Report No. 68399-SS

Agricultural Potential, Rural Roads, and Farm Competitiveness in South Sudan

May 23, 2012

Agriculture and Rural Development Unit
Sustainable Development Department
Country Department AFCE4
Africa Region

Document of the World Bank

ACRONYMS AND ABBREVIATIONS

AEZ	Agro-Ecological Zone
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CLC	Cropland Connectivity Index
ESW	Economic Sector Work
FAO	Food and Agriculture Organization
GFRP	Global Food Crisis Response Program
GIS	Geographic Information System
GoSS	Government of South Sudan
HH	High production potential and high population density
HL	High production potential and low population density
IFPRI	International Food Policy Research Institute
LGP	Length of Growing Period
LH	Low production potential and high population density
LL	Low production potential and low population density
MAF	Ministry of Agriculture and Forestry
MARF	Ministry of Animal Resources and Fisheries
MDTF-SS	Multi-Donor Trust Fund for Southern Sudan
MH	Medium production potential and high population density
ML	Medium production potential and low population density
NBHS	National Baseline Household Survey
RAI	Rural Accessibility Index
SDG	Sudanese Pound
SSCCSE	South Sudan Centre for Census, Statistics, and Evaluation
US$	United States Dollar
WFP	World Food Programme

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ACKNOWLEDGMENTS

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The task team is grateful to the Ministry of Agriculture, Forestry, Cooperatives and Rural Development, the Ministry of Animal Resources and Fisheries, and the South Sudan Center for Census, Statistics and Evaluation for the data and information, as well as for comments provided on this Economic Sector Work.

Hyoung Wang (Economist, FEUUR) and Jeeva Perumalpillai-Essex (Sector Leader, EASTS) served as peer reviewers. Cecilia Briceño-Garmendia (Senior Infrastructure Economist, AFTSN) provided guidance on the methodology for developing rural infrastructure. William Battalie (Senior Economist, AFTP2) advised on fiscal sustainability of road investments and helped link this analytical work with other sector activities, including the South Sudan Development Plan. Tesfamichael Nahusenay Mitiku (Senior Transport Engineer, AFTTR) provided guidance on road investments, including unit costs and the priority framework. John Jaramogi Oloya (Senior Rural Development Specialist, AFTAR), Christine Cornelius (Consultant, AFTAR), and Mylinda Night Justin (Consultant, AFTAR) provided advice and comments throughout the report.

Bella Deborah Bird (Country Director, AFCE4), Laura Kullenberg (Country Manager, South Sudan), Laurence Clarke (Country Director, AFCS2 and former Country Manager, Juba), Karen McConnell Brooks (Sector Manager, AFTAR), and Louise Scura (Sector Leader, AFTAR) supported the study and ensured that resources were available for its implementation. Amy Gautam, Hawanty Page, and Gbangi Kimboko edited the report.

EXECUTIVE SUMMARY

1. **South Sudan has a huge but largely unrealized agricultural potential**. Favorable soil, water, and climatic conditions render more than 70 percent of its total land area suitable for crop production. However, less than 4 percent of the total land area is currently cultivated and the country continues to experience recurrent episodes of acute food insecurity. Limited use of productivity-enhancing technologies, capacity constraints, non-tariff barriers, high labor costs and poor infrastructure hinder progress and also constrain production, productivity and the competitiveness of South Sudan's agriculture relative to its neighbors. This report presents information to guide planners and decision makers not only in addressing both short- and medium-term food security needs but also in positioning South Sudan's agriculture sector to effectively compete with its neighbors.

2. **Most analytical work conducted by the World Bank in the agriculture sector in South Sudan has so far focused on how to provide immediate responses to food security emergencies and price spikes**. This includes the Bank's input to the Government's Development Plan and several agricultural value chain studies funded under the Multi- Donor Trust Fund for Southern Sudan. This analytical work is different in that it has a longer-term and forward looking perspective. Such an outlook is equally important at this time as it helps ensure that ongoing immediate responses are coherent and in sync with the overriding objective of agricultural policy which is to lower food costs, reduce poverty and increase the sector's competitiveness at lowest costs.

3. **The report assesses agricultural potential in South Sudan and the possibility of increasing agricultural production through increases in cropped area and per capita yield improvements**. It highlights the importance and contribution of rural roads to improving agriculture production in South Sudan, identifies road networks that are necessary to accelerate expansion of cultivated land in areas that are considered to have high agricultural potential and provides estimates of the budgetary requirements for road investments in those areas. The report also assesses the implications of infrastructure investments on agricultural competitiveness and the scope for reducing production costs in South Sudan to enable producers to compete with food imports, especially from Uganda.

4. **The value (realized agricultural potential) of total agricultural production in South Sudan was estimated at US$808 million in 2009**. Seventy-five percent (US$608 million) of this value accrues from the crop sector, while the rest is attributed to the livestock and fisheries sectors. The average value of household production is US$628, of which US$473 is realized from crops. Average value of production per ha is US$299 compared to US$665 in Uganda, US$917 in Ethiopia, and $1,405 in Kenya in 2009.

5. **Increasing cropland from the current 4 percent of total land area (2.7 million ha) to 10 percent of total land area (6.3 million ha) under a modest cropland expansion scenario would lead to a 2.4-fold increase in the value of total agricultural output relative to the current level (i.e., to approximately US$2 billion versus the current US$808 million).** If coupled with a 50 percent increase in per capita yields, this cropland expansion would lead to a 3.5-fold increase in the value of total agriculture output (i.e., to US$2.8 billion) and would also increase the value of crop production per ha from US$227 to US$340. If per capita yields double, the value of total agriculture production under a modest cropland expansion scenario would increase to US$3.7 billion, and would outstrip the current value of agricultural production in neighboring Uganda. Increasing productivity threefold would increase the value of agricultural production to US$5.5 billion.

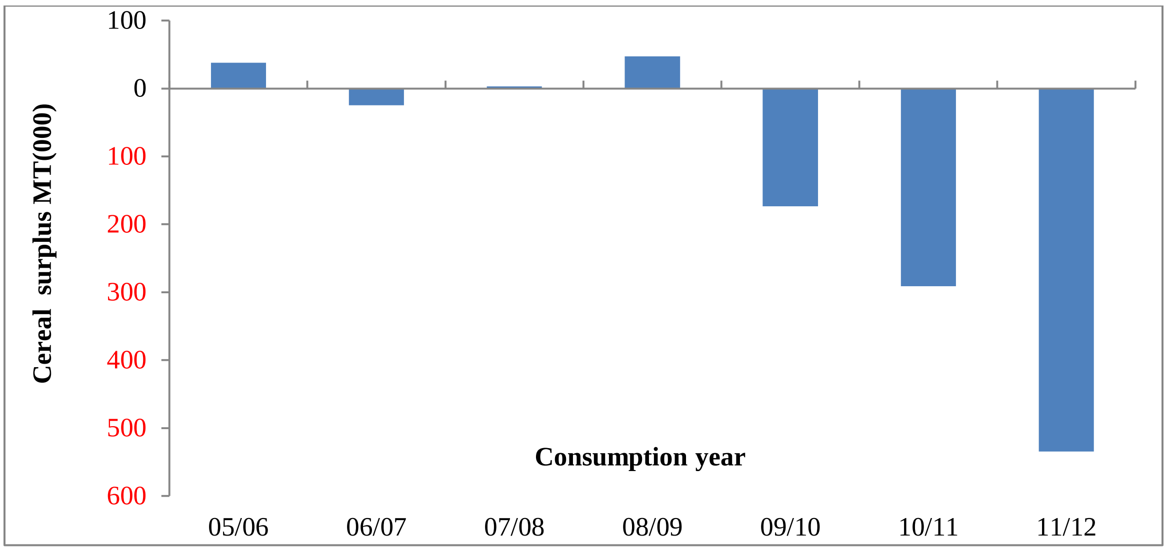
6. **Investments to improve rural connectivity would not only have to first target areas identified as having high agricultural potential, but would also have to adopt a pragmatic approach towards the quality (type) of the roads given severe budget constraints and competing development needs, as well as the low capacity of the local construction industry.** A pragmatic approach implies construction of lower quality roads (with lower unit costs) and larger boundaries for assessing roads coverage. This would reduce the capital requirement for rural roads from US$5 billion to US$2 billion and accelerate the achievement of rural connectivity. Full paving investments would be deferred to the future. These investments in roads have to be accompanied by other measures geared towards reducing transport prices, including the promotion of competition among transport service producers and abolishment of various non-tariff barriers to trade, both internal and at cross-border points if they are to translate into reduced food prices, improved food security and competitiveness. If investments in roads reduced current transport prices by half (from US$0.65 per ton-km to US$0.32 per ton-km), maize prices in Juba would fall from the current US$689 to US$628 per ton, or by 9 percent if other factors remain constant. If transport prices decline from US$0.65 to US$0.33 per ton-km, or by 49 percent, the derived sorghum prices in many markets would fall by 30 percent.

7. **Improved rural connectivity, especially if combined with good transport policy and regulations, will be transformative, but in and of itself will not be sufficient to sustain the competitiveness of South Sudanese farmers**. Neighboring countries still have lower production costs and will benefit from better roads by providing more affordable prices to South Sudanese consumers, especially in urban areas. Complementary productivity-enhancing investments and market-supportive regulations are therefore required to improve the competitiveness of South Sudan's agriculture. In the short term, removing bottlenecks to using the available seed varieties in the East Africa region would increase access to improved germplasm, and would help narrow the current yield gap. Investments in mechanization to reduce drudgery and high costs associated with cropping would also allow South Sudanese farmers to increase production at relatively lower costs. Support for adaptive agricultural research would allow release of new and superior seed varieties and would also help overcome other constraints (e.g., pests and diseases) to yield increases. Advisory services will be essential to maximize farm returns from the use of improved inputs, including mechanization and the development of irrigation. For all of these public investments, it is important to ensure that they "crowd in" private investment rather than discouraging it.

INTRODUCTION

1. **South Sudan has a huge but largely unrealized agricultural potential**. The country is richly endowed with a good climate and fertile soils rendering more than 70 percent of its total land area suitable for crop production. In fact, a few decades ago – in the 1980s-, South Sudan was a net exporter of food commodities. However, the prolonged conflict in the intervening years mediated a breakdown in agricultural support services, institutions, infrastructure and work ethic leading to the near collapse of the country's agricultural production systems. The country thus gained its independence amidst ongoing challenges in agriculture production and with a significant track record of negative food balances (Figure 1) which are typically addressed through food aid.

Figure 1: Cereals balance in South Sudan



Source: Data from WFP and FAO.

2. **The agriculture sector will be key to the post-conflict recovery and development of South Sudan.** A broad review of research (Brinkman and Hendrix, 2010) points to a nexus between food insecurity and conflict and concludes that food insecurity heightens the risk of civil and communal conflict. Therefore, South Sudan must immediately address its food security challenges if the country is to secure sustained peace and recovery and ensure legitimacy of the state. This would prevent the country from relapsing into conflict, as has happened in some post-conflict countries where the state was unable to provide food security for its citizens (Collier, 2007). Beyond food security, however, agriculture will be critical to the long term growth and development of South Sudan. Over 80 percent of the population in South Sudan depends on the agriculture sector as a source of livelihood, and there is a strong consensus in the Government of South Sudan (GoSS) that agriculture should be a vehicle for broad-based non-oil growth and economic diversification. The sector consequently, features prominently in South Sudan's 2011-2013 Development Plan.

3. **Despite its high potential and the important role that agriculture will have to play in the stability and eventual development of South Sudan, it's performance is largely suboptimal.** Production is primarily rain-fed, subsistence in nature, characterized by primordial

technology, high input costs, and low productivity. Where opportunities for surplus production exist, local producers have little or no incentive to produce for the markets because the poor status of roads limits connection to the centers of consumption. Retail markets in urban areas are hence mainly served by imports at very high prices, and with little secondary economic benefit to the rural areas that should otherwise be their natural supply.

4. In the short-term, lowering food prices and ensuring food security will hinge on progress in: (i) increasing agricultural productivity; (ii) creating and improving systems of agricultural services provision; and (iii) strengthening relevant institutions, policies and regulations. Through funding from the Multi-Donor Trust Fund for Southern Sudan (MDTF-SS) and the Global Food Crisis Response Program (GFRP), Trust Fund the World Bank is supporting GoSS in increasing the productivity and output of agricultural producers, strengthening agricultural institutions at both the central and state levels, and building human resource capacity in the agriculture sector. The Bank has also articulated policy options that the GoSS could adopt to lower the cost of food and promote farming with an eye towards future exports.

5. In the long-term however, beyond productivity gains, key to recapturing and realizing the full contribution of the agriculture sector to overall economic growth and diversification in South Sudan will be progress in resolving infrastructure (roads) bottlenecks to enable access to markets and distribution systems and implementing market-based measures to promote the country's competitiveness relative to its neighbors.

6. The work described in this report is a first step to addressing the longer-term issues related to the competitiveness of South Sudan's farmers in a regional context. It focuses on the options for increasing the amount and value of agricultural production in the crop sector, the potential contribution of rural roads to increasing crop production and how to sequence and prioritize rural road investments in a way that maximizes their contribution to realization of the country's full agricultural potential, especially in light of the competing needs for resources, the very high construction and maintenance costs of rural roads, and the low capacity of the local construction industry.[1] The report also explores possible ways of increasing the cost competitiveness of agriculture in South Sudan vis-à-vis its neighbors (Uganda and Sudan).

7. **The core sections of the report include:**

- A presentation of basic information on land use and production potential in South Sudan.
- An estimate and analysis of agricultural production in South Sudan.
- An assessment of the potential for expanding cropland to increase agricultural production.
- Assessment of the contribution and role of improved rural roads and enhanced access to markets in creating incentives for future expansion of cultivated land in areas with high agricultural potential.

[1] The focus is on crop production because data required for similar analyses for livestock, fisheries, and forestry resources, including gum acacia, are not yet available in South Sudan The recent value chain studies on livestock and gum acacia financed by the Multi Donor Trust Fund provide useful information for policy makers on these subsectors; to avoid duplication, this information is not repeated here.

- An estimation of budget requirements for road investments in areas with high agricultural potential.
- An analysis of the implications of better road infrastructure for agricultural competitiveness, including an assessment of farm price and cost competitiveness vis-à-vis Uganda and Sudan, to highlight areas where costs can be reduced to enable South Sudan to compete with food imports, even if local marketing and logistics costs decline in the future.

LAND USE, AGRICULTURAL POTENTIAL, AND POPULATION IN SOUTH SUDAN

8. **This section describes the current land use and land cover in South Sudan.** It focuses on agricultural uses and outlines the extent and coverage of various land use/cover types in the different states and livelihood zones.[2] Using the Length of Growing Period (LGP)[3] as a proxy, the section also describes the potential for agricultural production in South Sudan as well as the relationship between agricultural production potential and population.

1.1. Land use and land cover

9. **South Sudan is endowed with abundant virgin land under climatic conditions that are considered suitable for agriculture**. According to (Diao *et al.*, 2009), more than 70 percent of South Sudan has a LGP longer than 180 days and is therefore suitable for crop production. However, land use and land cover data (FAO, 2009) show that most of the land that is suitable for agriculture is still under natural vegetation. Only 3.8 percent (2.5 million ha) of the total land area (64.7 million ha) is currently cultivated, while the largest part of the country (62.6 percent) is under trees and shrubs (Table 1).[4] This ratio (cropland to total land) is very low in South Sudan compared to Kenya and Uganda, where despite less favorable LGPs, cropland accounts for 28.3 percent and 7.8 percent, respectively, of total land area.

10. **Most of the cropland in South Sudan is rainfed.** A two-step sequential process was used to derive land use/cover data from a 295 land use types depicted in the FAO (2009) land cover map for South Sudan. First, the 295 land use types were resampled and aggregated into eighteen land use types (see Annex 1), thirteen of them agriculture-related (including trees and tree crops). In the second step, the thirteen agriculture-related land use types were further aggregated into six categories (Table 1): cropland, grass with crops, trees with crops, grassland, tree land, and flood land (Diao *et al.*, 2011). Irrigated area is limited to only 32,100 ha, mainly in Upper Nile. Flood land used for rice production is also limited, at about 6,000 ha, and is located primarily in Northern Bahr el Ghazal (Figure 2).

[2] The country is divided into seven livelihood zones that are defined based on climate conditions and farming systems (SSCCSE, 2006): Eastern Flood Plains, Greenbelt, Hills and Mountains, Ironstone Plateau, Nile-Sobat Rivers, Pastoral, and Western Flood Plains. Ironstone Plateau is the largest zone, accounting for 23.5 percent of total land area. The second largest zone is Eastern Flood Plains, which accounts for 20.4 percent of national land. The Western Flood Plains and Greenbelt account for 14.2 and 12.7 percent of total national land, respectively.

[3] Length of Growing Period is the concept used in the Global Agro-Ecological Zone (AEZ) project led by International Institute for Applied Systems Analysis and the UN Food and Agriculture Organization. See Fisher *et al*. (2002) for details.

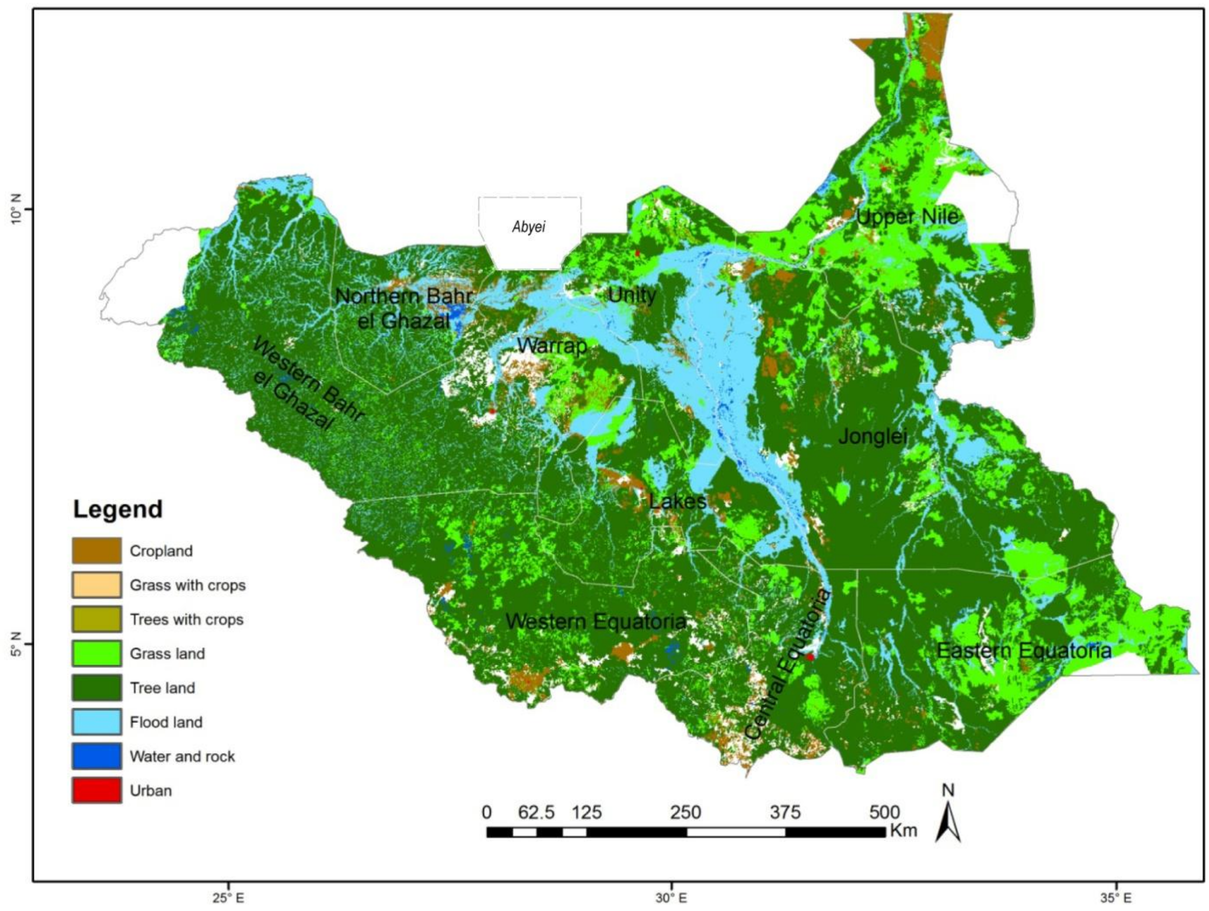
[4] In this analysis, the total land area of South Sudan is estimated at 64.7 million ha, using the data from the most recent Land Cover Database (2009).

