four crops, cash crops are much more likely to be grown on irrigated lands. For example, wheat and cotton are grown on irrigated lands over 80 percent of the time, while dates are almost exclusively grown on irrigated land.

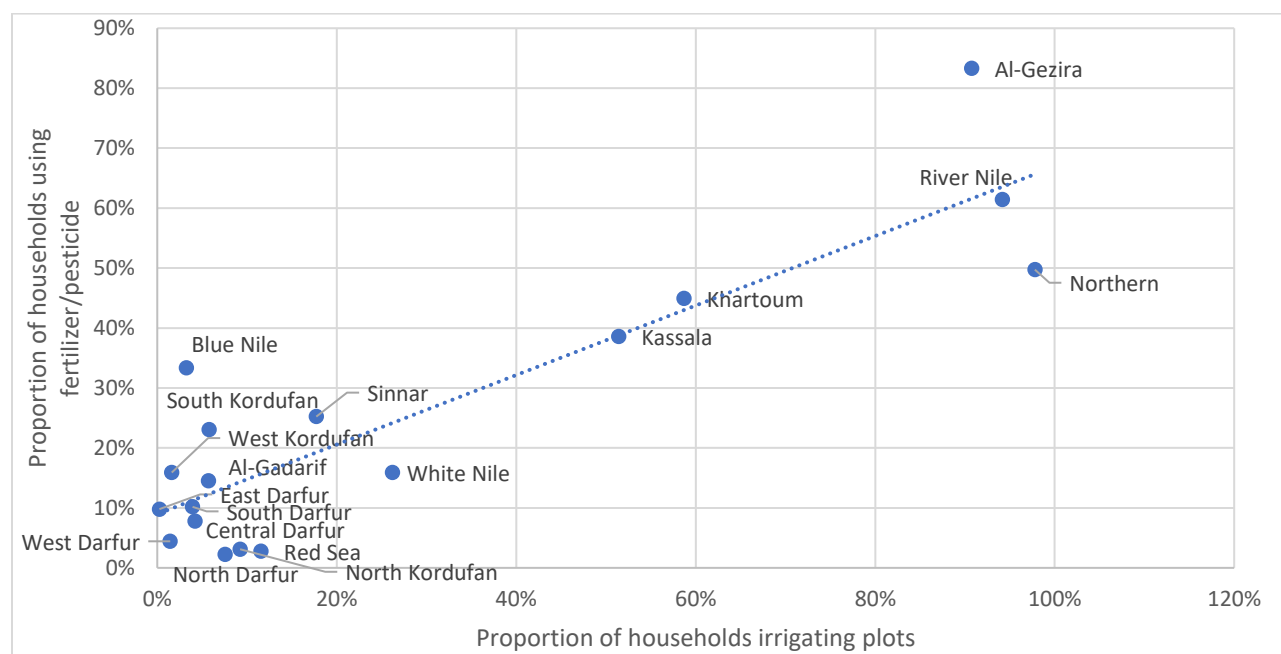
Figure 30: Proportion of Land Cultivated Irrigated by Crop Grown, 2014/15



Source: Authors' calculations using NHBPS 2014/15.

States with a high rate of fertilizer use also have high rates of irrigation (Figure 31). Al-Gezira, the River Nile, and the Northern states all have close to universal rates of irrigation and have very high rates of fertilizer/pesticide use. States such as the Red Sea, North Kordofan, and Central Darfur are at the other end of the spectrum, with low rates of fertilizer/pesticide use and low rates of irrigation. However, there is greater variability with fertilizer/pesticide input use, as many states have low rates of irrigation, with input use ranging from 3 percent for the Red Sea to up to 41 percent for the Blue Nile state.

Figure 31: Correlation between Fertilizer/Pesticide Use and Irrigation in Sudan, 2014/15



Source: Authors' calculations using NHBPS 2014/15.

Credit

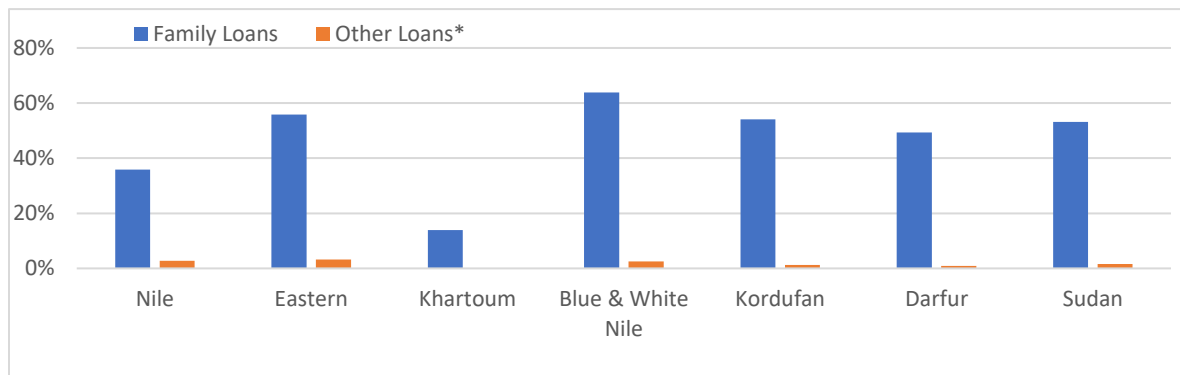
Over half the agrarian households access some form of credit, but most of this is from family and individual sources (Figure 32a). Very little credit comes from institutional sources, such as formal banks, the government, or microfinance institutions. As only 5 percent of agrarian households own a bank

account, this suggests there is large potential for improving access to credit for agrarian households. Though the most common reason households cite for not obtaining a loan is the lack of need for credit, over half the households that do not obtain a loan cite some sort of hindrance to obtaining a loan (Figure 32b).

The vast majority of agrarian households acquire loans for consumption needs (Figure 32c). However, close to one-fifth of agrarian households acquired loans for agricultural needs, the most common being farm inputs. Evidence from developing countries suggests that increased access to credit from institutional sources increases use of productivity-improving inputs, such as fertilizers and better-quality seeds, and thus improves crop productivity. Therefore, increasing access to credit can help improve farm productivity in rural Sudan.

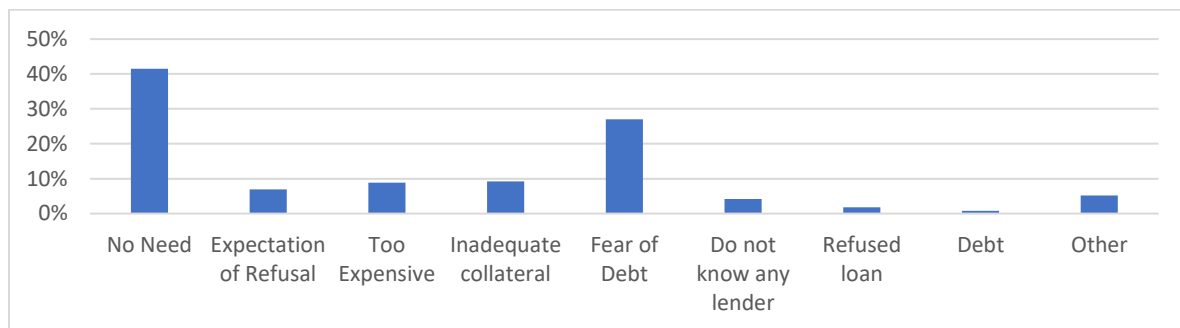
Figure 32: Access to Credit of Sudanese Agrarian Households, 2014/15