Table 1: Area and share of aggregated land uses in total national land area

Land use	Area (ha)	Share of total land (%)
Cropland	2,477,700	3.8
Grass with crops	325,100	0.5
Trees with crops	1,707,300	2.6
Grassland	9,633,800	14.9
Tree land	40,526,900	62.6
Flood land	9,497,600	14.7
Water and rock	482,700	0.7
Urban	37,000	0.1
Total	**64,688,300**	**100**

Source: Aggregated from Land Cover Database, FAO (2009).

Figure 2: Aggregated land use/cover map



Source: Modified from Land Cover Database, FAO (2009).

11. **Most cropland is concentrated in five states:** Upper Nile (19.0 percent of total crop land), Warrap (15.3 percent), Jonglei (14.3 percent), Western Equatoria (11.4 percent), and Central Equatoria (11.2 percent). As shown in Table 2, these five states account for 70 percent of

national cropland and 56 percent of national territory. Almost all irrigated crops (mainly rice) are in Upper Nile; rice on flood land is all in Northern Bahr el Ghazal (Annex 2). Fruit trees and tree plantations are exclusively in Western, Central, and Eastern Equatoria, most probably due to the suitable climatic conditions in these states.

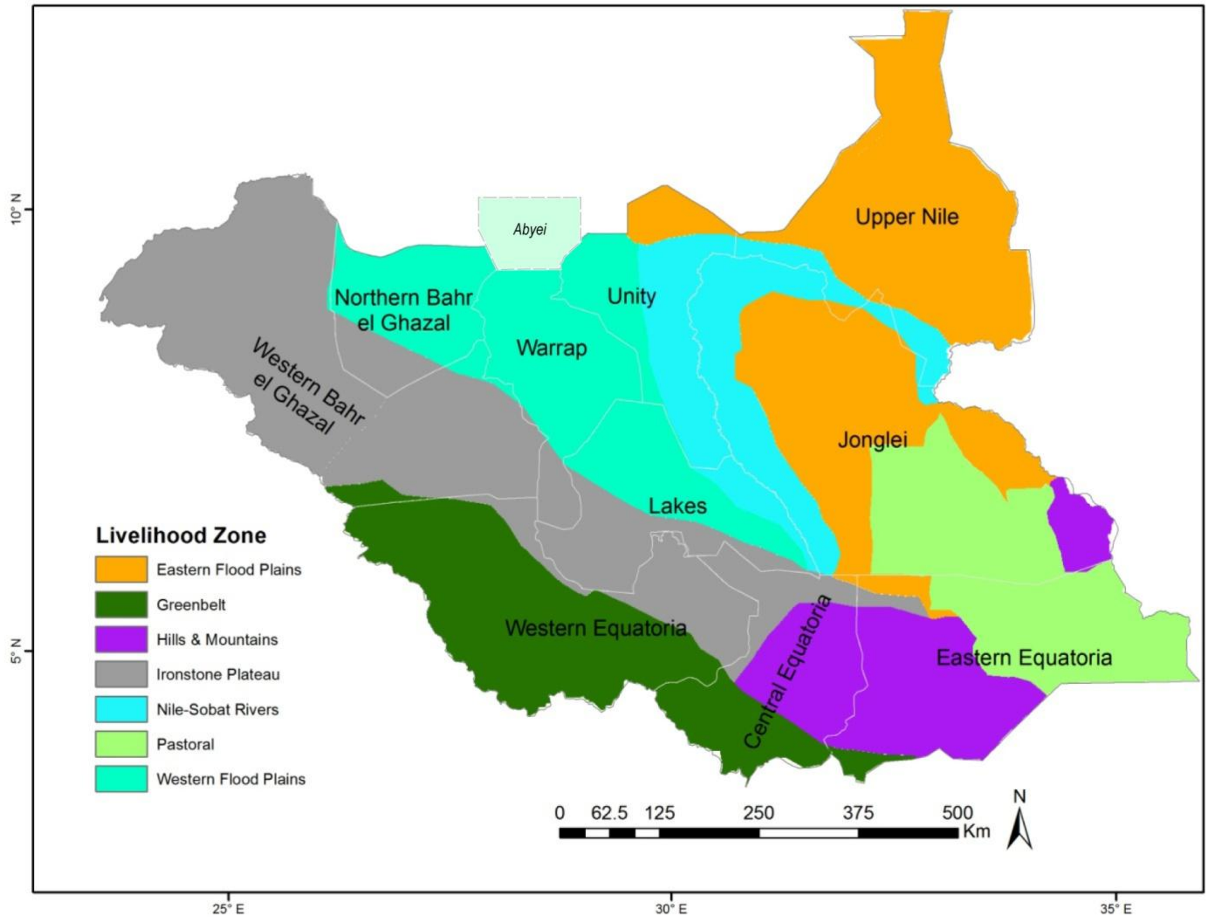
Table 2: Share of aggregated land uses by state (%)

State	Cropland	Grass with crops	Trees with crops	Grassland	Tree land	Flood land	Water and rock	Urban	Total
Upper Nile	19.0	26.0	7.1	27.1	7.8	9.0	9.5	25.8	11.4
Jonglei	14.3	25.2	7.3	14.8	19.7	26.7	17.3	8.8	19.5
Unity	4.5	16.1	2.5	7.7	3.7	14.9	6.4	17.1	6.0
Warrap	15.3	8.1	14.9	5.2	3.5	11.4	1.8	0.9	5.6
Northern Bahr el Ghazal	9.8	1.1	4.2	1.0	4.7	7.3	15.3	3.2	4.7
Western Bahr el Ghazal	2.0	4.0	12.9	4.2	18.6	13.5	18.5	10.4	14.9
Lakes	9.9	0.6	2.7	5.6	7.1	9.0	4.3	5.1	7.0
Western Equatoria	11.4	7.5	19.9	9.0	15.7	1.4	17.5	3.7	12.5
Central Equatoria	11.2	8.6	21.4	4.5	7.7	2.4	3.7	22.1	6.9
Eastern Equatoria	2.6	2.7	7.1	21.0	11.6	4.4	5.6	2.8	11.4
National average	**3.8**	**0.5**	**2.6**	**14.9**	**62.6**	**14.7**	**0.7**	**0.1**	**100.0**

Source: Authors' estimates based on FAO (2009).

12. The Western Flood Plains livelihood zone has the most cropland (34.2 percent of national cropland) (Figure 3). This zone has the highest ratio of cropland to total land, as cropland and grass with crops/trees with crops account for 8.5 and 5.4 percent of zonal territorial area, respectively (Table 3 and Annex 3).

Figure 3: Livelihood zones in South Sudan



Source: SSCCSE (2006).

Table 3: Share of cropland and other land uses by livelihood zone (%)

Livelihood zone	Crop land	Grass with crops	Trees with crops	Grass land	Tree land	Flood land	Water and rocks	Urban	Total
Eastern Flood Plains	26.2	49.2	8.1	35.2	18.3	14.4	8.9	32.4	20.4
Greenbelt	17.6	13.9	28.0	8.3	15.4	1.2	18.4	4.0	12.7
Hills and Mountains	4.2	4.1	10.3	8.6	11.0	3.5	3.4	22.5	9.2
Ironstone Plateau	7.0	5.6	18.0	10.5	29.5	16.8	19.4	13.7	23.5
Nile-Sobat Rivers	10.0	10.9	4.8	5.3	5.4	30.7	26.3	8.8	9.4
Pastoral	0.8	4.5	4.2	20.2	10.3	6.5	5.1	0.9	10.6
Western Flood Plains	34.2	11.8	26.5	12.0	10.1	26.8	18.5	17.6	14.2

Source: Authors' estimates based on the Land Cover Database FAO (2009).

1.2. Potential for agricultural production and population density

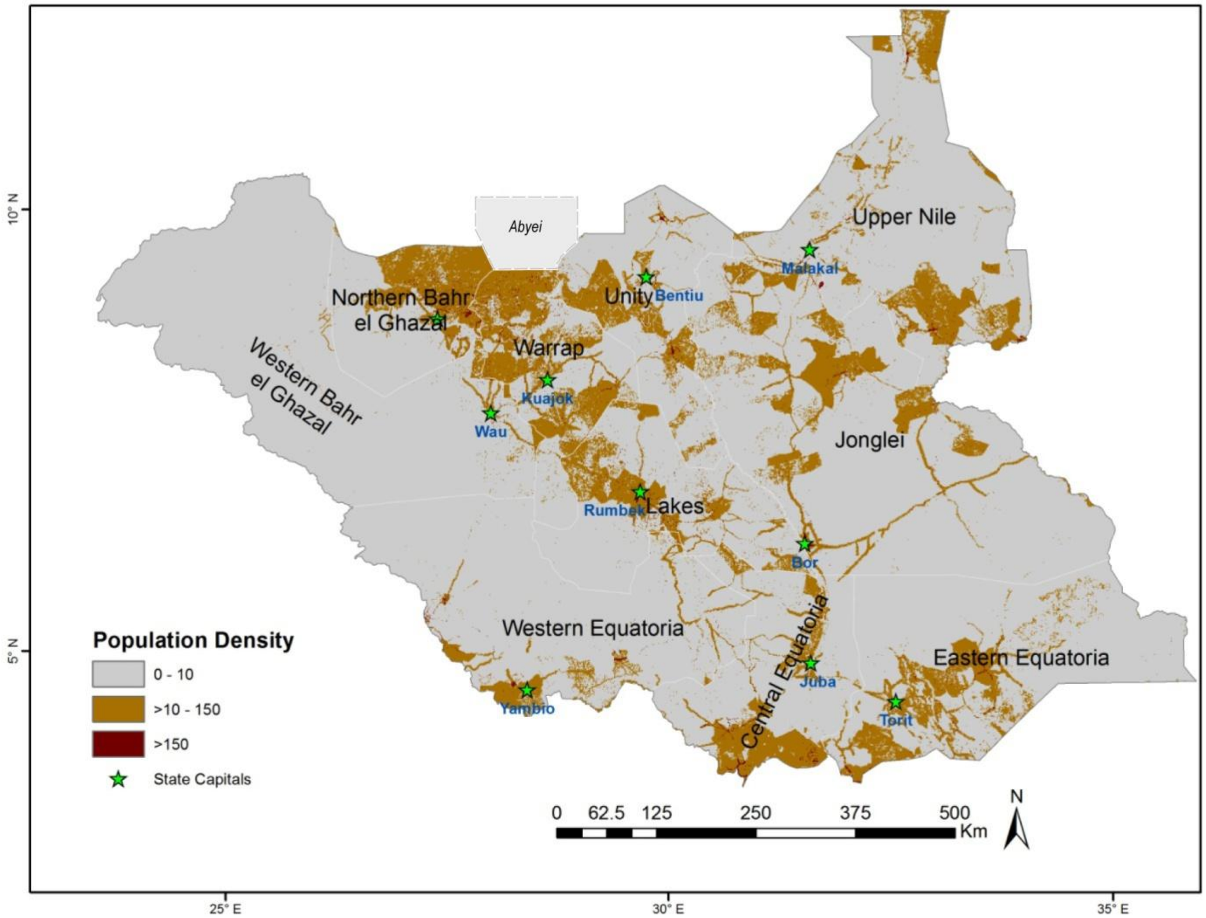
13. **To a large extent, the suitability of an area for agriculture is a key determinant of the performance of production systems**. A frequently used proxy for an area's suitability for farming is the LGP, defined as the number of days when both moisture and temperature conditions permit crop growth. Depending on its LGP, an area may allow for no crops or for only one crop per year (e.g., in arid or dry semi-arid tropics where LGP is less than 120 days a year), or it may allow for multiple crops to be grown sequentially within one year. Classifying the aggregated land use by LGP shows that 27.3 percent of cropland in South Sudan is located in areas where agricultural potential is high (LGP more than 220 days) and another 41.5 percent in areas with medium agricultural potential (LGP between 180 and 220 days).

14. **An association exists between population density and the potential for agricultural production in a given area.** According to the 2008 population census, there are 8.2 million people in South Sudan. The actual distribution of this population is difficult to map since a large number of returnees continue to come back each year, and their settlement location is hard to continuously update. Figure 4 shows population density based on the 2008 population census data and the latest LandScan population distribution data for South Sudan. The majority of South Sudanese live in rural space, which is classified as "low density" (population less than 10 per km^2) and "medium to high density" (population more than 10 per km^2) areas.

15. **The population density in South Sudan is very low compared to elsewhere in the region**. Average population density is estimated at 13 people per km^2 compared to 166 in Uganda, 70 in Kenya, 83 in Ethiopia, and 36 people per km^2 for Sub-Saharan Africa in 2009.[5] Two states have a population density of less than 10 people per km^2: Western Bahr el Ghazal (3 per km^2) and Western Equatoria (8 per km^2), while five states have a density that lies between 10 per km^2 and 20 per km^2 (Table 4). Of these, Upper Nile has the largest cropland area nationally but a population density of 13 per km^2. Three states, Warrap, Northern Bahr el Ghazal, and Central Equatoria, have a population density over 20 per km^2. These three states also have relatively high cropland shares in total land; i.e., 8.8, 8.3, and 6.4 percent, respectively.

[5] World Development Indicators, the World Bank.

Figure 4: Population density in South Sudan



Source: Compiled from a combination of GRUMP and LandScan (2009).

16. **There is a high spatial correlation between the potential for agricultural production and population density in an area.** Areas with "high" and "medium" production potential based on LGP have the highest population density. According to Boserup (1965; 1981), 50 people per km^2 is a threshold population that indicates the possibility of promoting agricultural intensification.[6] In South Sudan, population density in the high agricultural potential areas is about 66 per km^2, and 54 per km^2 in the medium agricultural potential areas (Table 5). Overall, there is high to medium population density in areas of high and medium agricultural potential. These areas, however, have low per capita cropland values.

[6] Rural population density varies positively with land productivity but only up to the point where overcrowding leads to land degradation.

Table 4: Cropland, population, and population density by state

State	Cropland (ha)	Grass/trees with crops (ha)	Total land (ha)	Share of cropland in total land (%): Cropland	Share of cropland in total land (%): Grass/trees with crops	Population (person)	Population density (person/km² total land)
Upper Nile	470,100	206,100	7,658,500	6.1	2.7	964,353	13
Jonglei	354,800	205,800	12,106,300	2.9	1.7	1,358,602	11
Unity	110,900	95,500	3,729,600	3.0	2.6	585,801	16
Warrap	379800	280,100	4,329,100	8.8	6.5	972,928	22
Northern Bahr el Ghazal	243,600	74,700	2,946,500	8.3	2.5	720,898	24
Western Bahr el Ghazal	50,000	234,200	10,208,800	0.5	2.3	333,431	3
Lakes	245,600	47,200	4,375,400	5.6	1.1	695,730	16
Western Equatoria	281,400	364,300	7,780,100	3.6	4.7	619,029	8
Central Equatoria	276,300	393,900	4,315,200	6.4	9.1	1,103,592	26
Eastern Equatoria	65,100	130,700	7,238,800	0.9	1.8	906,126	13
National total	**2,477,700**	**2,032,500**	**64,688,300**	**3.7**	**3.1**	**8,260,490**	**13**

Source: Authors' estimates based on LandScan (2009) and SSCCSE (2010).

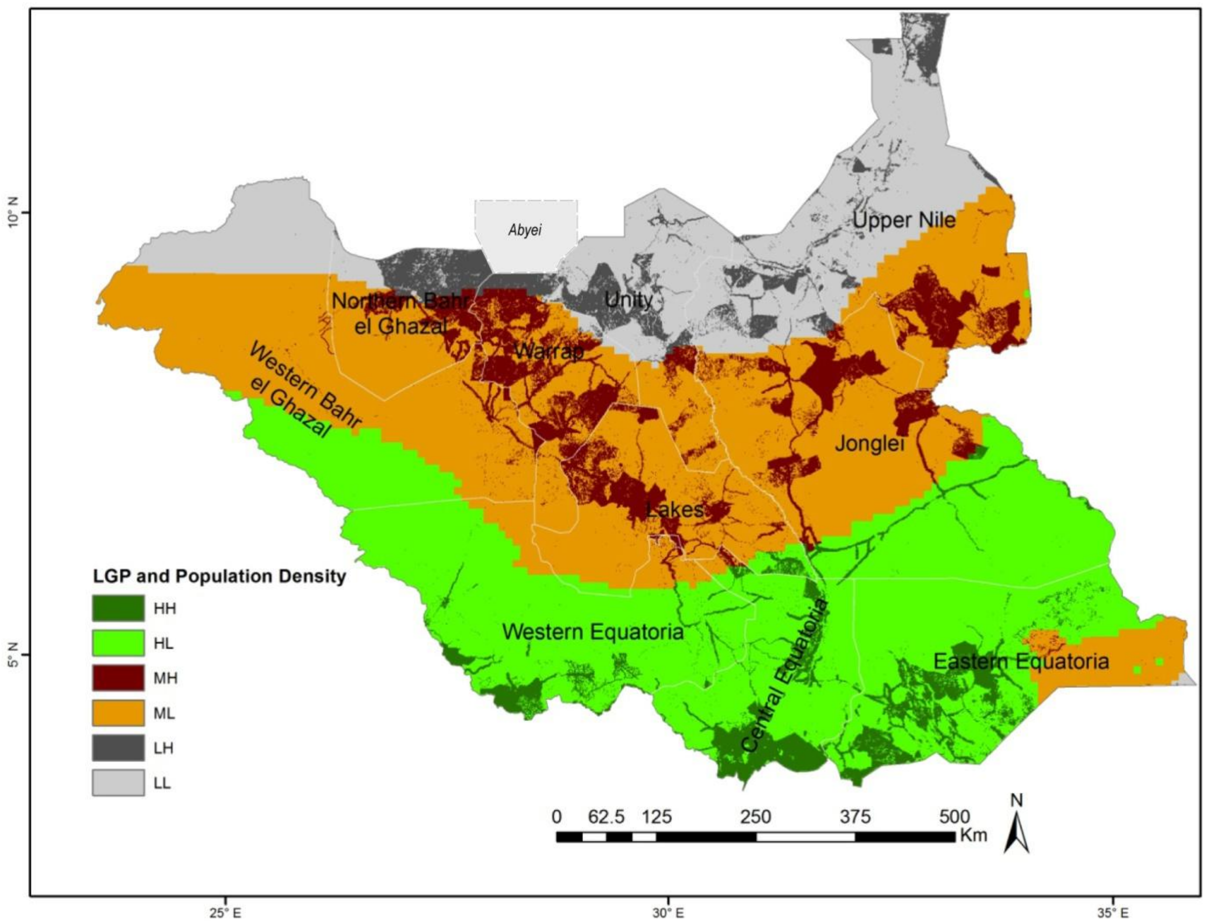
Table 5: Population, population density, and cropland according to agricultural potential

Population density			Agricultural potential defined by LGP: High (LGP>220 days)	Medium (180-220 days)	Low (<180 days)	Total
	High-medium	Population	25.4	33.8	15.8	75.1
		Population density	66	54	51	57
		Land	4.8	7.8	3.9	16.6
		Cropland area	15.3	26.7	17.9	59.9
		Cropland ha per capita	0.18	0.23	0.33	0.24
	Low	Population	8.7	11.9	4.4	24.9
		Population density	3	4	3	4
		Land	31.5	35.2	16.7	83.4
		Cropland area	12.0	14.9	13.2	40.1
		Cropland ha per capita	0.41	0.37	0.89	0.48
	Total	Population	34.1	45.7	20.2	100.0
		Population density	12	13	12	13
		Land	36.4	43.0	20.6	100.0
		Cropland area	27.3	41.5	31.1	100.0
		Cropland ha per capita	0.24	0.27	0.46	0.30

Source: Authors' estimates based on LandScan (2009) and SSCCSE (2010).