(a) Credit Access by Region

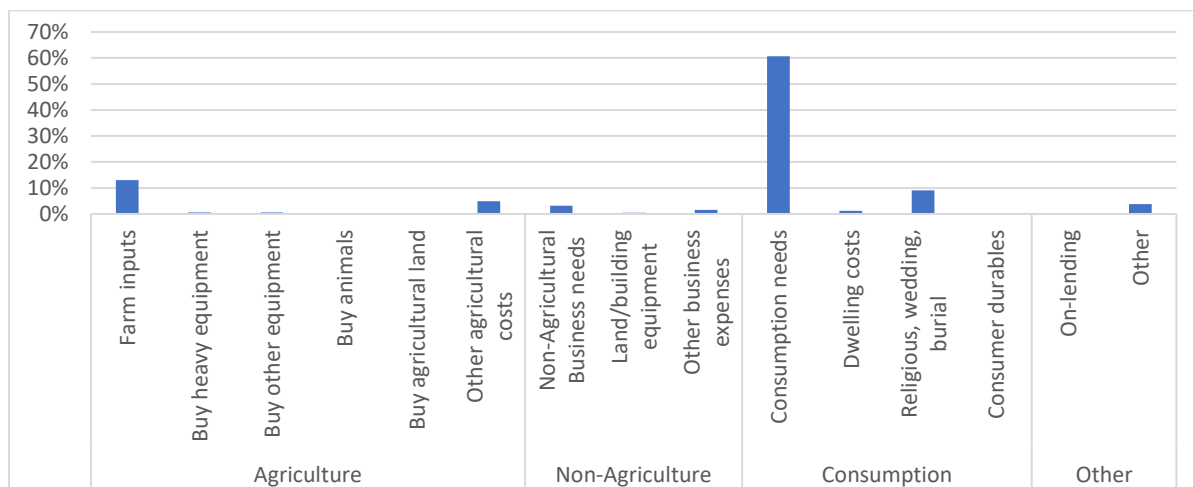


Note: * Other loans include those originating from banks and government agencies, nongovernmental organizations (NGOs), microfinance institutions, and employers or landlords.

(b) Reasons for Not Acquiring Loan



(c) Purpose of Acquiring Loan



Source: Authors' calculations using NHBPS 2014/15.

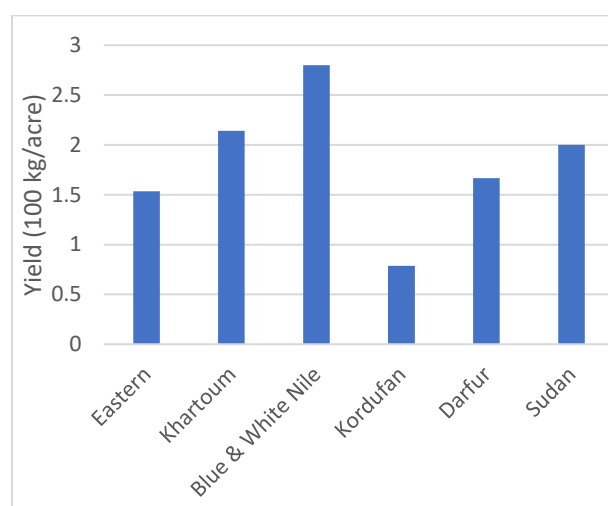
IV. Crop Productivity

A. Regional Variation in Productivity

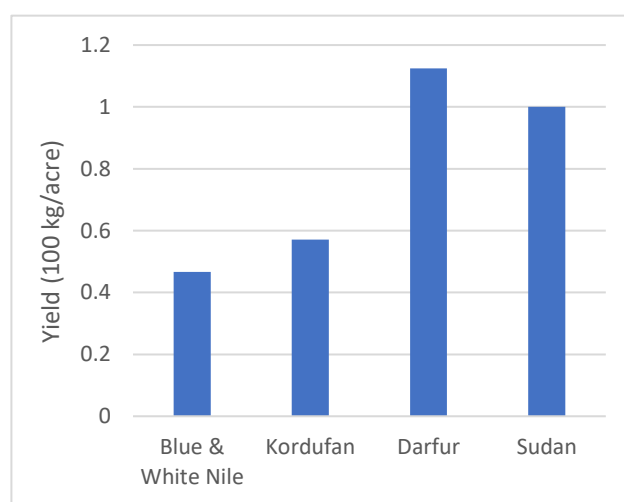
The Blue and White Nile regions tend to have the highest yields for three of the four major crops produced (Figure 33Error! Reference source not found.a–d)—sorghum, sesame, and groundnut. The millet yield is highest in the Darfur region, where it is predominantly grown. Though sesame is predominantly grown in Kordofan, the region has very low yields of the crop. Kordofan also has the lowest yields of sorghum and groundnut.

Figure 33: Yield of the Four Major Cultivated Crops in Sudan (in Relevant Growing Regions), 2014/15