17. **Figure 5 shows the spatial patterns of agricultural potential and population density according to the six possible permutations of population density (High-medium and Low) and agricultural potential (High, Medium, and Low)**. This spatial presentation expands information presented in Table 5. High agricultural potential/high-medium population density areas (HH), high agricultural potential/low population density areas (HL), and medium agricultural potential/high-medium population density areas (MH) are the ones best positioned to generate quick wins and development benefits from public and private investments, and thus should be prioritized for agricultural development programs in the country. Annex 4 and Annex 5 provide details of population density and cropland by agricultural potential by state and livelihood zones, respectively.

Figure 5: Spatial patterns of agricultural potential and population density



Source: Authors' presentation.
Note: **HH**: LGP >220 days per year and population density >=10 per km^2; **HL**: LGP >220 days per year and population density <10 per km^2; **MH**: LGP between 180 and 220 days per year and population density >=10 per km^2; **ML**: LGP between 180 and 220 days per year and population density < 10 per km^2; **LH**: LGP < 180 days per year and population density >=10 per km^2; **LL**: LGP < 180 days per year and population density <10 per km^2.

AGRICULTURAL PRODUCTION

18. **There are no official agricultural production statistics in South Sudan**. But there are data on household consumption that can be used to derive production estimates, given the predominance of subsistence agriculture in the country. In this study, household consumption data from the 2009 National Baseline Household Survey (NBHS) were used to derive food production estimates. This section begins with a presentation of household food consumption and then estimates current agricultural production based on household consumption.

1.3. Household food consumption

19. **Cereals, primarily sorghum and maize, are the dominant staple crops in South Sudan**. According to the NBHS, more than 75 percent of rural households in the country consume cereals (Annex 6). At the state level, the percentage of rural households that consume cereals varies from 62 percent in Western Bahr el Ghazal to as high as 95 percent in Northern Bahr el Ghazal. There are four states in which more than 80 percent of rural households consume cereals, and five states in which 60 to 65 percent of rural households consume cereals.

20. **For the country as a whole, cereal consumption accounts for 48 percent of total primary food consumption in value terms** (Table 6). The share of cereals in total primary food consumption increases to 52 percent when only rural households are considered.[7] When non-cereal consuming rural households are excluded, this share further increases to 57 percent, indicating that cereals are the most important staples in rural households' food consumption bundle (Annex 7). At the state level, the share of cereals in total rural households' primary food consumption ranges from 63 to 81 percent in four states (Unity, Warrap, Northern Bahr el Ghazal, and Lakes), and is more than 55 percent in Jonglei.

Table 6: Share of various food items in household consumption (%)

State	Cereals	Roots	Pulses & oil seeds	Other crops	Livestock	Fish
Upper Nile	26.7	2.0	6.1	31.4	30.8	3.0
Jonglei	55.1	0.2	1.5	3.5	38.8	0.9
Unity	76.7	0.8	1.4	11.7	8.3	1.1
Warrap	74.7	0.0	6.4	3.8	11.6	3.5
Northern Bahr el Ghazal	60.3	0.2	2.6	5.5	23.2	8.2
Western Bahr el Ghazal	24.0	1.2	5.3	17.5	40.3	11.7
Lakes	68.5	1.2	2.6	4.9	12.9	9.9
Western Equatoria	34.6	5.5	6.8	16.9	27.8	8.4
Central Equatoria	35.8	4.6	3.8	21.5	31.8	2.5
Eastern Equatoria	43.2	0.9	2.1	7.9	44.0	1.9
National total	**48.0**	**1.8**	**3.8**	**12.7**	**29.7**	**4.0**

Source: Estimated from NBHS (2009).

[7] Food is defined as all crops including processed crop products (such as cereal flour and root flour), livestock (i.e., meat, milk, eggs), and fish products.

21. **While cereals are the most important food crops for the country as a whole, almost a quarter of rural households do not consume cereals at all, depending instead on other staples** (Annex 7, column 6). Thirty-five to thirty-seven percent of households in five states (Central Equatoria, Western Equatoria, Lakes, Western Bahr el Ghazal, and Upper Nile) and only 5 percent of households in Northern Bahr el Ghazal and 8.5 percent in Eastern Equatoria fall under this category.

22. **Livestock is another important food source in South Sudan.** Although estimates differ by source, South Sudan is known to have one of largest livestock herds in Africa. According to FAO's 2009 estimates, South Sudan has a cattle population of 11.7 million, 12.4 million goats, and 12.1 million sheep (Table 7). Using these estimates, South Sudan ranks 6th in Africa in terms of livestock population size, but these numbers are considered conservative in the country. Livestock population estimates generated from the 2008 Sudan Census show a cattle population of 35.5 million, 20.8 million goats, and 27.3 million sheep (Annex 8).

Table 7: Estimated livestock population in South Sudan

State	Population (head)				Share in national total (%)			
	Cattle	Goats	Sheep	Total	Cattle	Goats	Sheep	Total
Upper Nile	983,027	439,741	640,209	2,062,977	8.4	3.5	5.3	5.7
Jonglei	1,464,671	1,207,214	1,400,758	4,072,643	12.5	9.7	11.6	11.2
Unity	1,180,422	1,754,816	1,487,402	4,422,640	10.1	14.1	12.3	12.2
Warrap	1,527,837	1,369,005	1,290,045	4,186,887	13.0	11.0	10.7	11.6
Northern Bahr el Ghazal	1,579,160	1,630,361	1,285,231	4,494,752	13.5	13.1	10.7	12.4
Western Bahr el Ghazal	1,247,536	1,120,095	1,265,977	3,633,608	10.6	9.0	10.5	10.0
Lakes	1,310,703	1,464,421	1,232,282	4,007,406	11.2	11.8	10.2	11.1
Western Equatoria	675,091	1,153,283	1,169,705	2,998,079	5.8	9.3	9.7	8.3
Central Equatoria	878,434	1,153,283	1,265,977	3,297,694	7.5	9.3	10.5	9.1
Eastern Equatoria	888,278	1,132,541	1,025,297	3,046,116	7.6	9.1	8.5	8.4
National total	**11,735,159**	**12,424,760**	**12,062,883**	**36,222,802**				

Source: FAO Livestock Population Estimates Oct 2009.

23. **Nationally, livestock account for 30 percent of total primary food consumption in value terms, a share which is similar across rural and urban households (**Table 6**).** In three states, livestock products account for close to or more than 40 percent of rural households' primary food consumption (39 percent in Jonglei, 40.3 percent in Western Bahr el Ghazal, and 44 percent in Eastern Equatoria) as shown in Table 7. When measured by quantity of red meat consumption, only Jonglei and Eastern Equatoria have an average meat consumption (i.e., 32 kg and 47 kg per capita, respectively) that is significantly higher than the national average (17 kg per capita).[8]

24. **Fish accounts for 4 percent of food consumption at the national level.** It is, however, relatively more important in four states: Northern Bahr el Ghazal, Western Bahr el Ghazal, Lakes, and Western Equatoria, where the share of fish in total household consumption is 8.2

[8] Total consumption of red meat is estimated at 145,000 tons, assuming 17 kg per capita consumption as reported in the NBHS (2009). This is four times more than that reported in Musinga *et al*. (2010), who estimated total annual meat production to be 41,124 tons.

percent, 11.7 percent, 9.9 percent, and 8.4 percent, respectively (Table 6). When households that consume cereals and/or roots and tubers are excluded, the share of fish products in total food consumption increases to 12 percent for rural households (NBHS, 2009).

1.4. Current agricultural production estimates

25. **There are geographical differences in food consumption among rural households in South Sudan.** This heterogeneity manifests itself in spatial patterns, considered here to be indicators of heterogeneity in production. Therefore, NBHS food consumption data are used to estimate the current spatially disaggregated agricultural production[9]. It is assumed that, with the exception of cereals, all agricultural products consumed in South Sudan are produced domestically. For these products, total consumption as outlined in the previous section is assumed to equal domestic production. Since South Sudan imports significant amounts of maize from Uganda and sorghum from Sudan, cereal production is estimated separately.

26. **A multi-step process was used to estimate cereal production**. First, cereal flour consumption was converted into grain, assuming that it takes 1.25 kg of grain to produce 1 kg of flour. Second, post-harvest losses (the difference between gross and net production in Table 8) are estimated at 20 percent, following the assumption used by FAO/WFP. Third, it is assumed that only 55 percent of grain purchased by rural households is produced locally, while the rest is attributed to imports. For urban households, all market purchases are assumed to come from imports. Local grain production is then defined as the consumption met by households' own production, household stocks, and 55 percent of total rural households' purchases. The computations at the state and national levels are reported in Table 8.

27. **These estimates of cereal production are higher than those reported in the FAO/WFP annual assessments, with the exception of 2008/09**. The divergence mainly arises from differences in per capita consumption assumptions. In Eastern Equatoria, for example, per capita grain consumption is estimated at 247 kg in the NBHS (2009) and 124 kg by FAO/WFP (2011). At the national level, per capita grain consumption is estimated at 108 kg by FAO/WFP, versus 157 kg in the NBHS. As shown in Table 8, the ratio of net cereal production to consumption is 0.64 at the national level, while it is 1.05 and 0.70 in the FAO/WFP assessments for 2008/09 and 2010/11, respectively. State level cereal production is also different in these two data sets. For example, Western Equatoria is ranked the largest cereal producing state in the FAO/WFP assessment, while according to the NBHS, Eastern Equatoria, Jonglei, and Warrap all produce more cereal than is estimated for Western Equatoria in the FAO/WFP assessment.

28. **From these production estimates (for both cereals and other agricultural products that are considered to be domestically produced), the value of current agricultural production is calculated at the state level**. The calculation considers both quantity of consumption and production for individual crops (Annex 9) and their corresponding prices. The prices used in the calculation are averaged from individual households' reports in the NBHS. When the price for a specific product in a state is extremely low or high compared to the other states, the national average price is used. If the price for a particular product is not available in the survey or is extremely low compared to that in neighboring countries, the lowest relevant price from neighboring countries is used.

[9] The accuracy of our estimates in turn depends on the accuracy of the NBHS data.

Table 8: Estimates of cereal production from the NBHS and WFP/FAO assessments

	NBHS (2009)			
	Gross production	Net production	Consumption	Ratio of net production to consumption
National	**1,019,341**	**849,451**	**1,320,468**	**0.64**
Upper Nile	64,419	53,682	93,745	0.57
Jonglei	190,810	159,008	258,476	0.62
Unity	41,715	34,763	51,151	0.68
Warrap	140,688	117,240	180,927	0.65
Northern Bahr el Ghazal	101,361	84,467	136,776	0.62
Western Bahr el Ghazal	16,331	13,609	24,987	0.54
Lakes	112,972	94,144	152,881	0.62
Western Equatoria	68,462	57,052	79,087	0.72
Central Equatoria	72,441	60,367	130,303	0.46
Eastern Equatoria	210,142	175,118	212,313	0.83
	FAO/WFP (2008/09)			
	Gross production	**Net production**	**Consumption**	**Ratio of net production to consumption**
National	**1,252,230**	**1,001,785**	**953,204**	**1.05**
Upper Nile	49,278	39,421	64,788	0.61
Jonglei	101,594	81277	103,623	0.78
Unity	46,253	37,001	59,815	0.62
Warrap	247,415	219,534	189,505	1.16
Northern Bahr el Ghazal	83,605	66,884	118,436	0.56
Western Bahr el Ghazal	68,409	54,728	54,337	1.01
Lakes	136,215	108,972	91,823	1.19
Western Equatoria	273,218	218,574	96,822	2.26
Central Equatoria	132,363	105,890	82,399	1.29
Eastern Equatoria	86,880	69,504	91,656	0.76
	FAO/WFP (2010/11)			
	Gross production	**Net production**	**Consumption**	**Ratio of net production to consumption**
National	**873,823**	**695,226**	**986,230**	**0.70**
Upper Nile	61,234	48,985	86,429	0.57
Jonglei	104,844	83,874	158,133	0.53
Unity	29,647	23,714	57,710	0.41
Warrap	117,496	93,998	104,216	0.90
Northern Bahr el Ghazal	80,256	60,378	87,378	0.69
Western Bahr el Ghazal	42,205	33,765	41,465	0.81
Lakes	82,843	66,274	84,181	0.79
Western Equatoria	140,103	112,080	87,903	1.28
Central Equatoria	115,968	92,775	156,655	0.59
Eastern Equatoria	99,227	79,380	122,160	0.65

Sources: Authors' estimates based on NBHS and compared with FAO/WFP (various years).
Note: NBHS production is calculated by consumption met by own products, stocks, and 55 percent of food purchases in rural areas.

29. **The value of total agricultural production in South Sudan is estimated to have been US$807.7 million in 2009**. Crop production only is estimated at US$607.6 million (Table 9). This agricultural value represents the presently realized agricultural potential in South Sudan. For the country as a whole, the average household's agricultural production value is US$628, of which US$473 is from crops. Western Equatoria has both the highest total and crop agricultural values, accounting for 18.4 and 22.2 percent, respectively, of national values. Measured by household agricultural value, Western Equatoria is also the richest state. Central Equatoria has the second largest total agricultural and crop value, accounting for 17.5 and 18.9 percent of national totals, respectively, and also ranks second in terms of agricultural value per household.

30. Western Bahr el Ghazal (2.5 percent of national total) and Unity (3.3 percent) have the lowest values of agricultural production and are among the states with the lowest agricultural values per household.

Table 9: Value of agricultural production in South Sudan

State	Total value ('000 US$)		Percentage		Per household (US$)	
	Inc. livestock & fish	Crop only	Inc. livestock & fish	Crop only	Inc. livestock & fish	Crop only
National	**807,694**	**607,617**	**100**	**100**	**628**	**473**
Upper Nile	87,373	49,860	10.8	8.2	627	358
Jonglei	112,535	72,446	13.9	11.9	598	385
Unity	26,512	18,092	3.3	3.0	385	263
Warrap	67,188	56,660	8.3	9.3	401	338
Northern Bahr el Ghazal	48,450	36,475	6.0	6.0	370	279
Western Bahr el Ghazal	20,376	12,657	2.5	2.1	354	220
Lakes	63,448	51,800	7.9	8.5	703	574
Western Equatoria	148,473	135,024	18.4	22.2	1,284	1,168
Central Equatoria	140,999	114,857	17.5	18.9	801	653
Eastern Equatoria	92,340	59,744	11.4	9.8	611	395

Source: Estimated based on NBHS (2009).

31. **The agricultural output value in South Sudan in 2009 is low compared to that in neighboring countries**. The value of agricultural output per ha in South Sudan was less than half of the agricultural value added in Tanzania and Uganda, a third of that in Ethiopia, and less than one quarter of that in Kenya (Table 10). The gap in agricultural value added per capita is smaller because of the smaller population in South Sudan. It is worth noting, however, that the comparison is between South Sudan's agricultural output and agricultural value added in other countries,[10] meaning that the actual difference is even larger than that presented in Table 10.

Table 10: Regional comparison of agricultural performance in 2009

Country	Agricultural value added (current US$ million)	Agricultural value added per ha (current US$)	Agricultural value added per capita (current US$)
Ethiopia	13,632	971	165
Kenya	7,304	1,405	184
Tanzania	5,563	618	127
Uganda	3,658	665	112
South Sudan	808	299	99

Source: World Development Indicators for East African countries and NBHS 2009 for South Sudan.

[10] There are no data on variable costs in South Sudan to calculate agricultural value added. On the other hand, there are no recent data on agricultural output in 2009 denominated in US$ for countries in question to compare the values of agricultural output.

AGRICULTURAL POTENTIAL

32. **As outlined in the previous section, the current agricultural production and its attendant value in South Sudan are low**. Given the abundant land and favorable climatic and soil conditions, there is considerable scope to increase production. At a fundamental level, agriculture production in South Sudan can be increased through two approaches that can be mutually reinforcing: increasing the area of cropped land and increasing the amount of production per unit area. This section estimates the potential agricultural value that would accrue from expanding cropland area and increasing crop productivity. The value of other subsectors, e.g., livestock and fisheries, is assumed to remain constant.

1.5. Methodology

33. **Although current cropland is limited, there is abundant unutilized land that is suitable for crop production in South Sudan**. Presently, this land is mainly under natural vegetation, such as grass and trees, but could be converted into cropland if it became profitable for its users. Based on LGP, population density, and current land use/cover, potential cropland expansion is estimated with five and ten year horizons. The precision and accuracy of the cropland expansion projections are hindered by lack of additional location specific information and the inability to ground truth the estimates. In addition, realizing the agricultural potential of new cropland depends on many other factors, such as public policies and investment, which are not considered in the projections here.

34. **The cropland projections are based on the land use/cover data presented in Section 2.** First, it is assumed that the ratio of crop area to the total area under "grass with crops" and "trees with crops" land uses is 10 percent. Current cropland is then derived from land use coverage in Table 1 and is computed as the sum of land use area under "cropland" and 10 percent of land use area under "grass with crops" and "trees with crops" (Table 11). From this computation, it is estimated that cropland area is 2.7 million ha or 4.1 percent of total land area in South Sudan. Anecdotal information indicates that currently, cropland in South Sudan is mainly expanding into areas with trees (see Section 6). Hierarchically in this cropland expansion model, therefore, all land currently under "trees with crops" (2.6 percent of total land) is the first to be converted into cropland. Once this potential for expansion is exhausted, further cropland expansion occurs at the expense of "tree land" (currently accounting for 62.6 percent of total territory). There is considerable uncertainty as to the condition of forests in South Sudan, and the quality of forests unfortunately cannot be captured by the GIS data available for this analysis. Ideally, cropland expansion would need to occur in low value forests, to avoid the loss of communities' access to forest resources, upon which their livelihood depends, and for environmental conservation purposes. To prevent farmland expansion into high value productive forests and gazetted areas, it is critical for the GoSS to develop a coherent policy, regulatory, and strategic framework for the sector that reconciles the twin goals of conservation and livelihood support, for example by promoting participatory forest and woodland management, and enhancing forest-related environmental and other services.[11]

[11] See World Bank (2010) for further details.

35. **Land under "grass with crops" and "grassland" is unlikely to become cropland due to unfavorable climatic and soil conditions and is therefore assumed not to be converted**. Other land uses in Table 1 also remains in non-crop use in the modeled time frame. The crop expansion model uses raster-based GIS neighborhood analyses in which a pixel (with a resolution of 1 km^2) is the basic unit of land and is assumed to be under a single land use. Two scenarios are modeled based on the rate of expansion: (1) a moderate expansion rate scenario, and (2) a high expansion rate scenario.

36. **The cropland expansion pattern will vary based on climatic conditions, soil characteristics, and population density** but is likely to follow the logic schematically presented in Figure 6 and detailed below for the moderate expansion scenario (Scenario 1):

- In a high production potential/high population density (HH) area, if a pixel C (current cropland) is surrounded by pixels under tree land, then the eight immediate adjoining pixels (identified with 1s in Figure 6), the sixteen pixels (identified with 2s) immediately surrounding the pixels identified with 1s, and the twenty-four pixels (identified with 3s) immediately adjacent to those identified with 2s are assumed to become cropland in the next five to ten years (all the 1s, 2s, and 3s in Figure 6 are candidates).
- For HL and MH areas, cropland expansion will be more modest; only the eight pixels (identified with 1s in Figure 6) immediately adjoining pixel C and the sixteen pixels (identified with 2s) are assumed to become cropland in the future if they are currently covered by tree land.
- In ML and LH areas, the expansion is even lower; only the eight pixels immediately adjoining pixel C are assumed to become cropland in the future if currently covered by tree land.

37. **It is assumed that any land that is currently not under crops in LL areas will not become cropland in the future**. Thus in the moderate expansion scenario, for each square kilometer of current cropland, the maximum possibility is to convert another 48 km^2 into cropland in HH areas, 24 km^2 into cropland in HL and MH areas, and 8 km^2 in ML and LH areas.

Figure 6: Illustration of cropland expansion at the pixel level

5	5	5	5	5	5	5	5	5	5	5
5	4	4	4	4	4	4	4	4	4	5
5	4	3	3	3	3	3	3	3	4	5
5	4	3	2	2	2	2	2	3	4	5
5	4	3	2	**1**	**1**	**1**	2	3	4	5
5	4	3	2	**1**	**C**	**1**	2	3	4	5
5	4	3	2	**1**	**1**	**1**	2	3	4	5
5	4	3	2	2	2	2	2	3	4	5
5	4	3	3	3	3	3	3	3	4	5
5	4	4	4	4	4	4	4	4	4	5
5	5	5	5	5	5	5	5	5	5	5

Source: Authors' illustration.

38. **The high expansion scenario (Scenario 2) doubles the cropland in the moderate expansion scenario**. The results of this scenario occurring in the next five to ten years are based on the following assumptions:

- Pixel sets 1, 2, 3, 4, and 5 surrounding pixel C (current cropland) in a HH area are assumed to become cropland if they are currently covered by tree land.
- In HL and MH areas, pixel sets 1, 2, 3, and 4 surrounding pixel C and currently covered by tree land are assumed to become cropland in the future.
- In ML and LH areas, only pixel sets 1, 2, and 3 are assumed to become cropland if currently covered by tree land.

1.6. Cropland expansion

39. **The rate of expansion of cropland will be area - and context-specific**. The actual extent of expansion will be determined by access to markets, land and forest policy and regulations, and access to tools and labor required for land clearing and tree cutting. In Scenario 1, other factors being constant, cropland will increase by 2.3 times, from the current 2.7 million ha to 6.3 million ha (Table 11 and Figure 7).

40. **The expansion is likely to take place through a conversion of tree land into cropland, yet with low relative decline in forested areas.** The share of tree land in total land area would decline from 62.6 percent to 59.5 percent (Table 12). The largest expansion of cropland area is expected in Western Bahr el Ghazal (from a very low base) and the three Equatorial states. It is projected that Western and Central Equatoria would account for 20 percent and 19 percent, respectively, of the new cropland, with the shares in Warrap, Upper Nile, and Jonglei at 10 to 13 percent. About 20 percent (and above) of the total land area in Warrap, Central Equatoria, and Western Equatoria would be cultivated as a result of the cropland expansion under Scenario 1.

Table 11: Current and projected cropland area under Scenario 1

State	Current cropland* (ha)	Expanded cropland (ha)	Increase from base (x times)	Share of cropland in total state area (%)	
				Current	Expanded
Upper Nile	504,900	683,700	1.4	6.6	8.9
Jonglei	373,600	636,100	1.7	3.1	5.3
Unity	119,500	167,900	1.4	3.2	4.5
Warrap	405,400	723,600	1.8	9.4	16.7
Northern Bahr el Ghazal	247,600	394,100	1.6	8.4	13.4
Western Bahr el Ghazal	73,100	447,000	6.1	0.7	4.4
Lakes	248,200	431,200	1.7	5.7	9.9
Western Equatoria	317,000	1,294,700	4.1	4.1	16.6
Central Equatoria	313,900	1,192,300	3.8	7.3	27.6
Eastern Equatoria	77,600	296,700	3.8	1.1	4.1
TOTAL	**2,680,900**	**6,267,400**	**2.3**	**4.1**	**9.7**

Source: Authors' estimates.

Note: *Current cropland area includes 10 percent of "grass with crops" and "trees with crops."

41. **As expected, most cropland expansion is projected in areas with high agricultural potential**. The Greenbelt would increase its share of cropland from 18.2 percent to 25.7 percent of total cropland in South Sudan (Annex 10). Significant cropland expansion is also projected in the Ironstone Plateau (from 7.6 percent to 17.4 percent) and Hills and Mountains (from 4.6 percent to 8.5 percent) livelihood zones. The areas with high to medium production potential and population density, i.e., HH, HL, and MH, would expand from the current 52.7 percent to 64.9 percent of total cropland area.

42. **An increase in cropland would result in larger farm sizes under the moderate expansion scenario**. If the expansion occurs in the next five years, per capita cropland size would increase from 0.32 ha to 0.67 ha, assuming a 2.5 percent annual population growth. If expansion takes ten years, per capita cropland size would increase to 0.59 ha.

43. **While the rate of cropland expansion is already rapid in Scenario 1, the per capita cropland endowment would still be lower than in neighboring countries**. A scenario that doubles the rate of expansion under Scenario 1 results in a 3.5-fold increase in cropland compared to the current cropland area (Table 12). Cropland area would increase to 9.2 million ha, or 14.3 percent of national land. As a result, the share of tree land in total land would decline from the current 62.6 percent to 54.9 percent. The per capita cropland area under this scenario increases from 0.32 to 0.99 ha if expansion takes place within the next five years and to 0.87 ha if expansion occurs over a ten year period.

44. Figure 7 and Figure 8 show the spatial patterns of land expansion under the two scenarios.

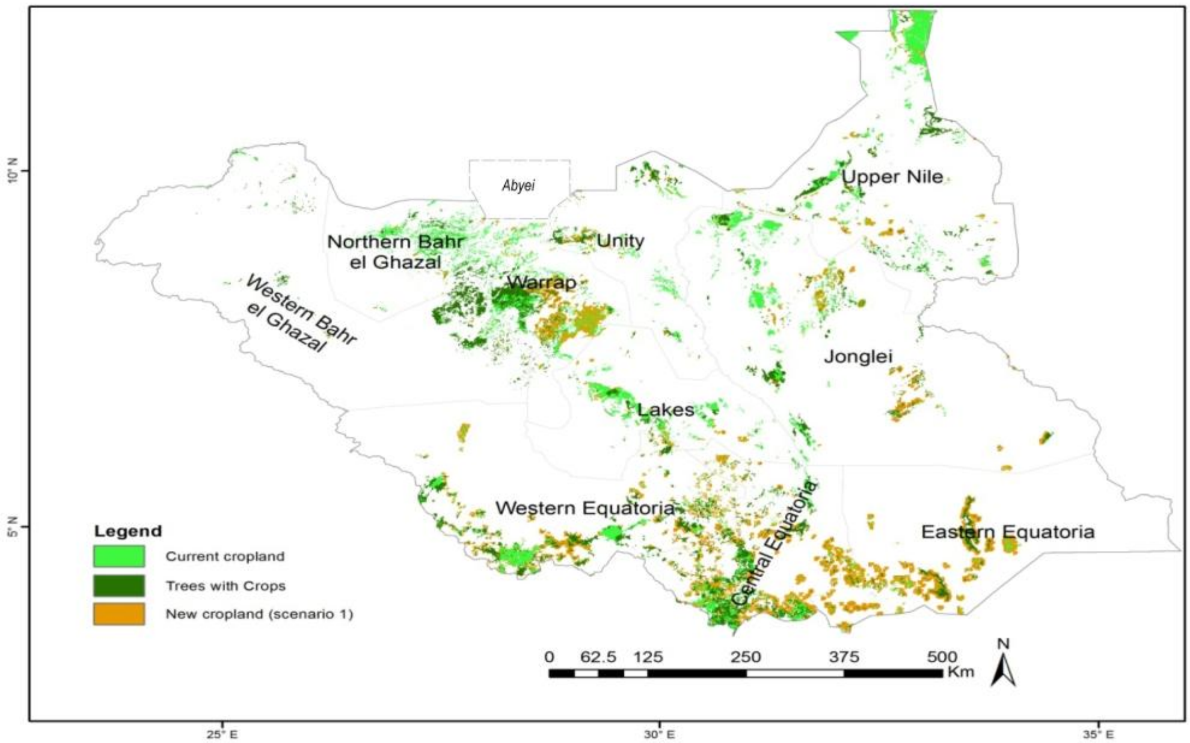
Table 12: Cropland and other land uses under moderate and high expansion scenarios

Land use category	Area (ha)			Share of total land (%)		
	Current	Scenario 1	Scenario 2	Current	Scenario 1	Scenario 2
Cropland	2, 477,700	6,267,400	9,237,400	3.8	9.7	14.3
Grass with crops	325,100	292,600	292,600	0.5	0.5	0.5
Trees with crops	1,707,300	0	0	2.6	0.0	0.0
Grass land	9,633,800	9,633,800	9,633,800	14.9	14.9	14.9
Tree land	40,526,900	38,477,100	35,507,100	62.6	59.5	54.9
Other land use*	10,017,300	10,017,300	10,017,300	15.5	15.5	15.5
Total	**64,688,300**	**64,688,300**	**64,688,300**	**100.0**	**100.0**	**100.0**

Source: Authors' estimates.

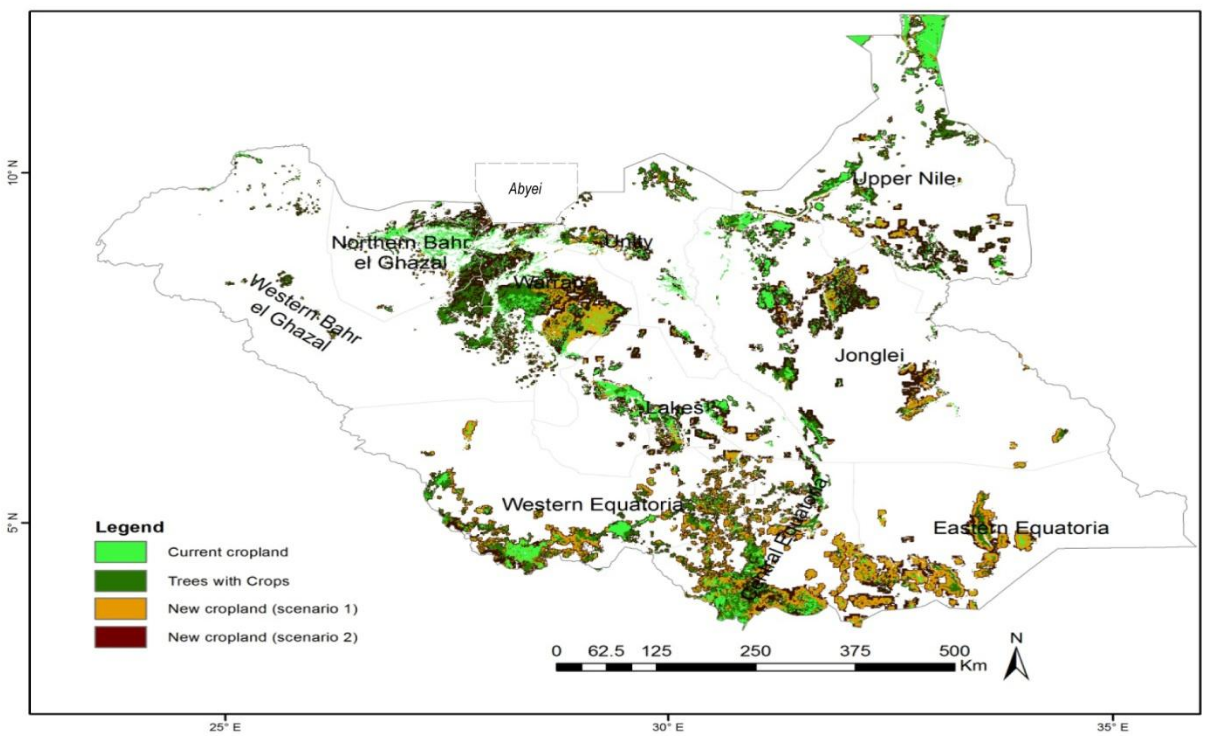
Note: Other land use includes Flood land, Water and rock, and Urban as categorized in Table 1.

Figure 7: Cropland expansion under Scenario 1



Source: Authors' estimates.

Figure 8: Cropland expansion under Scenario 2



Source: Authors' estimates.

1.7. Potential agricultural production values

45. **The increase in cultivated area through cropland expansion would lead to higher agricultural output and correspondingly, to a higher value of agricultural production**. Even the modest cropland expansion (Scenario 1) would lead to a 2.4-fold increase in the value of total agricultural output (crops, livestock and fisheries) compared to the current estimated output value (Table 13). Potential agricultural production may reach US$2 billion, up from the current US$808 million, which is still far below the level of output produced in neighboring countries (Table 10). The largest increase is expected in the three Equatorial states, Western Bahr el Ghazal, and Warrap.

46. **Improvements in agricultural productivity are necessary if South Sudan is to increase production to levels comparable to those observed in the region**. Average cereal yields in South Sudan are estimated at 0.8-0.9 tons per ha (FAO/WFP, 2011). Real obtained yields could actually be lower than these averages since the cropland area used in the FAO/WFP (2011) assessments is much lower than that observed in the FAO land cover map (FAO, 2009).

47. These average cereal yields are lower than those in Uganda (1.6 tons per ha), where there is minimal use of tradable inputs, and much lower than in Kenya (2 tons per ha) and Ethiopia (3 tons per ha), where more tradable inputs are used. The wide gap between actual and biophysically attainable yields per unit area (Fisher *et al.*, 2002) in South Sudan points to an immense scope for increasing the average cereal yields.

Table 13: Current and potential agricultural value due to cropland expansion

State	Current cropland (ha)	Current agricultural value ('000 US$)	Potential agricultural value due to land expansion ('000 US$)	
			Scenario 1	Scenario 2
Upper Nile	504,900	87,373	105,027	174,381
Jonglei	373,600	112,535	163,443	282,402
Unity	119,500	26,512	33,839	54,902
Warrap	405,400	67,188	111,662	176,754
Northern Bahr el Ghazal	247,600	48,450	70,018	113,642
Western Bahr el Ghazal	73,100	20,376	85,112	183,642
Lakes	248,200	63,448	101,630	162,464
Western Equatoria	317,000	148,473	564,908	893,758
Central Equatoria	313,900	140,999	462,360	789,355
Eastern Equatoria	77,600	92,340	261,019	530,365
TOTAL	**2,668,000**	**807,694**	**1,959,028**	**2,796,474**

Source: Authors' estimates.
Note: The estimate of potential agricultural value assumes changes in the value of crop production due to the expansion of cropland, keeping the values of livestock and fisheries output constant.

48. **Several levels or magnitudes of possible yield improvement are considered**. Average cereal yields per ha are assumed to increase by 50 percent to reach the average level in Uganda, by 100 percent to attain the level in Kenya, and by 200 percent to achieve the average yields in Ethiopia. A 50 percent yield increase would translate into a 3.5-fold increase in the current value of agricultural production in South Sudan. This increase in agricultural value would also be 45 percent higher than an increase accruing from Scenario 1 of land expansion at current yield

levels (Table 14). The value of crop production per ha would grow from US$227 to US$340. If yields can increase to the average levels obtained in Kenya, the value of total agricultural production in South Sudan would outpace the current value in Uganda (compare with Table 10) and crop value per ha would reach US$453. A 200 percent increase (to match levels in Ethiopia) in yield per unit area would increase crop value to US$1,020 per ha.

Table 14: Current and potential agricultural value under increased cropland and yield/ha

States	**Current agricultural value ('000 US$)**	**Potential agricultural value ('000 US$)**			
		Land expansion only (Scenario 1)	**Land expansion (Scenario 1) With 50% yield increase**	**Land expansion (Scenario 1) With 100% yield increase**	**Land expansion (Scenario 1) With 200% yield increase**
Upper Nile	87,373	105,027	138,783	172,540	240,054
Jonglei	112,535	163,443	225,120	286,797	410,151
Unity	26,512	33,839	46,549	59,259	84,678
Warrap	67,188	111,662	162,229	212,796	313,930
Northern Bahr el Ghazal	48,450	70,018	99,040	128,061	186,104
Western Bahr el Ghazal	20,376	85,112	123,824	162,525	239,929
Lakes	63,448	101,630	146,622	191,613	281,596
Western Equatoria	148,473	564,908	840,637	1,116,366	1,667,825
Central Equatoria	140,999	462,360	680,469	898,578	1,334,796
Eastern Equatoria	92,340	261,019	375,232	484,444	717,868
TOTAL	**807,694**	**1,959,028**	**2,838,504**	**3,717,979**	**5,476,930**

Source: Authors' estimates.

49. **Realization of the projected agricultural potential will hinge on many factors and the appropriate resolution of a number of constraints**. Some of the factors are institutional (such as land ownership) while others are policy related (e.g., decisions on investment in public goods that support agriculture growth). The GoSS has made considerable progress towards formulating policies that positively contribute to increases in agriculture production and has also attempted to lessen the impacts of a number of constraints to increased production. However, rural connectivity is still a binding and overriding constraint to increased production. Without improved connectivity and reduced transport costs, the agricultural potential of South Sudan will not be realized and food insecurity will not be effectively ameliorated. Table 15 presents the findings of a recent study on Sub-Saharan Africa showing that the realization of agricultural potential (column 4) depends on access to markets (columns 1 and 2). An area that is nine hours away from the market, for example, realizes only 8 percent of its agricultural potential, compared to 46 percent for an area only four hours away from the market. Thus, to realize agricultural potential in South Sudan as discussed above, public investments are required to "reduce the distance" between production and consumption areas. The next section presents a strategy for investing in roads to maximize their contribution to the realization of agricultural potential in South Sudan and reducing food prices.

Table 15: Relationship between rural connectivity and realization of crop production potential in Sub-Saharan Africa

Travel time (hours)	Distance to ports (km)	Total crop production (US$ million)	Crop production relative to potential production (%)
1.7	470.0	12,469	41.1
3.0	527.7	10,168	45.6
4.1	569.2	7,823	46.6
5.1	607.5	6,959	33.2
6.3	656.0	4,594	20.2
7.6	696.0	3,479	16.3
9.3	741.4	2,580	8.2
11.7	762.6	2,031	5.9
15.4	770.9	1,316	4.7
24.8	716.1	1,405	2.9

Source: Dorosh *et al.* (2008).

Note: Agricultural potential reported in Table 15 is estimated by IFPRI using the same methodology as in this report.

INVESTING IN ROADS

1.8. Roads in South Sudan

50. **The transport system in South Sudan is characterized by low levels of accessibility, dilapidated infrastructure, and high transport cost**. South Sudan's road network is one of the worst in Africa, ranking far below other African countries in all aspects (Table 16). Less than 5 percent of the existing 7,171 km of primary roads are in good condition, and with the exception of the newly constructed urban paved roads and the Juba-Nimule road, the entire network is gravel, dilapidated, and mainly inaccessible during the rainy season.

Table 16: Benchmarking South Sudan's roads against other African countries

Indicator	South Sudan	East Africa	Resource-rich countries	Low income countries	Middle income countries
Classified road density (km per 1,000 sq-km of arable land area)	**15**	101	57	88	278
Primary network paving ratio (% roads)	**2**	n/a	82	72	32
Unpaved road traffic (vehicles per day)	**53**	47	54	39	75
Condition of national and regional roads (% in good or fair condition)	**5**	59	80	86	n/a

Source: World Bank (2011a).