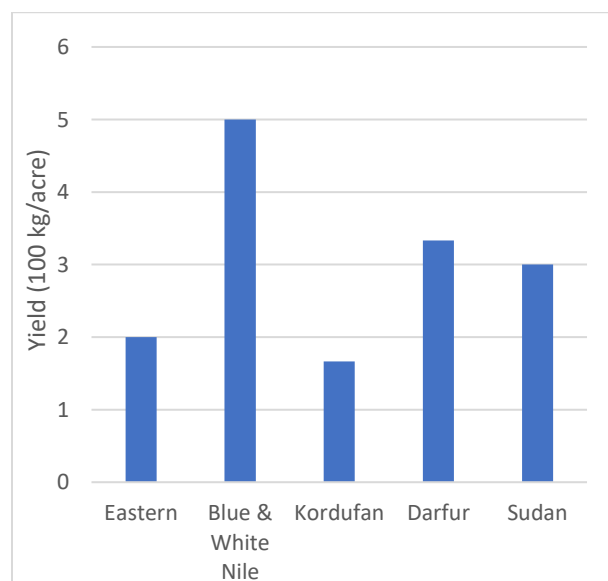
(a) Sorghum



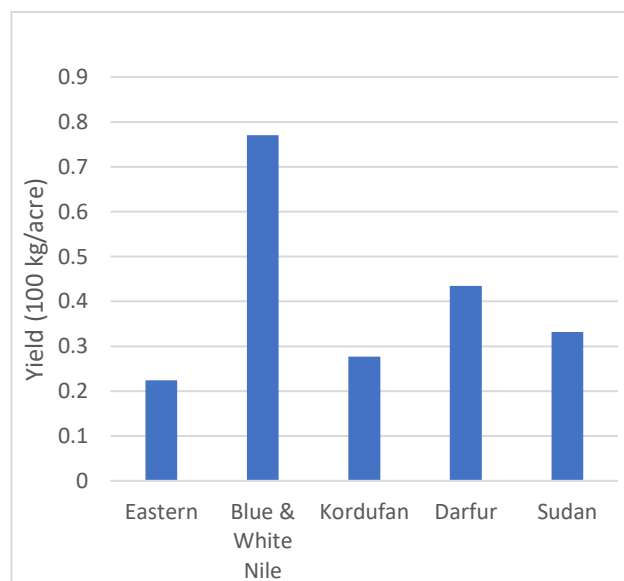
(b) Millet



(c) Groundnut



(d) Sesame

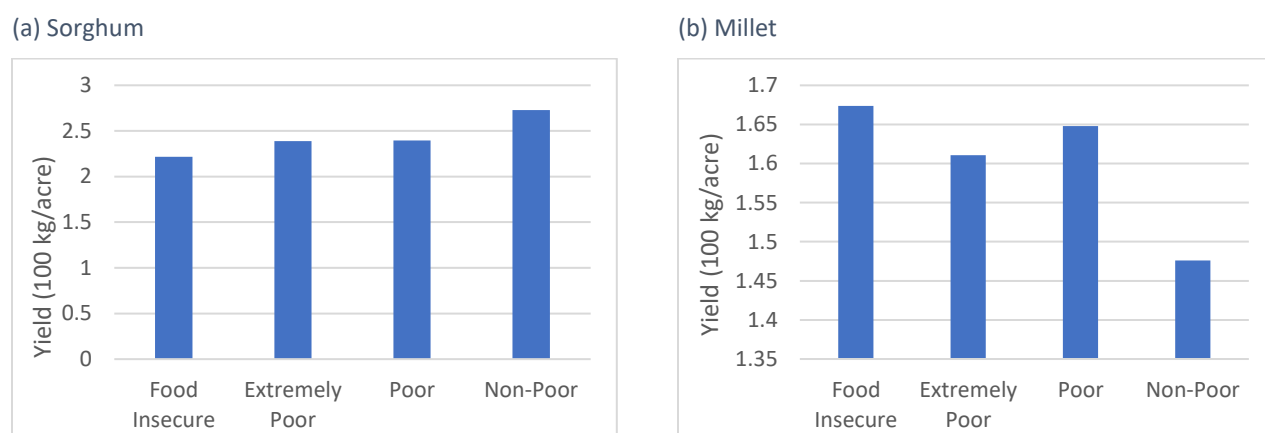


Source: Authors' calculations using NHBPS 2014/15.

B. Productivity and Rural Welfare

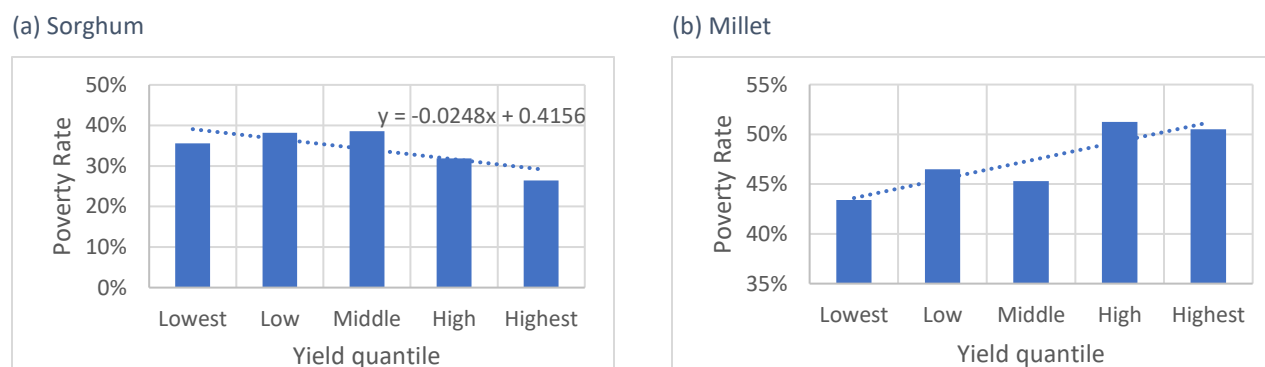
Comparing poverty classifications with yields of sorghum and millet reveals a negative relationship for sorghum and a positive relationship for millet (Figure 34). The NHBPS 2014/15 classifies households into four income classifications. Households are first classified into the poor and non-poor. Within the poor, households may be extremely poor; within the extremely poor, households may additionally be food insecure. Therefore, the four income classifications—the food insecure, the extremely poor, the poor, and the non-poor—represent households from increasing to decreasing levels of poverty. Each classification represents individuals who meet that classification but not a lower poverty classification, that is, the poor represent households that are neither extremely poor nor food insecure. The non-poor have the highest yields of sorghum; the food insecure have the lowest yields. The non-poor have the lowest yields of millet; the food insecure have the highest yields. Poverty rates by yield quantiles show a similar relationship for sorghum and millet (Figure 35).

Figure 34: Sorghum and Millet Yield by Poverty Classification, 2014/15



Source: Authors' calculations using NHBPS 2014/15.

Figure 35: Poverty Rates by Yield Quantile for Sorghum and Millet



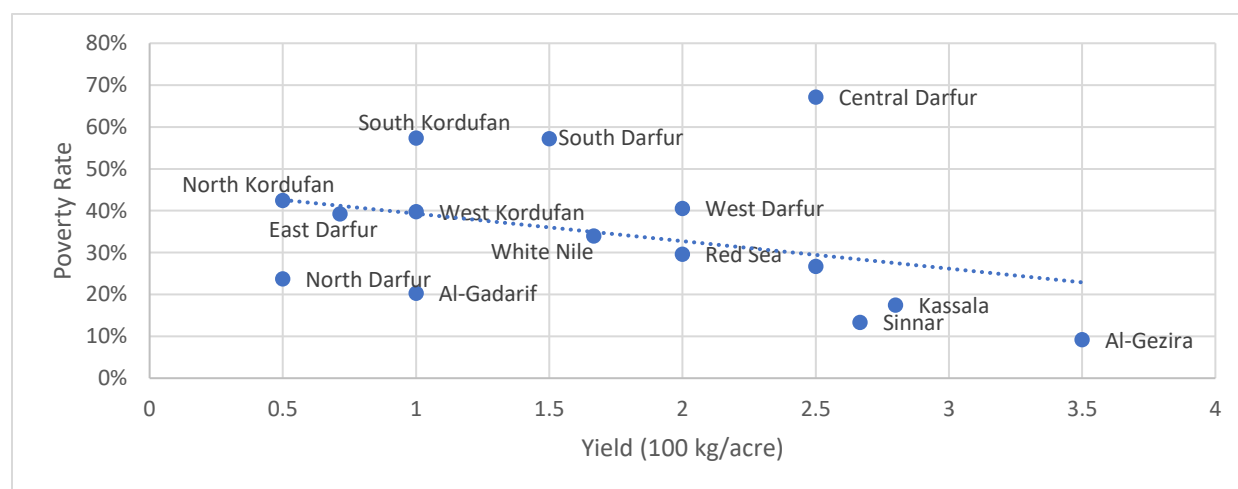
Source: Authors' calculations using NHBPS 2014/15.

States with higher yields of sorghum tend to have lower poverty rates, but this relationship again reverses for millet (Figure 36). The positive trend for sorghum and the negative trend for millet are explained by the more universal cultivation of sorghum, as opposed to millet, which is grown primarily

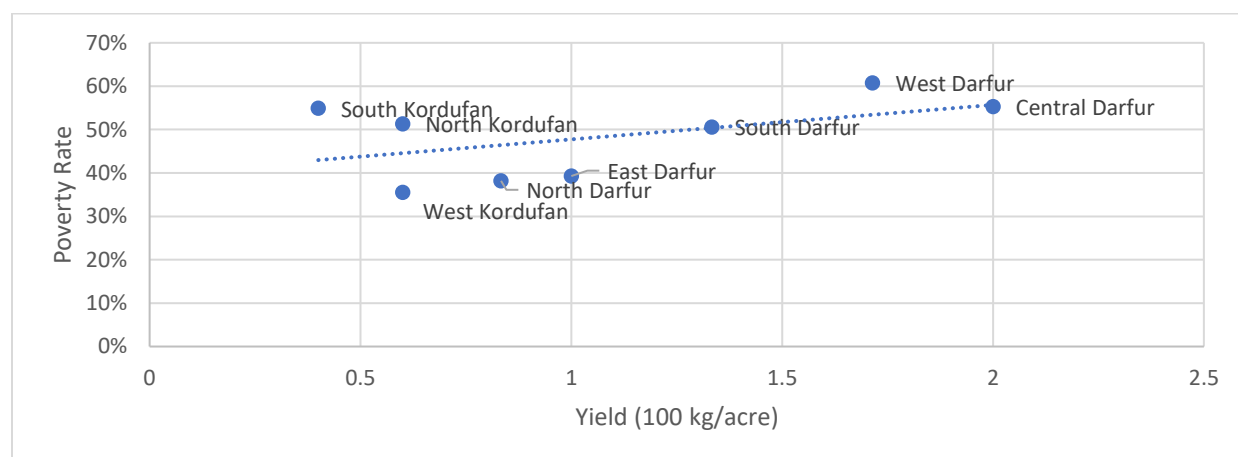
in Kordofan and Darfur. As seen previously, though both crops are primarily grown for subsistence, on average only one-fifth of a household's millet production is sold, compared to, on average, one-third of production for households growing sorghum. Millet ranks as the most subsistent of all crops grown. The greater subsistence requirement of millet means that households that rely on it for their own caloric needs may take greater efforts to ensure that it is cultivated efficiently, and sufficient is produced. Due to the relative poverty of subsistence households, this may be one reason why we observe a positive relationship between millet yield and poverty.

Figure 36: Sorghum and Millet Yield and Poverty by State, 2014/15

(a) Sorghum



(b) Millet



Source: Authors' calculations using NHBPS 2014/15.

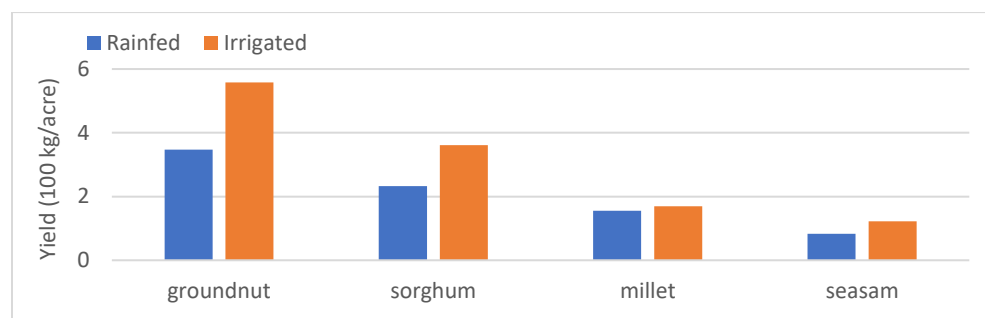
C. Productivity and Farm Characteristics

Irrigation

Of the four main crops grown in Sudan, yields of sorghum, groundnut, and sesame are higher when grown on irrigated lands (Figure 37). For millet, only a statistically insignificant increase is observed, though this may be due to the very uncommon occurrence of millet being grown on irrigated lands. For

the other three crops, the gains in productivity are significant and all lead to approximately 50 percent increase in yields. Better irrigation can also help agrarian households in times of drought and flooding, which affected 8 percent and 15 percent,⁶ respectively, of agrarian households in 2014/15. Irrigation can help mitigate damages to crop production during these times of adverse shocks and thus improve the households' short- and long-run welfare.

Figure 37: Yield of Major Crops for Irrigated versus Rain-fed Cultivation, 2014/15

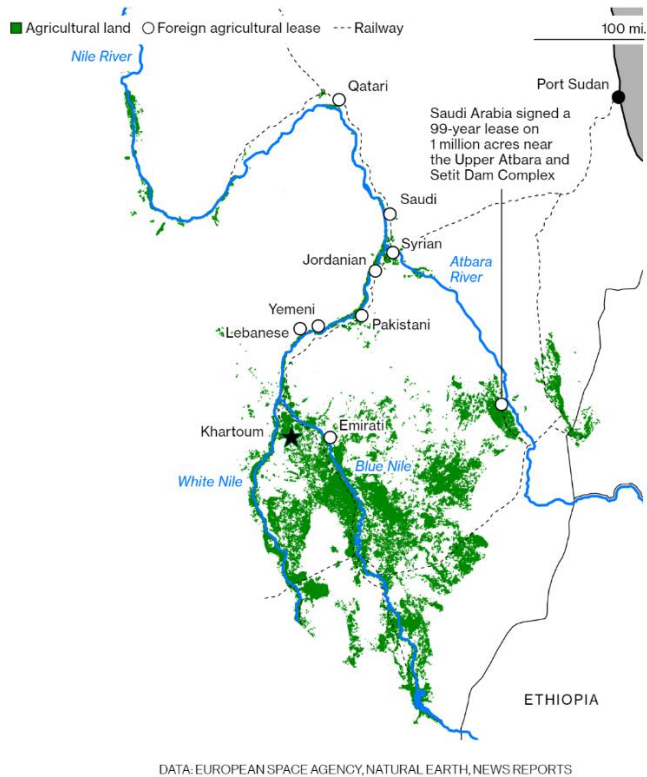


Source: Authors' calculations using NHBPS 2014/15.

As Sudan has allowed for large-scale foreign ownership of fertile lands near the Nile, efficient and equitable distribution of Sudan's water resources will need to be a policy priority. As seen in Figure 38, the previous Sudanese government leased out lands to foreign entities for agricultural operations. Irrigation on these foreign owned operations near Sudan's major waterways need to be carefully regulated so that communities that rely on those waters for their own livelihoods are not adversely affected by the operations of these foreign agricultural enterprises. Some operations have already had detrimental effects on local communities (Schwartzstein 2019). As these operations also have the potential to employ large numbers of Sudanese agrarian workers and provide foreign investment into the country, ensuring a balanced approach in regulating the operations of these entities is vital for ensuring prosperity of the communities in and around these operations.

⁶ Source: Authors' calculations using NHBPS 2014/15.

Figure 38: Known Location of Major International Holdings



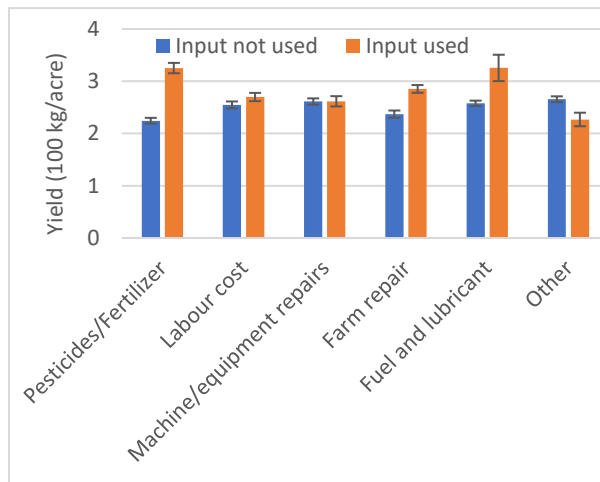
Source: Schwartzstein 2019.

Input Use

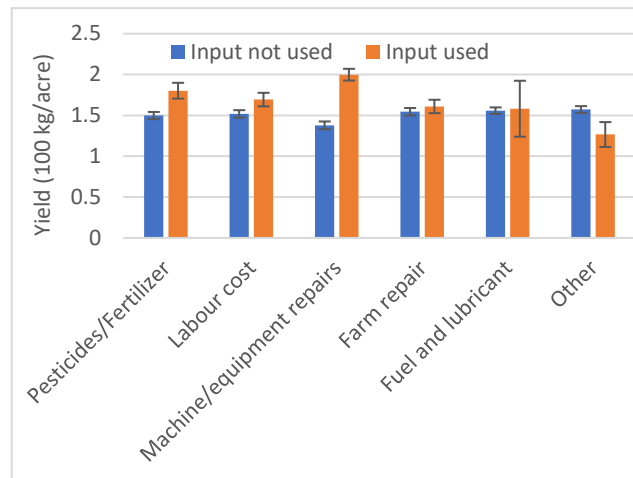
Pesticide and fertilizer use tend to increase crop yields (Figure 39a–d). This holds true for sorghum, millet, and groundnut but not for sesame. Machine use is associated with higher yields of millet and sesame. Fuel use is associated with higher yields of sorghum and sesame. Increased labor costs are associated with greater yields of millet and groundnut, and marginally of sorghum.