51. **Freight tariffs in South Sudan are very high and at least twice those found in the main African corridors and even in Sudan** (Table 17). The price differential is explained by very poor quality of the road network and the asymmetry of trading patterns. Poor infrastructure forces trucks to carry small loads and face much longer travel times. Small loads over long distances automatically increase the average unit cost of transportation. For instance, limitations along the Juba Bridge preclude trucks from carrying more than 45 tons (World Bank, 2011c). Furthermore, South Sudan's trading is concentrated in the south with its East African neighbors and follows a very asymmetric pattern that essentially doubles transport costs faced by trucking companies. Trucks enter South Sudan with import goods but return empty to Uganda and Kenya (World Bank, 2011b).

Table 17: Benchmarking international freight for South Sudan's road network against regional corridors

	South Sudan	Sudan	West African Corridor	Central African Corridor	East African Corridor	Southern African Corridor
Freight tariff (US cents/ton-km)	**20**	8-10	8	13	7	5
Roads in good condition (%)	**5**	26	72	49	82	100

Source: World Bank (2011a).
Note: South Sudan and Sudan figures include only regional and national roads.

52. **Transport prices for domestic routes are even higher than those for regional routes**. From Yei to Juba, for example, transport prices reach US$0.65 per ton-km. In other locations, they are even higher. In Uganda and Kenya, average transport prices are about US$0.15-0.20 on primary roads (World Bank, 2009).

53. **The fragmented and sparse transport infrastructure networks, enormous travel time, and high transport prices impede access to rural and agricultural production areas**. Road density is only 15 km per 1,000 km^2 of arable land area, below the average in the rest of Africa (Table 16). Large parts of the economically productive areas in the country are isolated from markets and are vastly underutilized. Except for those living along the interstate roads, most of the rural population has no access to markets during the rainy season, which spans over five to seven months.

54. **Underdeveloped road infrastructure amidst competing demands for limited resources present significant trade-offs in the spatial allocation of road investments**. While the current stage of roads development in South Sudan is such that upgrading the core interstate roads network to an acceptable standard is essential before embarking on feeder roads development, such investments, if not accompanied by corresponding investments in feeder roads that enhance access to agriculturally important areas, will not effectively contribute to agriculture growth and will not necessarily yield the best possible return on investment. Resource constraints dictate that any feeder roads be developed with enormous selectivity, and coordinated and sequenced with interventions in trunk roads. Ideally, geographic areas or clusters of agriculture areas with the highest potential as identified in Section 4 (and with fewer infrastructure hurdles) should be prioritized first for feeder roads to more rapidly link productive areas and markets. This section details the prioritization of road investment to achieve the highest connectivity in agriculturally important areas at least cost. The next subsection describes the methodology used.

1.9. Rural connectivity: methodology

55. **Rural connectivity can be computed and measured in various ways.** One frequently used measure is the Rural Accessibility Index (RAI), which measures the share of the rural population living within 2 km of an all-weather road. RAI is principally a social measure of rural connectivity (Carruthers *et al.*, 2009). It does not factor in "economic" differences of rural areas, and is often criticized for its use of a two km boundary as a threshold of accessibility. Another approach to measure rural connectivity focuses on the market accessibility of agricultural production zones and is described as a market measure of rural connectivity. The African Infrastructure Country Diagnostic (AICD) studies (2009) used this approach to estimate the road network required to ensure that areas accounting for certain predefined percentages of total value of current and potential national agricultural output were connected to specified regional and national road networks.

56. **In this ESW, both social and market connectivity measures are used.** The latter, however, is modified into an adjusted market connectivity measure which adds more flexibility and pragmatism to the approach used in AICD (2009), due to the rich data available for South Sudan compared to the continent-wide less detailed dataset used in the AICD study. The adjusted market connectivity measure:

- Combines agricultural potential and population density, emphasizing the need to invest in more populated areas. Priority is accorded to areas with "high production potential and high population density" (HH), "high production potential and low population density" (HL), and "medium production potential and high population density" (MH). Together, these areas are regarded as having high agricultural potential.

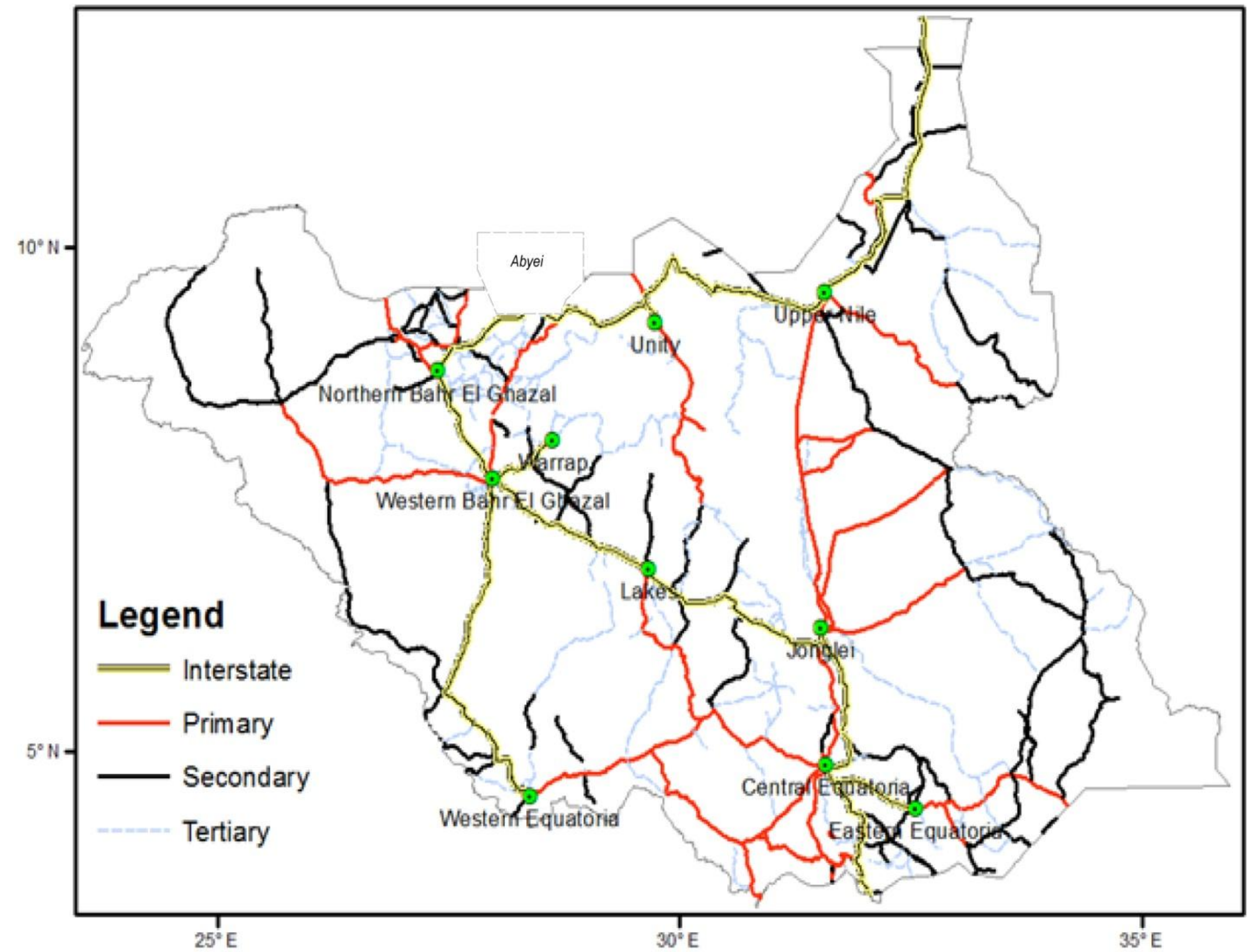
- Aims to connect cropland area ranked by production potential and population density rather than the value of agricultural production, to achieve the highest Cropland Connectivity (CLC) index.
- Presents the calculations for 2 km and 5 km boundaries or catchment areas. While a 2 km catchment area can provide easier access to markets than a 5 km boundary, in many countries this difference is insignificant (Starkey, 2007). In Uganda, for example, only after a 4.5 km threshold is less household consumption found to be correlated with distance to markets and distance to a tarmac road (Merotto and Verbeek, 2010). In the current study, therefore, cropland connectivity is computed for both 2 km and 5 km boundaries, the latter representing a pragmatic scenario designed to more affordably connect rural agricultural areas.

1.10. Roads for agricultural development in South Sudan[12]

57. Roads considered in this study are those needed to move consolidated agricultural output to the nearest market center. This covers the existing: (i) core interstate primary roads; (ii) other primary roads; (iii) secondary roads; and (iv) tertiary roads. It does not include roads needed to connect fields to the nearest village, which need not be all-weather, as often a track suitable for people**,** motorcycles, or carts is sufficient. It also does not include any new roads in addition to the existing network, realizing the great need and priority to focus first on upgrading and rehabilitating existing roads. There are about 15,764 km of roads in South Sudan, most of which are in poor condition. The road network consists of 2,696 km of "interstate primary roads" (connecting all state capitals plus major cross-border corridors); 4,475 km of "other primary roads"; 6,292 km of secondary roads; and 2,301 km of tertiary roads (Table 18 and Figure 9). Secondary and tertiary roads, as well as some primary roads, are considered "rural." About 10,200 km, or 65 percent of the total road network, are located in areas with high agricultural potential (HH, HL, and MH) (Table 19).

[12] The estimates for roads investments used in this section are taken from a report commissioned for this ESW (see Diao *et al*., 2011).

Figure 9: Different road types in South Sudan



Source: WFP maps.

Table 18: Different types of roads and their lengths (km) by state, South Sudan

State	Interstate	Other primary	Secondary	Tertiary	Total
Upper Nile	506	311	984	0	1,801
Jonglei	49	1,056	833	589	2,527
Unity	326	323	55	0	704
Warrap	215	323	559	0	1,096
Northern Bahr el Ghazal	130	239	567	0	936
Western Bahr el Ghazal	316	364	790	0	1,470
Lakes	369	123	357	3	853
Western Equatoria	335	533	688	538	2,095
Central Equatoria	312	891	187	561	1,950
Eastern Equatoria	139	312	1,271	610	2,332
Total	**2,696**	**4,475**	**6,292**	**2,301**	**15,764**

Source: Authors' estimates based on the WFP maps.

Table 19: Total length (km) of different types of roads by agricultural potential zone

Agricultural potential zone	Interstate	Other primary	Secondary	Tertiary	Total
HH	389	1,249	1,004	887	3,529
HL	485	641	1,570	1,416	4,112
MH	582	874	1,121	0	2,577
ML	276	939	1,193	0	2,408
LH	443	373	535	0	1,350
LL	522	400	862	0	1,783
Total	**2,696**	**4,475**	**6,292**	**2,301**	**15,764**

Source: Authors' estimates based on the WFP maps.

58. **Focusing on areas with the highest agricultural potential and population density would have the highest development impact**. It would yield the highest payoff to investments in rural roads, allowing farmers to compete with food imports in the short run and to also conquer cross-border markets in the medium to long run. Cropland (current and potential from the expansion scenarios in Section 4.2) and roads data were used to compute requirements to meet cropland connectivity targets, conservatively estimated at 60 percent of current cropland and 50 percent of potential expanded cropland areas in high agricultural potential areas.

59. **At this stage in the reconstruction of South Sudan, the GoSS's investments are likely focused primarily on completing the interstate primary roads and interconnecting the state capitals.** But investments in interstate roads will only marginally improve rural connectivity. The completion of all interstate primary roads across the country will provide access to roads to 18 percent of the population (using the RAI) and 7 percent of the current cropland in high agricultural potential areas (based on the CLC index) within a 2 km boundary (Table 20).

Table 20: Access to different roads by agricultural potential zone using a 2 km boundary

	HH	HL	MH	Total high potential zones	Total	RAI
	Interstate primary roads					
Current cropland	0.06	0.05	0.09	0.07	0.06	0.18
Cropland under expansion Scenario 1	0.04	0.03	0.08	0.05	0.04	0.12
Cropland under expansion Scenario 2	0.04	0.03	0.08	0.04	0.04	0.11
	Interstate and other primary roads					
Current cropland	0.28	0.16	0.17	0.20	0.15	0.39
Cropland under expansion Scenario 1	0.24	0.12	0.17	0.16	0.14	0.34
Cropland under expansion Scenario 2	0.22	0.08	0.17	0.13	0.11	0.32
	Primary and secondary roads					
Current cropland	0.34	0.21	0.27	0.27	0.22	0.47
Cropland under expansion Scenario 1	0.32	0.15	0.26	0.23	0.20	0.43
Cropland under expansion Scenario 2	0.31	0.11	0.26	0.19	0.17	0.41
	Primary, secondary, and tertiary roads					
Current cropland	0.43	0.30	0.42	0.39	0.32	0.58
Cropland under expansion Scenario 1	0.41	0.23	0.40	0.33	0.29	0.54
Cropland under expansion Scenario 2	0.39	0.17	0.38	0.27	0.25	0.51

Source: Authors' estimates.

60. **Investing in other roads is necessary to achieve a higher rural connectivity**. Completing all primary roads will increase the CLC index to 20 percent in high agricultural potential areas and 15 percent in the whole country. The RAI will be 39 percent. The maximum share of current cropland that can be accessed through the existing roads (primary, secondary,

and tertiary), once fully rehabilitated, is 39 percent for high agricultural potential areas and 32 percent for the country as a whole, under a 2 km boundary assumption. The highest RAI would be 58 percent (Table 20).

61. **If cropland expansion occurs according to the two expansion scenarios, rural connectivity will actually decline**. With the existing roads, the rural connectivity index in high agricultural potential areas will decline from 39 percent to 33 percent under expansion Scenario 1 and to 27 percent under expansion Scenario 2 (Table 20). Correspondingly, the RAI will decline to 51 percent compared to the current 58 percent.

62. **A more pragmatic approach to road investments is to increase the catchment area from 2 to 5 km as discussed above**. When this wider boundary is considered, the CLC index for current cropland rises to 64 percent in high agricultural potential areas compared to 39 percent within a 2 km boundary (Table 21). Even under the high crop expansion scenario, about 51 percent of total cropland (with 71 percent of the population) in high agricultural potential areas will be connected to roads. This coverage is deemed sufficient to provide the necessary impetus for long term agricultural growth in the country.

Table 21: Access to different roads by agricultural potential zone using a 5 km boundary

	HH	HL	MH	Total high potential zones	Total	RAI
	Interstate primary roads					
Current cropland	0.10	0.09	0.17	0.13	0.11	0.27
Cropland under expansion Scenario 1	0.06	0.06	0.15	0.09	0.09	0.20
Cropland under expansion Scenario 2	0.06	0.06	0.15	0.08	0.08	0.19
	Interstate and other primary roads					
Current cropland	0.46	0.32	0.32	0.36	0.28	0.54
Cropland under expansion Scenario 1	0.39	0.25	0.30	0.30	0.26	0.49
Cropland under expansion Scenario 2	0.36	0.20	0.29	0.26	0.24	0.46
	Primary and secondary roads					
Current cropland	0.55	0.39	0.48	0.47	0.39	0.64
Cropland under expansion Scenario 1	0.51	0.33	0.45	0.42	0.37	0.60
Cropland under expansion Scenario 2	0.50	0.28	0.44	0.37	0.34	0.58
	Primary, secondary, and tertiary roads					
Current cropland	0.69	0.56	0.66	0.64	0.54	0.77
Cropland under expansion Scenario 1	0.64	0.49	0.64	0.58	0.53	0.74
Cropland under expansion Scenario 2	0.62	0.42	0.61	0.51	0.49	0.71

Source: Authors' estimates.

63. **More than 11,000 km of existing roads need to be rehabilitated to meet the rural connectivity targets in high agricultural potential areas; i.e., a CLC index of 60 percent of the current cropland and 50 percent of the expanded cropland areas**. This would account for 72 percent of the existing total road network in South Sudan, without building any new roads (Table 22). The share of "rural roads" (secondary and tertiary) in this requirement is estimated at 52 percent.

Table 22: Types and lengths of roads needed to meet rural connectivity targets

	Km required to connect to market: 60% of current cropland and 50% of expanded cropland	Total road network (km)
Roads needed to satisfy market-access criterion	11,458	15,759
Of which:		
Core interstate primary roads	2,696	2,696
Other primary roads	2,764	4,475
Secondary roads	3,695	6,285
Tertiary roads	2,303	2,303

Source: Authors' estimates.

64. **Most roads will have to be completed in the three Equatorial states and in Jonglei**. These four states account for 79 percent of the roads network required to meet the rural connectivity targets (Table 23), or about 11,000 km (Annex 12). From a livelihood zone perspective, most roads are located in the Greenbelt (34 percent) (Table 24 and Annex 13). This zone also has the longest network of rural roads, together with the Hills and Mountains zone. These are the areas with the highest agricultural potential in terms of favorable climate and population density and thus they should be prioritized for earlier investments to provide the fastest stimulus to agricultural growth in the country (Figure 10).

Table 23: Roads distribution by state in high agricultural potential zone (%)

State	Interstate primary	Other primary	Secondary	Tertiary	Total
Upper Nile	0.0	3.1	4.7	0.0	2.5
Jonglei	3.1	20.0	17.9	25.6	18.1
Unity	0.0	2.6	0.4	0.0	0.8
Warrap	4.8	4.7	7.7	0.0	4.7
Northern Bahr el Ghazal	7.4	2.6	3.4	0.0	3.0
Western Bahr el Ghazal	10.6	2.7	3.8	0.0	3.6
Lakes	21.3	2.5	6.3	0.1	6.0
Western Equatoria	21.8	18.5	18.6	23.4	20.1
Central Equatoria	21.4	32.2	5.1	24.4	19.1
Eastern Equatoria	9.5	11.0	32.3	26.5	22.0

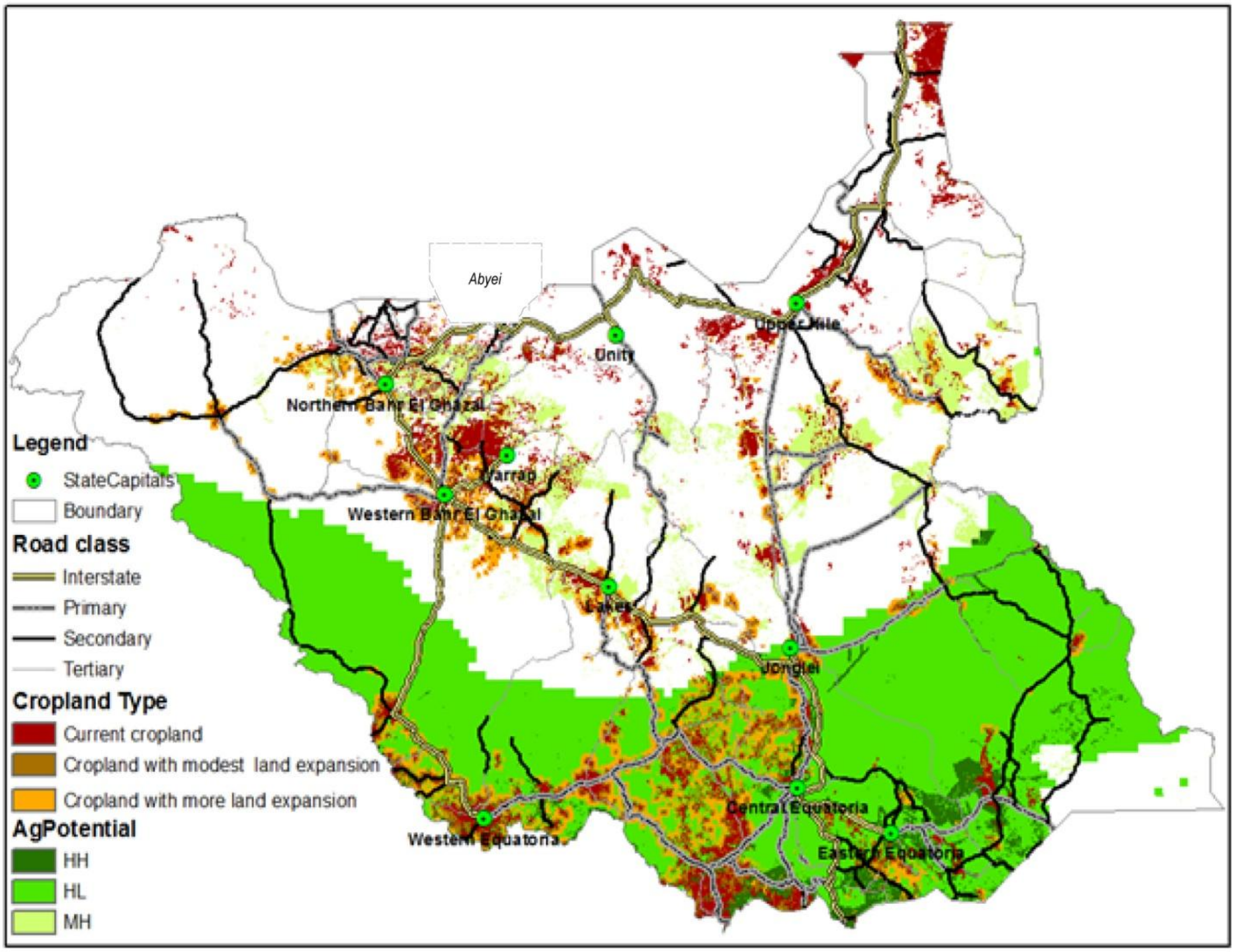
Source: Authors' estimates.