Figure 39: Yield and Input Use for the Four Major Crops, 2014/15

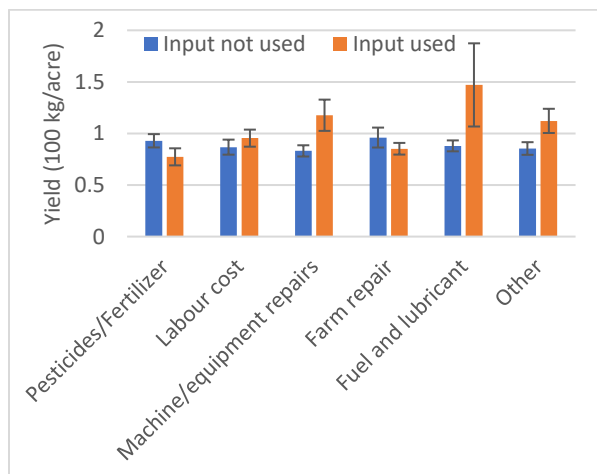
(a) Sorghum



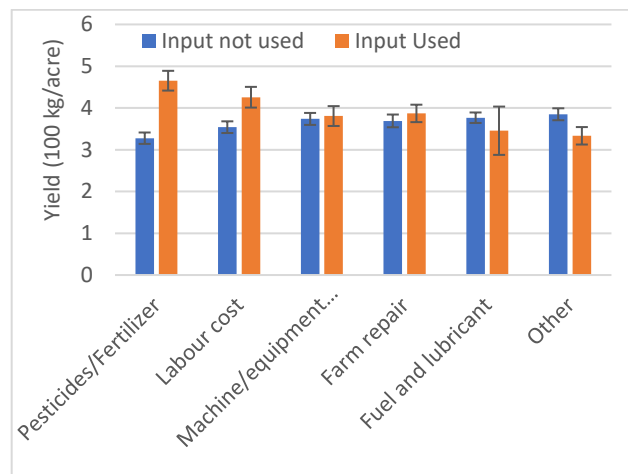
(b) Millet



(c) Sesame



(d) Groundnut

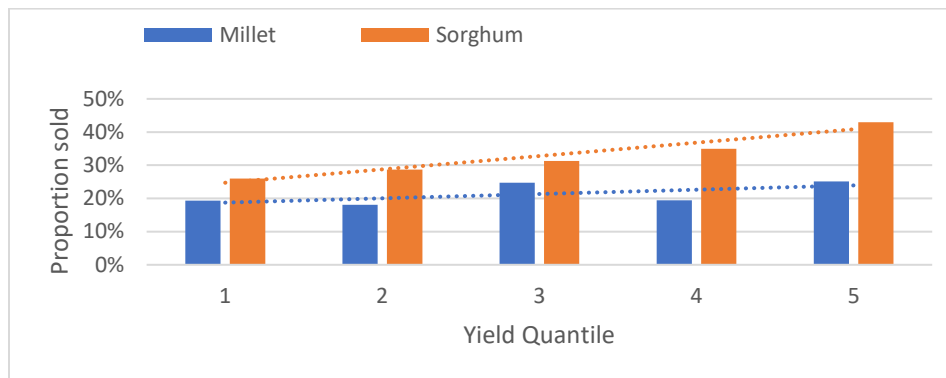


Source: Authors' calculations using NHBPS 2014/15.

Crop Sales

The proportion of sorghum yields to the crop sold in market exhibits a positive relationship, while millet yields do not show any such relationship (Figure 40). This helps explain why a negative relationship between yields and poverty exists for sorghum but not for millet. Increasing yields of sorghum are associated with improved welfare conditions, and this in turn correlates with the ability to sell more produce in the market. For millet, due to its subsistent nature of cultivation for households in rural Sudan, increasing yields are not associated with increased opportunities to sell surplus produce. Rather, these households produce efficiently but do not sell much produce in the market, precisely because of its need for household consumption.

Figure 40: Proportion of Total Crop Produce Sold by Yield Quantile for Millet and Sorghum, 2014/15



Source: Authors' calculations using NHBPS 2014/15.

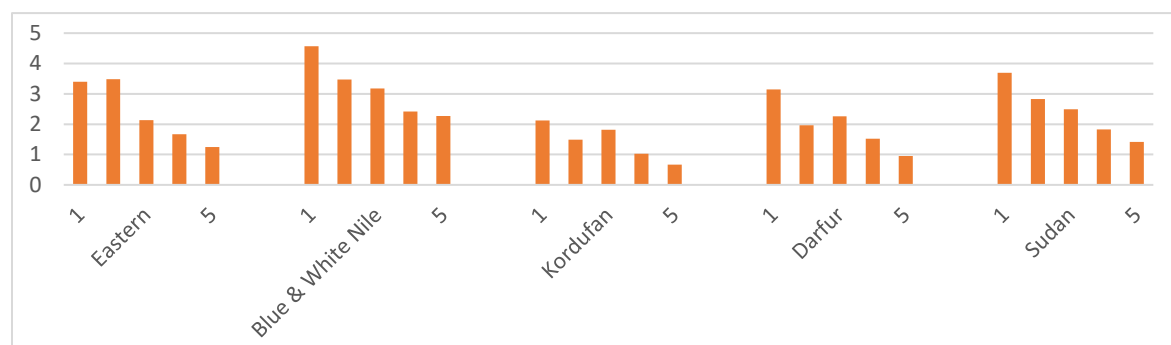
Farm Size

As has been observed in previous studies from around the world, yield and plot area have a strong negative relationship (Figure 41a–c). This phenomenon, known as the inverse farm-size productivity relationship, can be attributed to a variety of factors, though no definite explanation exists. Reasons cited for this relationship include market failures (Feder 1985; Sen 1966), omitted variables related to the quality of the land (Benjamin 1995; Bhalla and Roy 1988), and measurement error relating to the size of plots (Lamb 2003). Key omitted variables include farmer effort and farm management. Larger farms employ outside labor who may shirk work or not be as motivated as household-supplied labor, which is the norm in household farms with smaller plot sizes.

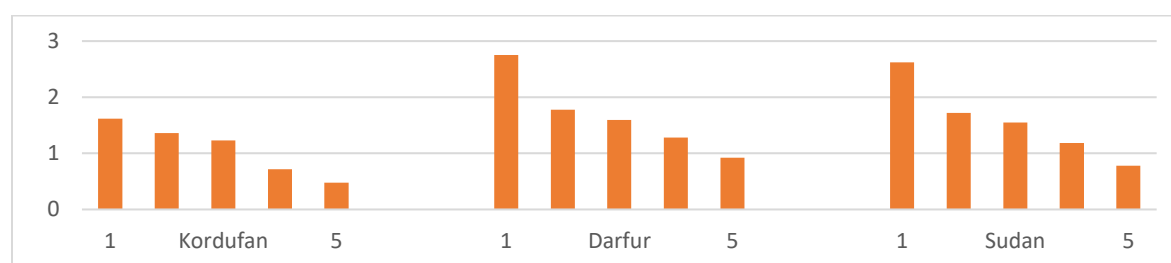
This negative relationship was observed for Sudan and its separate regions, for all four major crops (Figure 41a–c). These findings might suggest the need for land reform, to create smaller average landholding size to spur productivity growth, though the benefits of such a policy need to be carefully weighed against its possibly harmful repercussions. However, these results, and those in the following regression analysis, imply that larger plots are not necessarily helpful for increasing yields.

Figure 41: Yield by Land Area Quantile for the Four Major Crops in Sudan, 2014/15

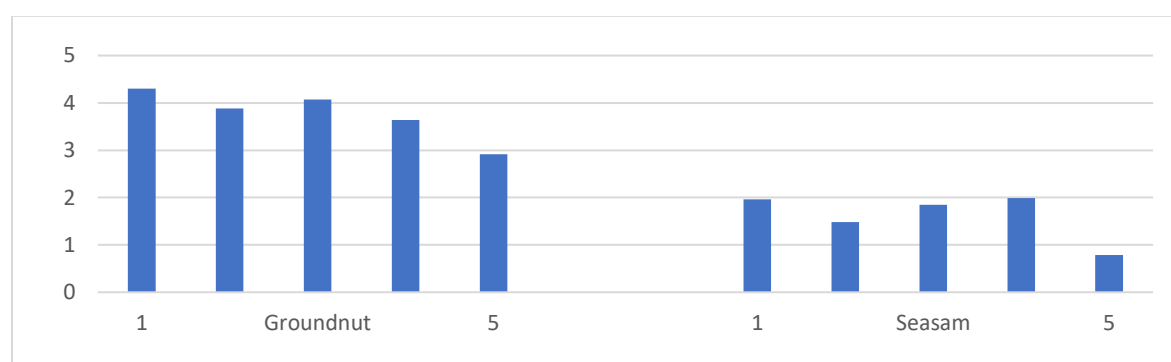
(a) Sorghum



(b) Millet



(c) Groundnut and Sesame



Source: Authors' calculations using NHBPS 2014/15.

D. Determinants of Crop Yield: An Empirical Investigation

To gain a better understanding of determinants of productivity, it is useful to empirically analyze the significant factors causing variation in yields across households. This can be done by regressing yields on potential determinants while controlling for certain household characteristics. An advantage of this approach, as opposed to looking at potential determinants individually, as done in Section IV.C, is that such analysis can account for the different determinants simultaneously and identify which among them is most accurate in explaining variations in productivity. Due to limitations of the data, this is not a causal analysis. Due to the likelihood for correlation between the determinant factors and the potential for omitted variables, it is impossible to use this analysis to conclude which factors, if changed at the household level, would lead to changes in productivity. However, it gives us a good starting point for

hypothesizing over the potential causal mechanisms by which to increase productivity for the agrarian Sudanese households.

The regression we run is as follows:

$$Y_i = \gamma_i + \beta_1 X_i + \beta_2 H_i + \varepsilon_i,$$

where Y_i is the variable of interest, which is logged crop yield ($Y_i = \log(\text{yield}_i)$), for household i , which we analyze for the four main crops (sorghum, millet, sesame, and groundnut) separately; γ_i are the state-level fixed effects, to account for regional heterogeneity; H_i are household characteristics, such as household size and education level of the household head; and X_i are all the potential determinants of crop productivity, such as input use and land ownership status. The results of this regression are presented in the following paragraphs.

Regressing yields on their potential determinants shows that yields for some crops are positively related to fertilizer/pesticide input use and the use of irrigation (Table 1). Though we do not see a universal impact of fertilizer/pesticide use on yields for all four crops, we do observe positive impacts for sorghum and millet. For irrigation, we observe a positive impact overall for millet and sesame but not for sorghum or groundnut. State-level controls absorb household-level variation in irrigation use.

Using labor and acquiring a nonagricultural loan are negatively related to sorghum yields (Table 1). This could be because households that require labor may not be able to adequately manage employment on their farms, compared to using household employment. Households that acquire nonagricultural loans might have faced an economic shock that adversely affected farm productivity, resulting in a negative relationship between these types of loans and yields. No such relationship is observed for loans acquired for agricultural purposes. Rented and communal lands also observe lower yields when compared to owned lands.

A negative relationship between plot size and yields is also observed for all crops, indicating the inverse productivity to farm size relationship. This supports our findings that show the negative relationship in Figure 41. Rented and communally owned lands show lower yields of sorghum than owned lands, indicating that perhaps cultivators are unwilling to make productive, long-term investments in such lands.

Table 1 presents regression results of the determinants of yield for Sudanese farmers. The regression includes the four major crops identified in the data—sorghum, millet, groundnut, and sesame—in four separate regressions. All input use variables specify whether the household used inputs greater than 100 Sudanese pounds. Regressions use household weights and standard errors are robust.

Table 1: Regression of Determinants of Yield, 2014/15

	(1) Sorghum	(2) Millet	(3) Groundnut	(4) Sesame
Logged Yield ⁷				
Poor	-0.118** (0.057)	-0.013 (0.060)	-0.205** (0.087)	0.142 (0.116)
Agricultural loan	0.108 (0.084)	-0.236 (0.154)	0.001 (0.173)	0.219 (0.159)
Nonagricultural loan	-0.166*** (0.052)	-0.172*** (0.053)	-0.076 (0.079)	-0.118 (0.110)
Input Use				
Fertilizer/pesticide	0.128* (0.075)	0.172 (0.117)	0.224 (0.180)	-0.057 (0.153)
Labor	-0.025 (0.055)	0.009 (0.067)	0.132 (0.106)	0.080 (0.108)
Machine	0.069 (0.059)	0.192*** (0.060)	0.115 (0.096)	0.228* (0.131)
Farm repair	0.039 (0.059)	0.070 (0.070)	-0.098 (0.093)	0.076 (0.104)
Fuel	0.067 (0.107)	-0.035 (0.187)	0.065 (0.251)	0.197 (0.196)
Other inputs	0.111 (0.078)	-0.248*** (0.089)	0.063 (0.107)	0.215 (0.158)
Irrigated	0.176 (0.112)	0.378*** (0.110)	-0.047 (0.359)	0.483** (0.203)
Land status (owned omitted)				
Rented	-0.052 (0.052)	0.088 (0.063)	0.018 (0.077)	-0.100 (0.119)
Partially owned	-0.030 (0.124)	0.237 (0.210)	-0.006 (0.431)	-0.245 (0.402)
Communal	-0.087 (0.088)	0.068 (0.102)	-0.047 (0.119)	-0.024 (0.190)
Area (plot size)	-0.032*** (0.003)	-0.050*** (0.005)	-0.054*** (0.009)	-0.031*** (0.004)
Household size	0.038*** (0.011)	0.018 (0.012)	0.049*** (0.017)	-0.002 (0.023)
Constant	-1.069*** (0.176)	0.797*** (0.157)	2.115*** (0.594)	-0.244 (0.192)
Observations	2257	1692	737	480
R-squared	0.373	0.410	0.386	0.334
State controls	Yes	Yes	Yes	Yes
Education of household head controls	Yes	Yes	Yes	Yes

Source: Authors' calculations using NHBPS 2014/15.

Note: Standard errors are in parenthesis. ***p < 0.01, **p < 0.05, *p < 0.1.

⁷ As a log linear regression, coefficients need to be transformed. Each unit increase of the independent variable increases yield by $100 \times (1 - e^{\beta})\%$, where β is the coefficient from the regression. For example, a coefficient on poor for sorghum of -0.118 means that the poor (assigned a value of $poor = 1$) have $100 \times (1 - e^{-0.118})\% = -11.3\%$ difference in yields when compared to the non-poor (assigned a value of $poor = 0$). Note that for coefficients close to 0, these estimates are approximately the same.