Table 24: Roads distribution by livelihood zone in high agricultural potential zone (%)

Livelihood zone	Interstate primary	Other primary	Secondary	Tertiary	Total
Eastern Flood Plains	2.0	7.4	9.7	11.3	7.0
Greenbelt	39.4	27.6	46.3	21.1	33.5
Hills and Mountains	15.4	22.4	20.0	36.3	21.6
Ironstone Plateau	16.2	2.0	7.2	18.9	7.6
Nile-Sobat Rivers	0.7	2.3	3.1	1.3	2.0
Pastoral	21.3	28.8	7.9	11.1	21.2
Western Flood Plains	5.0	9.6	5.8	0.1	7.0

Source: Authors' estimates.

Figure 10: Combination of roads, agricultural potential zones, and cropland areas



Source: Authors' presentation.

1.11. Budget requirements

65. **The unit cost of road construction in South Sudan is among the highest in Africa and extremely onerous by any standard** (Table 25). It is well recognized that in post-conflict economies, prices tend to escalate, due to political instability and insecurity, and also to construction booms, where high demand for reconstruction meets an inelastic supply response. In the case of South Sudan, the high cost situation is worsened by the shortage of skilled operators and technicians and the extraordinarily high cost of living and hardship for the mobilized labor force (World Bank, 2011c).

Table 25: Cost of rehabilitation and reconstruction of two-lane inter-urban roads

	South Sudan	DRC	Ghana	Mozambique	Nigeria	Ethiopia	Malawi
Average unit cost ('000 US$/km)	**1,000-1,300**	229	261	279	330	388	421

Source: World Bank (2011c).

66. **The domestic construction industry is very underdeveloped**. Developers have limited or no information on the potential for infrastructure developments and upcoming investments, and procurement practices are poor. Costs are further escalated because construction materials are not available locally, costs associated with shipping materials to the site of construction are enormous, there is almost non-existent competition in the construction market, and there is widespread incidence of land mines that need to be cleared prior to construction.

67. **High quality roads are critical for economic development in South Sudan**. However, given the many urgent competing demands on government resources, the significant length of uncompleted roads, and the low capacity of the domestic construction industry, pragmatic decisions are required to develop roads in stages. In this analysis, two investment options are presented. The first is a *base scenario,* with desirable investments to achieve the highest standards of road rehabilitation and construction. Under this scenario, all interstate and other primary roads are upgraded to two-lane paved roads with double surface asphalt treatment, at an average unit cost of US$1,150,000 per km (Table 26)[13]. Secondary roads are upgraded to two-lane gravel standard with seal or wearing course. All tertiary roads are upgraded to two-lane gravel roads designed for fifty vehicles a day. Annual road maintenance is estimated to be US$30,000 per km, to cover spot improvements and repair works in addition to regular maintenance.

Table 26: Cost scenarios for road rehabilitation, construction, and maintenance in South Sudan

Road type	Base scenario	Pragmatic scenario
Interstate primary roads	US$1,150,000 per km Paved asphalt two-lane road	US$1,150,000 per km Paved asphalt two-lane road
Other primary roads	US$1,150,000 per km Paved asphalt two-lane road	US$370,000 per km Gravel two-lane road with seal or stabilized gravel wearing course
Secondary roads	US$370,000 per km Gravel two-lane road with seal or stabilized gravel wearing course	US$200,000 per km Gravel two-lane road designed for 50 vehicles a day, with adequate drainage structures and pavement
Tertiary roads	US$200,000 per km Gravel two-lane road designed for 50 vehicles a day, with adequate drainage structures and pavement	US$100,000 per km Gravel two-lane road designed for 30 vehicles a day, with critical drainage structures and basic surfacing and variable road width
Road maintenance	US$30,000 per km Including spot improvement and repair works	US$15,000 per km Routine maintenance only

Source: Authors' estimates based on input from the World Bank Transport Sector staff.

68. In addition, once capital investments are made, regular maintenance would require US$344 million annually in high potential zones and US$473 million for the total roads network, adding another 15 to 21 percent of the 2010 public expenditure (Table 28).14

[13] The road construction costs that are presented are conservative estimates and could be higher especially in areas far away from State Capitals.

[14] At the exchange rate of 2.5 SDG per US$1, the total budget in 2010 was about US$2,252 million. The total expenditure on transport and roads equaled US$192 million.

Table 27: Budget requirements for road investments under the base scenario (US$ million)

Road type	Roads in high potential zone	Total roads network
Interstate primary roads	3,100.6	3,100.6
Other primary roads	3,178.1	5,146.3
Secondary roads	1,367.2	2,325.4
Tertiary roads	460.6	460.6
Total capital spending	**8,106.5**	**11,032.8**
Road maintenance	*343.7*	*472.8*

Source: Authors' estimates.

Table 28: Approved budget in 2010 and 2011 in South Sudan (SDG million)

	2010	2011
Budget items for all sectors		
Salaries	2,234	2,433
Operating expenses	2,258	2,076
Capital expenditure	1,138	1,258
Total budget	**5,630**	**5,767**
Budget items for transport and roads		
Salaries	15	13
Operating expenses	9	6
Capital expenditure	456	496
Total budget for transport and roads	**480**	**515**

Source: GoSS budget estimates.

69. **Although the government's fiscal position has improved after independence, still these costs are very high in light of other needs in the country, and therefore a more pragmatic approach/scenario is recommended**. In this scenario, while all interstate primary roads are upgraded to the same standard as in the base scenario, other primary roads are constructed at the lower gravel standards (Table 26). Secondary roads are upgraded to class A rural roads designed for fifty vehicles per day, with adequate drainage structures and pavement; tertiary roads are designed for thirty vehicles per day, with critical drainage structures and basic surfacing. Lower standard feeder roads designed for ten vehicles per day or fewer are unlikely to be common in the high potential agricultural areas, though they may be a pragmatic solution in other rural areas.

70. **In the case of South Sudan, high end networked infrastructure services are not a feasible option in the short and medium term**. Adopting low-cost modern technologies could substantially reduce the cost of expanding access to roads, and help make the transitional period and the potential funding gap manageable. Initially adopting a gravel road standard – perhaps with some light asphalt stabilization or locally available sealing as discussed above – could help accelerate the achievement of rural connectivity, with full paving investments deferred to a later date. It is estimated that careful choice of technology and targeting feeder road interventions to the highest quality agricultural land could reduce the transport sector spending needs by 40 percent thus freeing up resources for other equally important investments. Under the pragmatic scenario, the budget needs for roads to meet rural connectivity targets are estimated at US$5.1 billion (including US$2 billion for rural roads), compared to US$8.1 billion (including US$5 billion for rural roads) under the base scenario (Table 29).

Table 29: Budget requirements for road investments under the pragmatic scenario (US$ million)

Road type	Roads in high potential zone	Total roads network
Interstate primary roads	3,100.6	3,100.6
Other primary roads	1,022.5	1,655.8
Secondary roads	739.1	1,257.0
Tertiary roads	230.3	230.3
Total capital spending	**5,092.4**	**6,243.6**
Road maintenance	*171.9*	*236.4*

Source: Authors' estimates.

71. **The largest share of the roads budget would be spent on interstate primary roads**. They are expensive and expenditure would need to be twice as large as the entire 2010 capital investment budget. It is therefore critical to reduce the unit costs of interstate primary roads, not only to reduce the overall budget envelope, but also to be able to turn quickly to construction of rural roads (i.e., secondary and tertiary roads) that are critical for rural connectivity. Rural roads are estimated at 6,000 km, and would require a budget of US$1.0 billion and US$1.8 billion, respectively, under the pragmatic and base scenarios.

1.12. Reducing transport prices and its potential effect on food prices

72. **Investments in roads will reduce transport costs and transport prices in South Sudan and should also reduce food prices and improve food security**. However, the extent of reductions will depend on policies on competition in the trucking sector, regulations, non-tariff barriers, and the functioning of the food collection and distribution systems among other measures. It is important to ensure that these policies complement the value of roads investment, rather than reducing it. The objective is to ensure: (i) that better roads result in lower transport costs for the trucking industry (through lower use of fuel and tires, and lower maintenance and other costs), and (ii) that the transport cost savings resulting from road improvements are passed on to producers and consumers.

73. **The critical precondition for this is competition among transporters.** Concerns about the competitive nature of transport operators have long been recognized, most recently in a study on international corridors in Africa (Teravaninthorn and Raballand, 2009). In a monopoly environment, investments in roads reduce transport costs but those cost savings are not usually transferred to end users through lower transport prices and reduced food prices. In other words, the lower transport costs increase profits of the trucking industry but do not reduce costs for producers and consumers. This has happened in many Western and Central African countries, for example, where strong cartels of transport firms oppose opening of the sector, resulting in an insignificant pass-through of any cost savings to end users of transport services (Table 30). The situation is different in competitive environments such as in East Africa, where a reduction in transport costs eventually led to a reduction in transport prices.

Table 30: Measures and outcomes for reducing transport prices along the main transport corridors in Central and West Africa

Measure	Decrease in transport costs (%)	Increase in sales (%)	Decrease in transport price (%)
Rehabilitation of corridor from fair to good	-5	Not substantial (NS)	+/0
20% reduction in border-crossing time	-1	+2/+3	+/0
20% reduction in fuel price	-9	NS	+/0
20% reduction of informal payment	-1	NS	+/0

Source: Teravaninthorn and Raballand (2009).

Table 31: Measures and outcomes for reducing transport prices along the main transport corridors in East Africa

Measure	Decrease in transport costs (%)	Increase in sales (%)	Decrease in transport price (%)
Rehabilitation of corridor from fair to good	-15	NS	-7/-10
20% reduction in border-crossing time	-1/-2	+2/+3	-2/-3
20% reduction in fuel price	-12	NS	-6/-8
20% reduction of informal payment	-0.3	NS	+/0

Source: Teravaninthorn and Raballand (2009).

74. **It is imperative for South Sudan, therefore, to promote competition among transporters to achieve results similar to those in East African countries**. Transport prices and costs in Kenya and Uganda are lower than in Central and Western Africa. The competitive nature of their transport industry results in the significant pass-through of cost savings, from improved roads to lower transport prices for end users (Table 31). Thus, if South Sudan promotes competition in the transport sector, better roads will translate into reduced food prices for most of the population and would produce nation-wide benefits in terms of food security.

75. **Non-tariff barriers should be eliminated to ensure that investments in roads provide benefits to farmers and consumers**. There are many reports pointing to a number of non-tariff barriers in South Sudan, ranging from road blocks and security checks to ambiguous collection of local taxes and various fees (Selassie, 2009; Asebe, 2010; World Bank, 2011b). On the route to Juba from the two border posts of Kaya and Nimule, trucks transporting goods are typically stopped to pay various fees every 7 to 15 km, or five to ten times (World Bank, 2011b). For large trucks, the total amount paid is often not large compared to the transport costs, but the main concern is the high opportunity cost of wasted time.[15] For smaller traders, however, the monetary costs of various fees are significant. Non-tariff barriers on certain routes can be a high proportion of transport costs, as is likely to be the case for trade between Lira, Uganda, and Juba, where the difference in maize price (US$550 per ton in April 2011) is only partially (32 percent) explained by transport fees (US$177).[16] Besides not bringing revenues to the budgets, these additional costs also reduce the value for money of roads investments and hurt agricultural competitiveness.

[15] In a recent World Bank report (2011b), the amount of such payments per ton-km was found to range from US$0.012 per ton-km for a 40 ton truck to US$0.046 per ton-km for a 10 ton truck. Total payment is estimated at SDG 200, using an exchange rate of 2.3 SDG per US$1. The distance between Kaya and Juba is 233 km, and between Nimule and Juba, 193 km.

[16] Transport prices between Lira and Juba are estimated using the following assumptions: the distance between Lira and Nimule (border post) is 212 km, with a transport price of US$0.25 per ton-km. The distance between Nimule and Juba is 193 km, with a transport price of US$0.65 per ton-km.

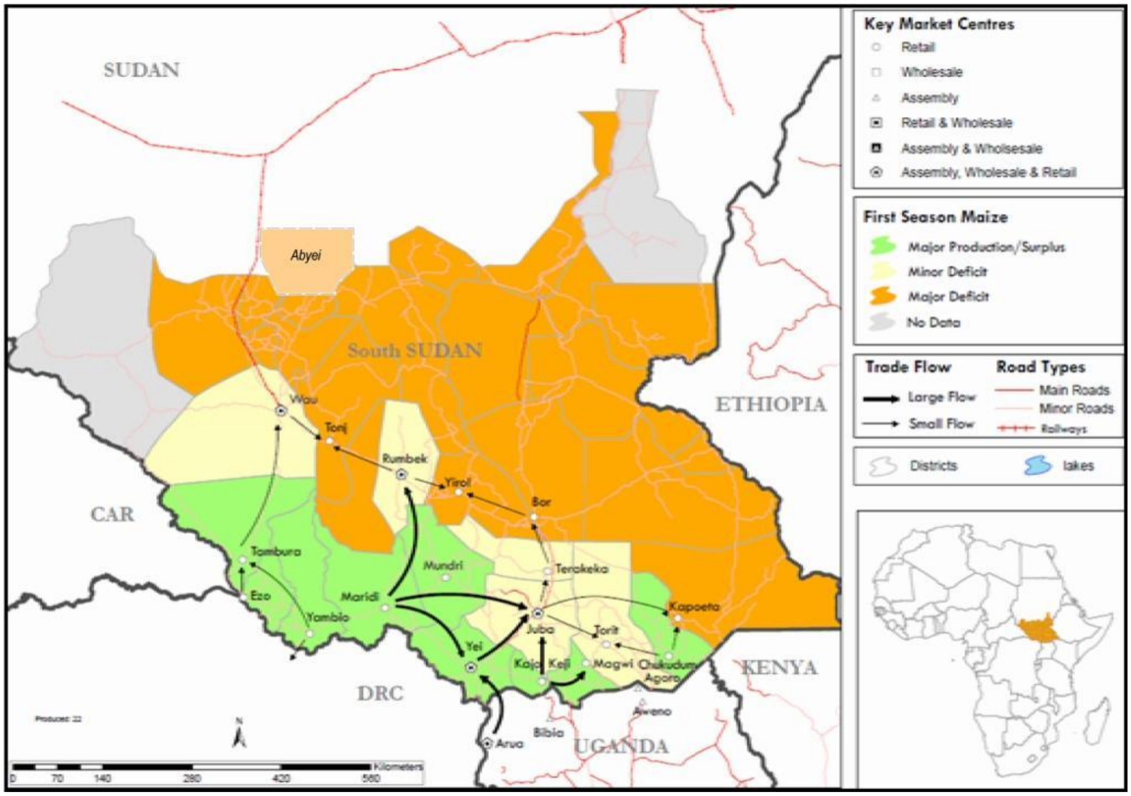
AGRICULTURAL COMPETITIVENESS

76. **Are investments in roads sufficient first to increase and then maintain competitiveness of South Sudan's agriculture?** Especially if complemented with good transport policy and regulations, roads will surely be transformative but not sufficient. The analysis below suggests that other productivity-inducing public investments are still needed if South Sudan is to compete with neighboring countries (e.g., Uganda and Sudan) that are currently very competitive in South Sudanese markets. These countries have lower production costs, and improved roads as analyzed in Section 5 would make them even more competitive by reducing the "distance" between their own farmers and South Sudanese consumers. This section, deals with price and cost competitiveness of farms in South Sudan vis-à-vis Uganda and Sudan, assessing the current situation and identifying farm cost-reduction strategies.

1.13. Price competitiveness

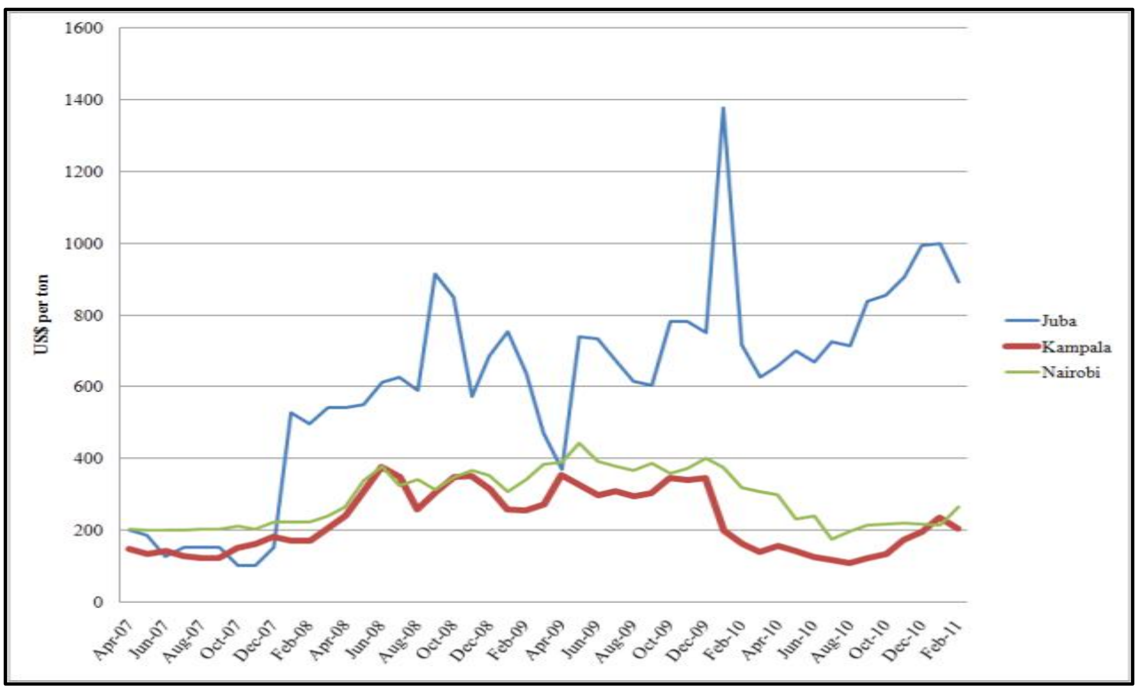
77. Staple food prices in South Sudan are very high, at least double those in the major markets in Sudan and Uganda. White maize is imported mainly from Uganda, as shown in Figure 11, and consumed in the southern part of the country. Ugandan maize prices are the lowest in East Africa, and thus very competitive; the price gap between Kampala and Juba can reach as high as US$800 per ton in some months. Sorghum, another key staple, is mainly imported from Sudan (Figure 13) and the import parity prices imputed from the prices in Kadugli, a border town in Sudan, are also much lower than in the major markets in South Sudan (Figure 14).The price wedge between Kadugli and Juba can reach US$500-600 per ton.