V. Conclusion and Policy Recommendations

Government efforts should focus on further reducing rural poverty. This paper shows that there has been a large reduction in rural poverty. In fact, the poverty rate in rural Sudan in 2014/15 was lower than that in urban areas, while it was significantly higher in 2009. As the majority of the population still resides in rural areas, a percentage point reduction in rural poverty will have a significantly larger welfare impact (in terms of the number of households affected) than a percentage point reduction in urban poverty. This necessitates investing in improving agricultural livelihoods in rural Sudan.

Increasing farm productivity can be an effective way of reducing poverty, particularly in rural areas where majority of the poor are engaged in agriculture. The data show a clear relationship between poverty and farm productivity. Though such a link does not imply causation, there are potential channels by which these two metrics are related. Increased farm productivity can increase household income or provide for greater subsistence food consumption, thereby increasing household welfare and reducing poverty. On the other hand, reducing poverty would allow households to invest in activities that may improve productivity. These include investing in agricultural inputs such as fertilizers and pesticides, diversifying their crop portfolio to include cash crops in the short-term, and investing in human capital to improve productivity in the long-term.

Recent evidence suggests that there has been a resurgence in agricultural activity in Sudan as IDPs return (FAO 2019). Due to improving security and stability in the region of Darfur, previously displaced households have started to return to their homes. For these households to reengage in agricultural activity is seen as a very significant development. However, public authorities need to ensure that these households can make the most of their economic potential, by ensuring that they have access to credit and inputs, and to output markets to sell their surplus produce. Such investments in these previously displaced households will ensure that they do not slip back into a cycle of poverty, which could further breed political instability.

Increasing input use, such as the rate of fertilizer and pesticide use, can increase farm productivity and thereby increase economic growth. Very few farmers, particularly among the poorest households, use such inputs to increase yields, even though strong evidence suggests that such inputs increase productivity and are generally economically viable (Duflo, Kremer, and Robinson 2008). Public policy initiatives, such as subsidizing these inputs, may help increase the adoption of input-intensive agricultural practices, though such initiatives will only benefit those regions with adequate market infrastructure to supply these inputs to farmers. These tend to be regions where farmers are already using these inputs. Policies that expand market access geographically to regions where existing markets do not serve agrarian households will have the largest impact on increasing smallholder farm productivity.

Novel strategies to increase access to credit can increase farm productivity and profitability. Public-private partnerships to increase access to credit through microfinance can allow agrarian households to invest in productivity-enhancing inputs or provide the capital needed to transition from subsistence to commercial farming. Additionally, these reforms can be leveraged on existing and emerging technologies such as mobile money to enhance financial inclusion and increase efficiency of providing credit to more remote areas where physical banking presence is not feasible. Such services are being pioneered in other African countries (Dahir 2019) and regions that share Sudan's low bank branch

penetration. For some households, especially among the poorest, the opportunity to save and therefore plan for the medium- and long- term may be more attractive than increasing access to credit. Such financial instruments and the savings they allow for make it possible for households to invest in farm productivity when the opportunity arises, or serve as an insurance policy during times of economic hardship.

Further reductions in rural poverty can be made by improving the non-agrarian economic opportunities available to rural Sudanese households. The findings suggest that nonagricultural households have lower rates of poverty than those solely engaged in farming. However, it is vital that economic policies do not create distortions that artificially inflate the value of nonagricultural work. As is shown in the Appendix, the discussion on the structural change in Sudan shows that Sudan's economic progress up until 2009 indicates an economy that is not industrial, even though relative agricultural production has fallen. This also indicates an economy with a bloated service and informal urban sectors. Instead, promoting nonagricultural employment tied to the agrarian economy would be most impactful on increasing the welfare of rural households. This can be done by promoting the marketing, storage, and transport of agricultural inputs and outputs, especially in a way that benefits smallholding agrarian households.

Creating the infrastructure that makes small-scale businesses viable in rural Sudan is vital to creating a vibrant rural economy. Such policies will encourage farmers to grow commercially viable crops, or to expand the production of their existing crop from subsistence levels to a level that makes selling in the market viable. Connecting rural communities physically, through a robust transport network, and improving communications networks can greatly improve the livelihoods of rural households. Improvements to the physical infrastructure can facilitate the marketing, storage, and transport of agricultural inputs and outputs in an economically viable way, while communication networks can improve the transfer of information to rural communities. This includes the infrastructure needed to make cell phones and the internet more accessible and useful in the rural areas of Sudan. Improved information will lead to better knowledge of agricultural prices, and a greater ability to develop novel agricultural techniques and grow profitable crop varieties.

A robust public farm extension system is vital to providing Sudanese farmers with the know-how to increase agricultural productivity. As seen in the Appendix, Section II, Sudan's public extension system employs less than one-tenth of Egypt's public extension system, for a population more than one-third the size. Extension services can inform farmers on how to make productive and profitable decisions in the face of changing climatic and economic conditions. Such information is vital for ensuring that the poorest agrarian households do not lag behind and can engage successfully and profitably in commercial farming opportunities.

Stagnating innovation in the agricultural sector can be reversed by collaborations between Sudan's public agricultural institutions and international organizations focused on increasing agricultural productivity. Such partnerships can promote improved agricultural practices, the introduction of new crop varieties, and the effective implementation of policies. Due to Sudan's recent international isolation, the returns from these partnerships can be considerable. Cognizant of the diversity of agroeconomic conditions in Sudan, such partnerships can access and implement proven solutions to impediments faced by farmers to achieving productivity growth..

Expanding and repairing Sudan's existing irrigation network can significantly increase farm productivity. Currently, most agrarian households do not have access to irrigation. The positive correlation between yields and irrigation shows that irrigation can increase productivity. Additionally, farmers producing on irrigated lands grow commercially viable crops. Improved access to irrigation makes farmers less vulnerable to the unpredictable nature of seasonal rains that rain-fed, non-irrigated farming relies upon. Much of Sudan's large irrigation network, on the River Nile in the north of the country and its tributaries further south, was constructed during colonial times and is in need of maintenance and rehabilitation (World Bank 2010). Furthermore, the fact that very few households report having access to irrigation reveals that irrigated lands are owned by a small share of farmers. Ensuring that smallholder farmers also have access to irrigation can lift these farmers out of subsistence farming. Regulation of foreign-owned agricultural operations is vital for ensuring equitable access to Sudan's rich water resources, while providing employment at these foreign-owned entities to those who need it.

Greater productivity of farmers with smaller landholdings suggests that distributive land reform policies can increase agrarian productivity. However, before such policies are enacted, it is important to first identify the reasons for differences in productivity levels. If market failures cause differences in productivity, addressing those market failures may have greater rewards than implementing the distributive land reform, which may come at significant political costs. Recent evidence suggests that such land reform can have unintended negative consequences, leading to reductions in overall productivity, as witnessed in the Philippines (Adamopoulos and Restuccia 2015).

Policies to increase farm productivity would need to design and implement unique strategies to cater to Sudan's regional diversity, for example, regional differences stemming from agro-economic differences between irrigated and rain-fed areas, differences between households growing subsistence crops and commercial crops, and differences in land ownership norms. Additionally, regions that are experiencing conflict may have different priorities concerning agricultural and rural development. Designing unique policies for the disparate and distinct groups of rural Sudanese households will best serve to improve the welfare of the nation. Finally, it is critical to adapt to the threat of climate change through green agriculture.

References

- Adamopoulos, T., and D. Restuccia. 2014. "Land Reform and Productivity: A Quantitative Analysis with Micro Data." Unpublished Manuscript. University of Toronto. 1667–1697.
- Anríquez, G., and K. G. Stamoulis. 2007. "Rural Development and Poverty Reduction: Is Agriculture Still Key?" *eJADE: electronic Journal of Agricultural and Development Economics* 4 (853-2016-56113) 5.
- Benjamin, D. 1995. "Can Unobserved Land Quality Explain the Inverse Productivity Relationship?" *Journal of Development Economics* 46 (1): 51–84.
- Bhalla, S. S., and P. Roy. 1988. "Mis-specification in Farm Productivity Analysis: The Role of Land Quality." *Oxford Economic Papers* 40 (1): 55–73.

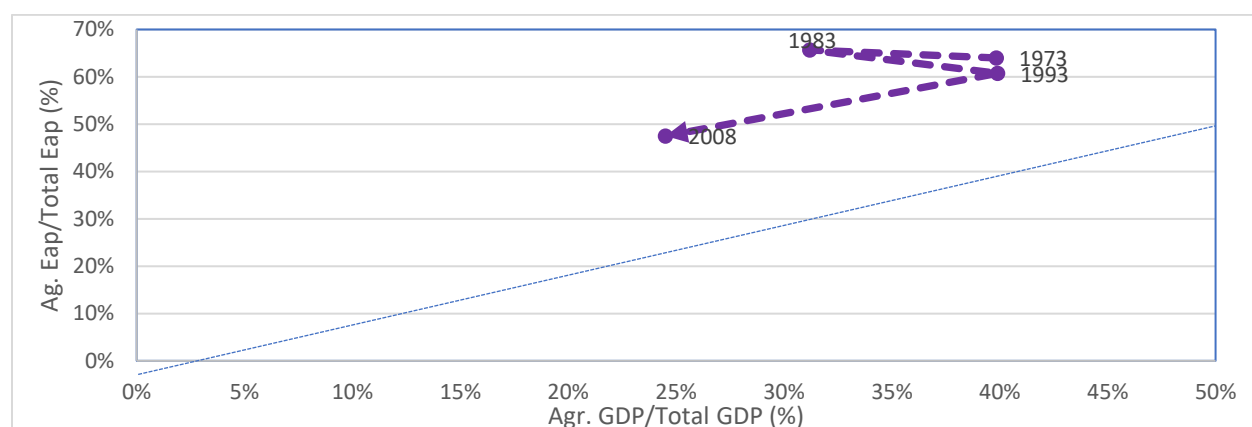
- Dahir, A. 2019. "Mobile Money Is the Key to Growing Africa's Banking Sector." (online) *Quartz Africa*. <https://qz.com/africa/1243637/mobile-money-is-key-to-growing-banks-in-africa/>.
- Duflo, E., M. Kremer, and J. Robinson. 2008. "How High Are Rates of Return to Fertilizer? Evidence from Field Experiments in Kenya." *American Economic Review* 98 (2): 482–88. FAO Special Report. 2019. Crop and Food Supply Assessment Mission to the Sudan. <http://www.fao.org/3/ca3660EN/ca3660en.pdf>
- Feder, G. 1985. "The Relation between Farm Size and Farm Productivity: The Role of Family Labor, Supervision and Credit Constraints." *Journal of Development Economics* 18 (2–3): 297–313.
- FEWS NET. 2015. *Livelihoods Zone Map and Descriptions for the Republic of Sudan*. Washington, DC: FEWS NET.
- Kym Anderson. 2010. "The Political Economy of Agricultural Price Distortions." Cambridge University Press, 2010. *World Trade Review*, 10(3), 417–421.
- Lamb, R. L. 2003. "Inverse Productivity: Land Quality, Labor Markets, and Measurement Error." *Journal of Development Economics* 71 (1): 71–95.
- Losch, B., S. Fréguin-Gresh, and E. White. 2011. *Rural Transformation and Late Developing Countries in a Globalizing World. A Comparative Analysis of Rural Change*. Final Report of the Rural Structural Program, revised version. Washington, DC: World Bank.
- Sen, A. K. 1966. "Peasants and Dualism with or without Surplus Labor." *Journal of Political Economy* 74 (5): 425–450.
- Schwartzstein, P. "One of Africa's Most Fertile Lands Is Struggling to Feed Its Own People." *Bloomberg.com, Bloomberg*, April 2, 2019. <https://www.bloomberg.com/features/2019-sudan-nile-land-farming/>.
- World Bank. 2018. *Sudan: Improving the Quality of Public Expenditures in Agriculture*. Washington, DC: World Bank.
- World Bank. 2019. *Poverty and Inequality in Sudan: 2009–2014*. Washington, DC: World Bank.
- World Bank, World Development Indicators. 2018. Agriculture, forestry, and fishing, value added (% of GDP) - Sudan. Retrieved from <https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=SD>.

Appendix

I. The Structural Gap in Agriculture in Sudan

The structural gap in agriculture has been near complete stagnation since the 1970s (Figure A.1). The structural gap is the difference between the percentage contribution of agriculture to a nation's GDP and the proportion of total labor employed in agriculture. For most developing countries, this gap is a negative value because of the relatively low productivity of labor in agriculture, due in part to the large numbers of labor force employed in that sector. As a country develops economically, we expect this gap to reduce. Increased capital intensification due to an expanding manufacturing base leads to decreasing labor intensity in the agricultural sector. Such a pattern of development has been observed in most developed economies. In Sudan, the economy has not experienced such a transition, and thus we observe stagnation in the structural gap. Though both agriculture's share of total GDP and the share of employment in agriculture have decreased, we do not observe a convergence toward equality between these two values (a movement toward the dotted line in Figure A.1). This illustrates Sudan's inability to meaningfully increase labor productivity in agriculture and elsewhere in the economy. Though the share of labor in agriculture has decreased in the economy, this has not been a result of increased employment in the manufacturing sector. It is instead likely to be a result of an increase in the low productivity services sector due to informal urban activities and the marketing of agricultural products (Losch, Fréguin-Gresh, and White 2011). To achieve sustainable economic growth, Sudan will need to close the structural gap in agriculture, by increasing productivity in both the agricultural and nonagricultural sectors.

Figure A.1: Share of Agriculture in GDP and Employment in Sudan (1973–2008)



Source: Authors' calculations using FAOSTAT and Census Reports by Sudanese Central Bureau of Statistics for 1973, 1983, 1993, and 2008.

II. Extension System in Egypt and Sudan

Egypt Agriculture and Livestock Extension System

Major Categories of Extension Staff	Secondary School diploma		2–3 yr. Ag diploma		B.Sc. degree		M.Sc./Ing. Agr. degree		Ph.D. degree	
	F	M	F	M	F	M	F	M	F	M
Senior Management Staff					61	148			1	7
Field Level Extension Staff	17	2,325			110	965				
Information, Communications and Technology (ICT) Support Staff					16	22				
In-Service Training Staff					5	3				
Total Extension Staff: 7,421	148	3,349			771	3,124			7	22

Sudan Agriculture Extension System

Major Categories of Extension Staff	Secondary School diploma		2–3 yr. Ag diploma		B.Sc. degree		M.Sc./Ing. Agr. degree		Ph.D. degree	
	F	M	F	M	F	M	F	M	F	M
Senior Management Staff	3	3	3	4	5	12	4	22		1
Field Level Extension Staff		45	13	20	243	109	25	39		1
Information, Communications and Technology (ICT) Support Staff		7			39	34	11	19		
In-Service Training Staff										
Total Extension Staff: 656	3	56	16	24	287	155	40	80		2

Sudan Animal Resources and Fisheries' Extension System

Department	Type of staff	Number of staff
Extension and Technology Transfer	Veterinary	11
Pastoralists' Development	Veterinary	12
Communication and Documentation	Extension Technician	9
Technical Office	Veterinary	6
Total staff:		38

<http://www.g-fras.org/en/world-wide-extension-study/africa/northern-africa/sudan.html>

<http://www.g-fras.org/en/world-wide-extension-study/africa/northern-africa/egypt.html>