Figure 11: Typical maize flows in South Sudan



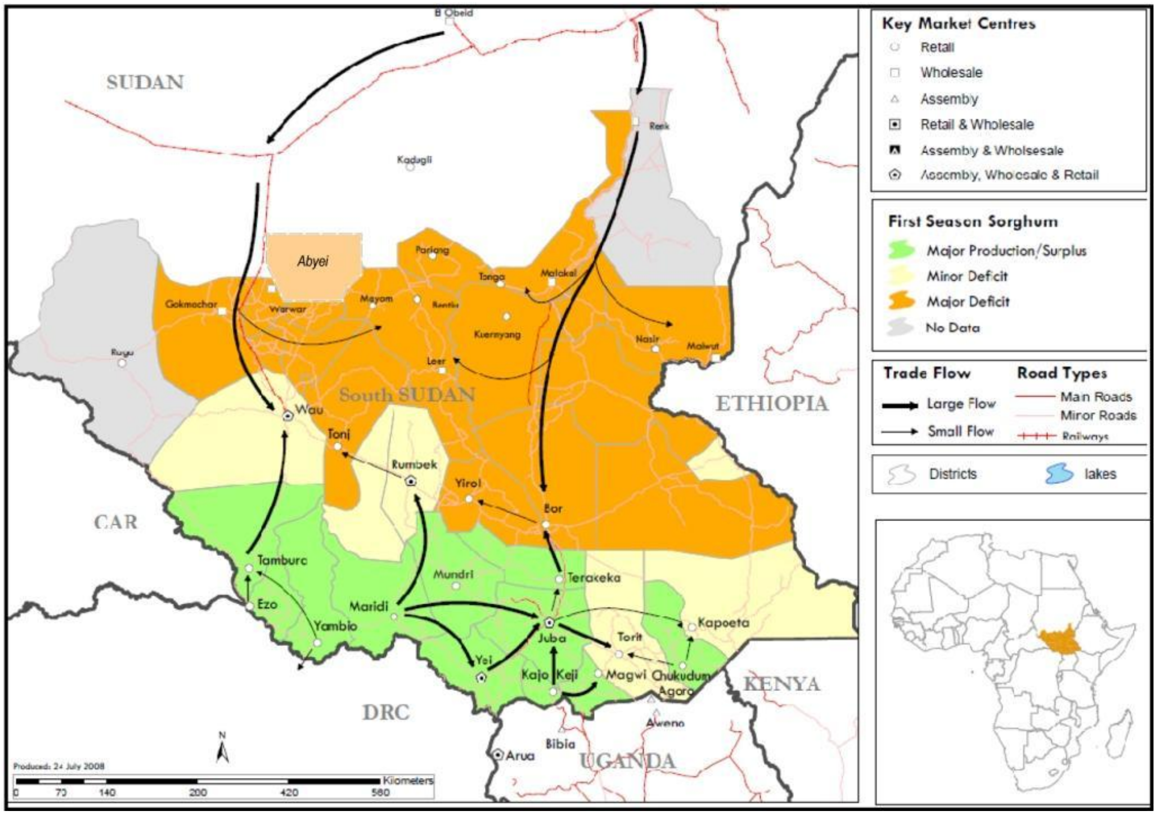
Source: www.fews.net.

Figure 12: Maize prices in Juba, Nairobi, and Kampala



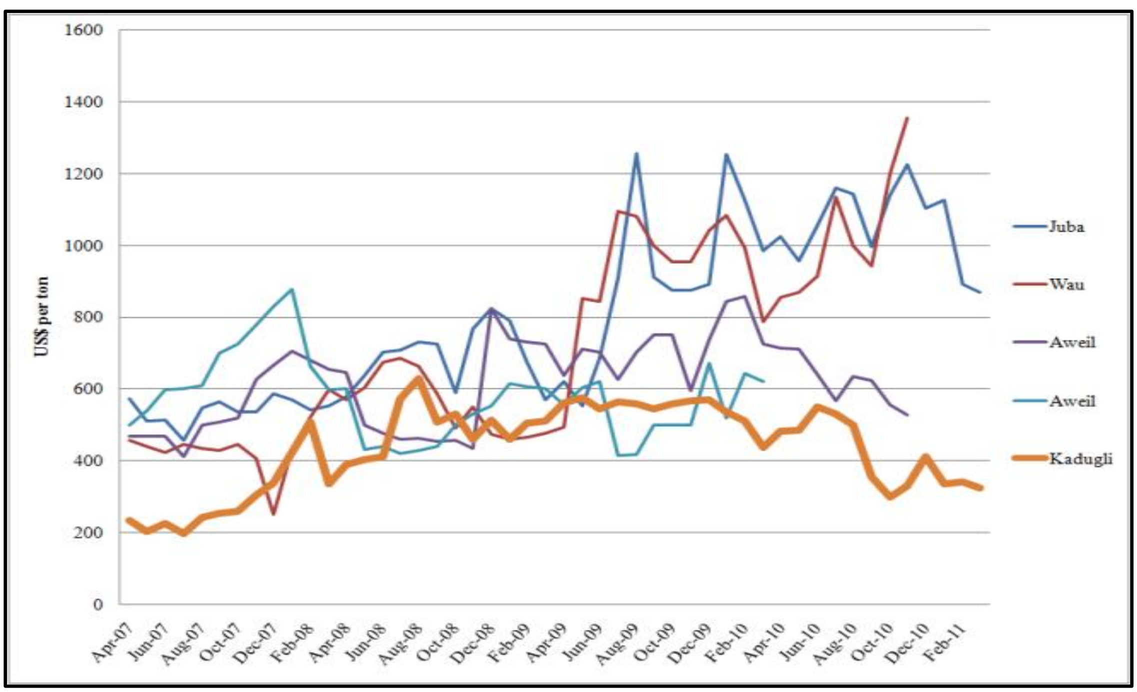
Source: www.fews.net and www.ratin.net.

Figure 13: Typical sorghum flows in South Sudan



Source: www.fews.net.

Figure 14: Sorghum prices in South Sudan and Kadugli (Sudan)



Source: www.fews.net.

78. **Import prices have been setting local prices on many markets**. Ugandan maize affects local prices in the markets closest to the Ugandan border. The landed maize prices from Lira are actually lower than local prices in some markets there (Table 32).[17] The same applies to sorghum that comes from the North. Although the "law of one price" cannot be strictly applied in South Sudan, due to very poor roads and many non-tariff barriers, the food imports exert and will continue exerting significant pressure on local prices.[18]

Table 32: Actual and landed prices by import source, March 2011 (US$/ton)

Market	Maize		Sorghum	
	Current price	**Simulated price**	**Current price**	**Simulated price**
Juba, Central Equatoria	759	689	843	1,433
Aweil, Northern Bahr el Ghazal	843	909	843	1,140
Bentiu, Unity	943	995	843	729
Bor, Jonglei	n/a	517	943	1,186
Kuajok, Western Bahr el Ghazal	843	878	843	846
Malakal, Upper Nile	1,686	1,846	716	1,211
Rumbek, Lakes	1,138	664	927	1,058
Torit, Eastern Equatoria	843	449	421	1,409
Wau, Warrap	674	812	674	1,043
Yambio, Western Equatoria	421	671	421	1,370

Source: Authors' estimates based on the distances between markets presented in Annex 14.

79. **Competitive pressure is likely to increase once market connectivity is improved in South Sudan**. In many markets, landed import prices will be lower than in the past once transport prices are reduced. Currently, the average transport price in South Sudan is about US$0.65 per ton-km. If investments in roads reduced these prices by half (from US$0.65 per ton-km to US$0.32 per ton-km), imported maize prices in Juba would fall from the current US$689 to US$628 per ton, or by 9 percent (Table 33). In Rumbek, the price reduction would be more dramatic, due to the longer distance to the Ugandan border. The largest output price effect of lower transport prices is expected in Yambio, assuming Ugandan maize flows through Juba. If transport prices in South Sudan decline to the level of average transport prices in Uganda, maize price reduction is expected to range from 12 percent in Juba to 57 percent in Yambio. If transport prices in South Sudan declined to the current level along major transport corridors in Africa (Table 17), the local price reduction would be even sharper.

[17] The landed price is estimated as output price at the source of imports (Lira for maize and Kadugli for sorghum) plus transport (distance times unit costs, $0.25 per ton-km in Uganda and $0.65 per ton-km in South Sudan) plus fixed non-tariff fees on the route from Lira to Juba.

[18] Under the law of one price, the price difference between a pair of markets equals the transport cost between the markets.

Table 33: Simulated impact of lower transport prices on maize prices in South Sudan (US$/ton)

	Juba	Rumbek	Torit	Yambio
Derived prices (at transport price of US$0.65/ton-km)	689	964	749	471
Derived prices (at transport price of US$0.33/ton-km)	628	768	658	271
Derived prices (at transport price of US$0.22/ton-km)	607	700	627	203
Derived prices (at transport price of US$0.10/ton-km)	584	626	593	128
Price reduction, simulation 1	-9%	-20%	-12%	-42%
Price reduction, simulation 2	-12%	-27%	-16%	-57%
Price reduction, simulation 3	-15%	-35%	-21%	-73%

Source: Authors' estimates.

80. **The decline in sorghum prices is expected to be even larger than that of maize prices if market connectivity in South Sudan is improved**. If transport prices decline from US$0.65 to US$0.33 per ton-km, or by 49 percent, the derived sorghum prices in many markets are expected to fall by 30 percent, compared to 9 to 20 percent for maize (Table 34). This large food price effect comes from the longer distances between the source of imports, Sudan, and markets in South Sudan, and thus a bigger share of transport expenses in wholesale sorghum prices (see Annex 14 with the distance matrix).

Table 34: Simulated impact of lower transport prices on sorghum prices in South Sudan (US$/ton)

	Juba	Aweil	Rumbek	Wau
Derived prices (at transport price of US$0.65/ton-km)	1285	992	910	895
Derived prices (at transport price of US$0.33/ton-km)	829	680	638	631
Derived prices (at transport price of US$0.22/ton-km)	672	573	545	540
Derived prices (at transport price of US$0.10/ton-km)	358	358	412	406
Price reduction, simulation 1	-36%	-31%	-30%	-30%
Price reduction, simulation 2	-48%	-42%	-40%	-40%
Price reduction, simulation 3	-72%	-64%	-55%	-55%

Source: Authors' estimates.

81. **South Sudan therefore cannot just invest in roads, but should also invest in other productivity-enhancing public goods to improve its competitiveness**. This is particularly important due to the high production costs in South Sudan, which prevent most farms from increasing food production even with very high current food prices in consumption areas. The high production costs are the result of low investments in land, high labor costs, high tradable input prices, and high upfront land clearing/tree uprooting costs. The next section looks at farm production costs and farm margins in detail.

1.14. Farm production costs[19]

82. Farm production costs in South Sudan are much higher than those in most of its neighboring countries. They are especially high compared to Uganda, where production costs and food prices are the lowest in East Africa. South Sudan lags behind in all key cost elements (Table 35) facing:

- Higher labor requirements, mainly due to the need for land clearing after many years of no land cultivation;
- Higher labor costs, ranging from US$5.2 per man-day in Kajo-Keji, Morobo, and Yambio, to about US$10.3 per man-day in Malakal, compared to US$1.0 in Uganda and US$2.3 in Tanzania;
- Lower yields; and
- Higher prices of tradable inputs and lower efficiency of their use.

Table 35: Key elements of maize production costs and revenues in South Sudan, Uganda, and Tanzania

	South Sudan	Uganda	Tanzania
Average yield (kg/ha)	800	1,200	1,120
Farm-gate price (US$/kg)	0.50	0.15	0.20
Labor requirements (man-days/ha)	72	47	52
Labor cost (US$/man-day)	7.50	1.00	2.31
Use of seeds (kg/ha)	10.5	5.4	7.0
Seed price (US$/kg)	1.57	0.92	1.35

Source: Authors' estimates based on various data sources and field surveys done by the World Bank.

83. **The largest contributor to farm production costs in South Sudan is labor, even where tractors are used for some operations**. Labor costs for sorghum production range from US$304 per ha in Kajo-Keji in Central Equatoria to US$565 per ha in Yambio, Western Equatoria (Table 36).[20] High labor cost is a result of: (i) high labor requirements for preparing land for cultivation; and (ii) high daily wage rates. High wages are, however, partially offset by low land rents (since land is typically available at no cost).

84. **Decades of conflict prompted farmers to flee their land, allowing regeneration and progression of vegetation towards climax formations (mainly forests and shrubs).** In most areas, therefore, significant upfront work (mainly cutting, uprooting, and removing trees) is required to clear the climax vegetation formations before the land is cultivable. In Morobo and Kajo-Keji areas, for example, sixteen to twenty man-days per ha are required just to uproot trees (Table 36). Such work is among the main cost disadvantages of South Sudan vis-à-vis its neighbors, where initial land clearing was completed many years ago. Labor is typically hired for this work, but is reported to be expensive and in short supply, especially during the planting and harvesting campaigns, making cropland expansion an expensive undertaking. Mechanized

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[19] The data on farm production costs were collected in February-March 2011 in various states by visiting farms, NGOs, and farmer groups. Primary data were collected for subsistence versus mechanized farms. Details are in Sebit (2011).

[20] All primary data for farm costs were collected in SDG and feddans. To convert all the data into US$/ha, the exchange rate used is 2.9 SDG per US$1, and 1 feddan equals 0.42 ha.

activities are only seen in Kajo-Keji and Morobo, in addition to the large mechanized operations in Malakal, Upper Nile, but are usually limited to tillage, harrowing, and planting, while most other operations are carried out manually using family labor. Farming in Yambio, Western Equatoria appears to be the most labor intensive due to the dense forestation formations, the need for frequent weeding (due to high rainfall and incipient soil fertility which promotes weed growth), and harvesting challenges in areas with many trees and shrubs (e.g., thick vegetation in Yambio; see Figure 15) versus harvesting in open fields in Malakal (see Figure 16).

Table 36: Labor costs for typical farm production activities in South Sudan

	Kajo-Keji, Central Equatoria	Morobo, Central Equatoria	Yambio, Western Equatoria	Yei, Central Equatoria	Tonj North, Warrap
Hired labor					
Tree cutting (man-days/ha)	19.85	15.88	17.00	5.66	13.9
First tillage using hand hoes (man-days/ha)	n/a	n/a	23.82	11.92	n/a
First tillage/plowing (man-days/ha)	7.9	7.1	n/a	n/a	n/a
Harrowing (man-days/ha)	7.9	7.1	n/a	n/a	n/a
Manure application (man-days/ha)	n/a	n/a	n/a	n/a	23.82
Total man-days/ha	**35.65**	**30.08**	**40.82**	**17.58**	**37.72**
Daily rate (US$)	5.17	5.17	5.17	6.89	10.34
Hired labor (US$/ha)	**184**	**156**	**211**	**121**	**390**
Family labor					
Land clearing/slashing (man-days/ha)	5.32	3.19	12	14.89	2.66
Harrowing and ranking (man-days/ha)	n/a	n/a	5.32	2.99	n/a
Planting (man-days/ha)	2.93	12.77	5.32	4.79	2.13
First weeding (man-days/ha)	4.52	2.66	10.64	11.98	1.33
Second weeding (man-days/ha)	4.52	2.66	7.98	n/a	1.33
Harvesting (man-days/ha)	4.26	12.77	21.28	3.35	2.66
Post-harvest activities, drying and threshing (man-days/ha)	1.6	0.71	15.96	9.98	1.2
Total man-days/ha	**23.15**	**34.76**	**78.5**	**47.98**	**11.31**
50% hired labor cost (US$/ha)*	60	90	203	165	58
100% hired labor costs (US$/ha)	**120**	**180**	**406**	**331**	**117**
Total costs (US$/ha)**	**304**	**335**	**617**	**452**	**507**

Source: Authors' estimates based on various data sources and field surveys done by the World Bank.
Notes:*Family labor is assumed to be half as expensive as hired labor. ** Family labor is priced at the same rate as hired labor in computing total costs.

85. **Daily wage rates in South Sudan are extremely high compared to that elsewhere in the region**. In the Equatorial states, wage rates are about US$6 per man-day, while in Warrap and Upper Nile they can reach US$10 per man-day. It is important to note, however, that in many villages, a working day is only four hours compared to the norm of eight hours. The effective wage rate, therefore, could be twice as high as indicated above if computed based on an eight hour work day. The true opportunity cost of family labor is not known in South Sudan, and though it does not cost as much as hired labor, its cost is not zero even in remote areas. In the analysis below, family labor is calculated at full and half of hired labor costs to estimate net farm margins.

86. **Labor cost is the largest, but not the only, element of farm production costs.** Other costs include seeds, hand tools, and tractor services. The use of tradable inputs is typically limited to seeds, often self-produced recycled seeds. Instances of fertilizer and agricultural chemical use are very rare, with the exception of the mechanized irrigation scheme in Malakal, Upper Nile. When these costs are added, they are often higher than the revenues generated from farm production output. Table 37 presents the gross and net margins of typical farms in various areas of South Sudan. Gross margins, estimated as revenue less variable costs, are positive in most areas, mainly due to high output prices. Many farms compensate for low yields with high output prices, but that advantage may disappear once the connectivity of urban consumption centers with imported food is improved. Further deducting the costs of family labor makes farm profits (i.e., net margins) very small, and in most instances, gross margins are not sufficient to cover labor costs valued at market wage rates.

Figure 15: Thick vegetation in Yambio

Figure 16: Open fields in Malakal

Source: Sebit (2011).

Table 37: Gross margins of sorghum production in South Sudan

	Kajo-Keji, Central Equatoria	Malakal, Upper Nile****	Morobo, Central Equatoria	Tonj North, Warrap	Yambio, Western Equatoria	Yei, Central Equatoria
Output price (US$/kg)	0.69	0.57	0.34	1.30	0.69	0.41
Yield (kg/ha)	952	429	1,000	952	1,000	1,000
Gross revenue (US$/ha)	**657**	**244**	**340**	**1,238**	**690**	**410**
Variable costs						
Hired labor (US$/ha)*	184	114	311	390	211	242
Seeds (US$/ha)	16	12	6	15	27	23
Hand tools (US$/ha)	n/a	164	41	21	82	25
Draft power (tractor) (US$/ha)	n/a	57	148	n/a	n/a	n/a
Gross margin (US$/ha)	**456**	**-103**	**-10**	**812**	**370**	**241**
Family labor (US$/ha)	120	n/a	180	117	406	331
Man-days (8 hour day)	23	n/a	35	11	79	48
Daily rate (US$/man-day)	5.17	n/a	5.17	10.34	5.17	6.89
Net margin 1 (US$/ha)**	**337**	**-103**	**-190**	**695**	**-36**	**-90**
Net margin 2 (US$/ha)***	**396**	**-103**	**-100**	**754**	**167**	**76**

Source: Authors' estimates based on the field survey, February-March 2011.

Notes: *Major hired labor activities are: tree uprooting (in all locations, particularly in the Equatorial states), first tillage with hand hoes (Yei and Yambio), tractor services for planting and harrowing (Kajo-Keji, Malakal and Morobo), manure application (Tonj North). **Net margin 1 assumes the cost of family labor is the same as that of hired labor. ***Net margin 2 assumes that family labor costs half as much as hired labor. ****All operations in Malakal are typically carried out by hired labor.

87. **Even when production costs are lower than revenues, they are still too high to compete with farm gate prices prevailing in Uganda and Sudan and with landed import prices in South Sudan**. If sorghum prices in Table 37 are reduced to US$0.2 per kg (the prevailing farm-gate price in neighboring countries), even gross margins (value added) would become negative. Over time, food prices in South Sudan are expected to decline due to the increased investments in roads and improved security dividends in terms of greater cross-border trade and higher domestic production. In anticipation of lower output prices in South Sudan, farmers need to raise yields to generate profits, because at the current low yields, farm profits that cover both variable and fixed costs can be generated only at farm prices ranging from US$334 per ton in Yei to US$523 in Yambio (Table 38).

Table 38: Production costs per ha and ton of output

Production costs	Kajo-Keji, Central Equatoria	Malakal, Upper Nile	Morobo, Central Equatoria	Tonj North, Warrap	Yambio, Western Equatoria	Yei, Central Equatoria
Variable costs (US$/ha)	201	347	350	426	320	169
Total costs (US$/ha)	261	347	440	484	523	334
Variable costs (U$/ton)	211	810	350	447	320	169
Total costs (US$/ton)	274	810	440	508	523	334

Source: Authors' estimates based on the field survey, February-March 2011.

1.15. Cost-reduction strategies

88. **Given the high cost of living in South Sudan and the experience of other natural resource-dependent countries, it is unlikely that labor wages – the most significant component of overall farm production costs – will decline appreciably in the short to**

medium term. Reductions in farm production costs in South Sudan would therefore have to accrue from a combination of increased land and labor productivity. Examples abound in the country where mechanization of some part of the production process has led to significant cost savings. Sebit (2011) shows that when some operations were conducted using tractors, 23 percent less labor was used in the production of sorghum than when all production-related activities were carried out using manual labor. Similarly, when tractors were used, 16 percent less labor was used in producing maize compared to situations in subsistence farmer holdings where only manual labor was used. The use of ox-ploughs in Yambio was shown to reduce the labor requirements for primary tillage by at least six days. Access to and greater use of mechanization will therefore help reduce overall farm production costs.

89. **South Sudan is in the incipient stages of formulating an agricultural mechanization policy that will help improve the use and efficiency of agricultural tools, implements, and machinery in agricultural production and value addition operations**. It is critical that the approach adopted to stimulate mechanization in the country takes into consideration lessons and experiences in other developing countries. For example, ambitious and politically motivated tractor schemes became fiscal burdens to both the governments and farmers without necessarily raising productivity. It is equally important to be aware that the same predicament befell schemes in countries where mechanization was heavily subsidized through the provision of government-planned and -operated machinery services. These experiences point to a general failure of government-run services to provide timely and profitable mechanization inputs to farmers. The government has to recognize that the private sector is better placed to provide mechanization services and should strive to create conditions for largely self-sustaining development of mechanization with minimal direct intervention. In South Sudan, successful private sector-driven models already exist in Upper Nile, Unity, and Central Equatoria. Other measures that can be used to reduce labor costs include the use of conservation tillage where feasible, reliance on herbicides where the skills for use are available, reliance on draught power, and other labor saving equipment, e.g., ox-ploughs.

90. **In tandem with mechanization, South Sudan has to pursue other productivity enhancing measures if it is to reduce farm production costs**. Key to this will be the use of tradable inputs and the provision of advisory services on technology and other production related activities. Production in South Sudan is predominantly based on local cultivars or land races of the main staple crops. The genetic potential of these land races is very low and they are generally unresponsive to improved crop management practices. Therefore, regardless of the other agronomic measures used, yields of these crops will still be low. Attempts should therefore be made to remove bottlenecks to the use of improved varieties. As the policy landscape on seeds evolves, and the necessary infrastructure is put in place, efforts should be made to ensure that South Sudan accesses seeds from neighboring countries. Seeds traded in the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) countries, for example, should be approved for sale in South Sudan without further regulatory approval other than truth-in-labeling. In the medium to long term, support will be needed to improve seed supply to farmers through investments, training, and technical assistance at several levels of the seed chain, from breeder seed through farmer-based seed production. Programs to upgrade the capacity of selected public research stations to produce and store breeder seed for targeted species through investments in irrigation, cold storage, other equipment, and operational support will also be needed. Further, support is needed to strengthen the enabling environment for seed trade and improving the capacity of seed traders. Availability of seed can also be increased by

assisting producers active in the informal seed market. Some of the informal seed producers could be helped to expand their markets and encouraged to graduate into seed enterprises in the long term.

91. **Realization of yield potentials for improved varieties requires a significant increase in the level of fertilizer use in South Sudan**. As elsewhere in Sub-Saharan Africa, fertilizer use is currently very low in the country. Comprehensive data are not available but on the basis of cultivated area, South Sudan uses less than 3 kg of plant nutrients per ha, most of which is used in the irrigated areas in Upper Nile and Unity. A synthesis of studies on factors that have undermined demand for fertilizer in Africa (Morris *et al.*, 2007) indicates favorable incentives (strong fertilizer response and favorable price relations, i.e., input/output price ratios) for maize and sorghum, the key crops in South Sudan. Fertilizer use should therefore be profitable if accessed at reasonable prices. Possible options to increase use of fertilizers include: (i) adopting favorable taxes and tariffs on fertilizer imports; (ii) improving access to finance for private sector investors in the fertilizer business; (iii) considering linking up with other fertilizer importers in the region for regional procurement purposes; and (iv) supporting the development and scaling up of networks of input dealers. In the long term, given the oil endowments in the country, the GoSS should assess the economic viability of local fertilizer production.

92. **Due to high transport costs and poor distribution infrastructure, prices of tradable inputs in South Sudan in general are expected to be above those prevailing in Uganda, Kenya, and Tanzania, and close to the level in other land-locked countries such as Rwanda, Burundi, and Zambia** (Table 39). These high input prices call for serious attention to the efficient use of inputs (e.g., through improvements in soil and moisture management) to enhance yield response to fertilizer. There will also be a need to promote small-scale irrigation to reduce the risk associated with rainfall variability and to increase the profitability of investments in fertilizer adoption.

Table 39: Retail input prices in the selected East and Southern African countries, May 2011 (US$/ton)

	NPK 17-17-17	Urea 46-0-0	DAP 18-46-0	Maize hybrid seeds	Maize OPV seeds
Burundi	940	780	1,080	n/a	540
Kenya	700	660	880	1,820	n/a
Malawi	n/a	860	n/a	2,710	2,560
Rwanda	680	580	820	2,500	530
Tanzania	820	600	960	2,310	1,450
Uganda	860	720	1,000	2,040	920
Zambia	n/a	900	n/a	4,000	n/a

Source: AMISTA, www.amista.org.

93. **Intensifying production is a knowledge intensive activity as it requires greater management of a wider range of factors**. Therefore, the GoSS will have to support the improvement of farmers' skills and knowledge through the provision of advisory services to help increase productivity and lower production costs. The public extension system is still dysfunctional after many years of conflict, and an overarching model of service provision has not yet evolved. Private parties, especially NGOs, dominate the agricultural extension system. The GoSS can take advantage of this situation and, in line with current best practice, develop a pluralistic advisory service system under which private extension providers are either funded to

provide extension field services or are incorporated in some way into the public sector extension system. The GoSS can consider promoting grassroot command of the extension system by devolving fiscal responsibility to the lowest possible level of authority, consistent with organizational competencies and the efficient use of funds. Technologies for dissemination can be drawn from those used in Ethiopia, Uganda, and Kenya, which have similar ecosystems and consumer tastes, and well-developed technologies.

94. **Reducing post-harvest losses through post-harvest management can lower the costs of production in South Sudan**. Besides training farmers in post-harvest management and government-led rehabilitation and upgrading of storage facilities, the government should promote private ownership and operation of storage facilities alongside those of the government.

95. **Promotion of rainwater harvesting and irrigation is also important**. Given the high cost of irrigation, irrigation development must promote benefits among as many beneficiaries as possible, including support to the emergence of forward and backward linkages between irrigated agriculture and markets through the private sector. South Sudan's vast water resources are not sufficiently developed to smooth overall variability or the impact of droughts. Currently, areas are mostly cultivated by subsistence-oriented smallholder farmers practicing rainfed agriculture. A strategy for irrigation development aimed at defining a set of medium to long term measures or action plans is important. An institutional framework for South Sudan's water sector has been developed, and a policy document was published in 2007. A more detailed strategic framework for the country's water policy is now needed, enabling the country to enact more specific laws on the provision of water for industry, agriculture, and the population.

96. **Production costs will not go down in the short term, but they can be reduced in the medium term**. Lower farm costs are preconditions for competitiveness, economic growth, and poverty reduction in South Sudan. It is important to establish a division of labor from the very beginning, such that the public sector creates conditions, via regulations and investments, for the private sector to invest and generate profits. Public goods, as discussed in this ESW, are numerous and are critical to spur agricultural growth. If these public goods are provided, South Sudanese farmers should be able to feed the nation and provide food to neighboring countries that are less endowed in terms of agricultural potential. If these public goods are not provided, South Sudan will continue to experience high levels of poverty and dependence on food aid.

CONCLUSIONS

97. **South Sudan has a huge but largely unrealized agricultural potential**. Favorable soil, water, and climatic conditions render more than 70 percent of its total land area suitable for crop production. For several reasons, however, less than 4 percent of the total land area is currently cultivated. Infrastructure bottlenecks, non-tariff barriers, high labor costs, and limited use of productivity-enhancing technologies hinder progress and also constrain the competitiveness of South Sudan's agriculture relative to its neighbors. This report proffers and describes possible strategies through which South Sudan's agricultural potential can be realized and its regional competitiveness improved to foster more inclusive growth.

98. **Using household consumption data from the NBHS and a GIS-based model, the report estimates current agricultural production in South Sudan.** It also assesses the potential for increasing agricultural production (and the respective attendant value) by increasing cropped areas and per capita yields. The report identifies rural roads that are necessary to accelerate expansion of cultivated land in areas that are considered to have high agricultural potential and provides estimates of the budgetary requirements for road investments in those areas. The report also assesses the implications of infrastructure investments on agricultural competitiveness and the scope for reducing production costs in South Sudan to enable producers to compete with food imports, especially from Uganda.

99. **The value (realized agricultural potential) of total agricultural production in South Sudan was estimated at US$808 million in 2009**. Seventy-five percent (US$608 million) of this value accrues from the crop sector, while the rest is attributed to the livestock and fisheries sectors. The average value of household production is US$628, of which US$473 is realized from crops. Average value of production per ha is US$299 compared to US$665 in Uganda, US$917 in Ethiopia, and $1,405 in Kenya in 2009.

100. **Increasing cropland from the current 4 percent of total land area (2.7 million ha) to 10 percent of total land area (6.3 million ha) under a modest cropland expansion scenario would lead to a 2.4-fold increase in the value of total agricultural output relative to the current level** (i.e., to approximately US$2 billion versus the current US$808 million). If coupled with a 50 percent increase in per capita yields, this cropland expansion would lead to a 3.5-fold increase in the value of total agriculture output (i.e., to US$2.8 billion) and would also increase the value of crop production per ha from US$227 to US$340. If per capita yields double, the value of total agriculture production under a modest cropland expansion scenario would increase to US$3.7 billion, and would outstrip the current value of agricultural production in neighboring Uganda. Increasing productivity threefold would increase the value of agricultural production to US$5.5 billion.

101. **Improved rural connectivity is necessary for land expansion, yield improvements, and the resultant increases in the value of agriculture output**. Required investments in rural roads would not only have to first target areas identified as having high agricultural potential, but would also have to adopt a pragmatic approach towards the quality (type) of the roads given severe budget constraints and competing development needs, as well as the low capacity of the local construction industry. A pragmatic approach implies construction of lower quality roads (with lower unit costs) and larger boundaries for assessing roads coverage. This would reduce the capital requirement for rural roads from US$5 billion to US$2 billion and accelerate the achievement of rural connectivity. Full paving investments would be deferred to the future.

These investments in roads have to be accompanied by other measures geared towards reducing transport prices, including the promotion of competition among transport service producers and abolishment of various non-tariff barriers to trade, both internal and at cross-border points.

102. **Improved rural connectivity, especially if combined with good transport policy and regulations, will be transformative, but in and of itself will not be sufficient to sustain the competitiveness of South Sudanese farmers**. Neighboring countries still have lower production costs and will benefit from better roads by providing more affordable prices to South Sudanese consumers, especially in urban areas. Complementary productivity-enhancing investments and market-supportive regulations are therefore required to improve the competitiveness of South Sudan's agriculture. In the short term, removing bottlenecks to using the available seed varieties in the East Africa region would increase access to improved germplasm, and would help narrow the current yield gap. Investments in mechanization to reduce drudgery and high costs associated with cropping would also allow South Sudanese farmers to increase production at relatively lower costs. Support for adaptive agricultural research would allow release of new and superior seed varieties and would also help overcome other constraints (e.g., pests and diseases) to yield increases. Advisory services will be essential to maximize farm returns from the use of improved inputs, including mechanization and the development of irrigation. For all of these public investments, it is important to ensure that they "crowd in" private investment rather than discouraging it.

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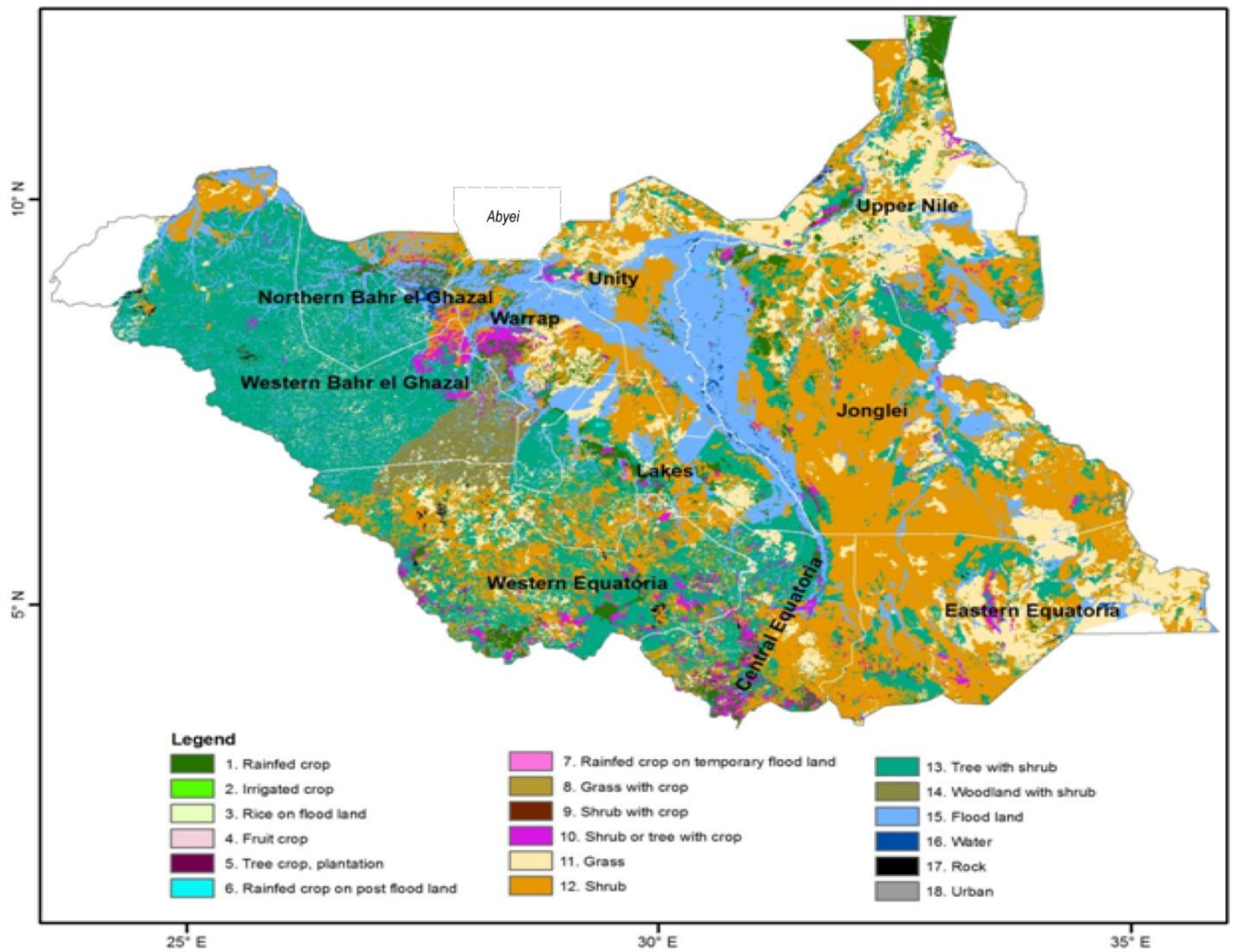
ANNEXES

Annex 1: Type of land use by 18 categories

Land use	Area (sq km)	Share of total land (%)	Land use	Area (sq km)	Share of total land (%)
Rainfed crop	23,793	3.7	Shrubs or tree with crop	17,030	2.6
Irrigated crop	321	0.0	Grass	96,338	14.9
Rice on flood land	60	0.0	Shrubs	205,066	31.7
Fruit crop	1	0.0	Tree with shrubs	176,949	27.4
Tree crop, plantation	62	0.0	Woodland with shrubs	23,254	3.6
Rainfed crop on post flood land	254	0.0	Shrubs, tree and woodland with flooded land	94,976	14.7
Rainfed crop on temporary flood land	285	0.0	Water	3,501	0.5
Grass with crop	3,251	0.5	Rock	1,326	0.2
Shrubs with crop	43	0.0	Urban	370	0.1

Source: Aggregated from Land Cover Database, FAO (2009).

Land use/cover aggregated into 18 categories



Source: Authors' presentation based on Land Cover Database, FAO (2009).

Annex 2: Type of land use by state

A: By 18 types of land use categories (sq km)	Upper Nile	Jonglei	Unity	Warrap	N. Bahr el Ghazal	W. Bahr el Ghazal	Lakes	Western Equatoria	Central Equatoria	Eastern Equatoria	National total
Rainfed crop	4227	3219	982	3458	1999	449	2171	2577	2505	574	22161
Irrigated crop	127	3	0	0	0	0	0	5	0	0	135
Rice on floodland	0	0	0	1	61	0	0	0	0	0	62
Fruit crop	0	0	0	0	0	0	0	0	0	1	1
Tree crop, plantation	0	0	0	0	0	2	0	24	37	0	63
Rainfed crop with temporarily flooded land	4	50	46	29	37	12	53	3	13	11	258
Rainfed crop on post flooding land	0	17	0	33	161	1	52	0	6	17	287
Grass with crop	856	830	531	266	36	133	19	247	282	90	3290
Shrub with crop	38	0	0	0	0	0	0	1	5	0	44
Shrub or tree with crop	1193	1254	436	2571	721	2239	459	3442	3703	1234	17252
Grass	26189	14334	7408	4991	1006	4039	5409	8688	4399	20270	96733
Shrub	21030	63817	13096	8033	3788	5873	13450	22395	16602	37099	205183
Tree with shrub	10359	15484	1842	5158	15257	60861	14040	31578	13906	9745	178230
Woodland with shrub	392	892	24	1087	1	8964	1254	9831	957	183	23585
Tree, shrub and other vegetation on flood land	8505	25213	14125	10753	6902	12795	8487	1354	2253	4186	94573
Water	315	803	299	83	701	537	194	122	111	237	3402
Rock	129	9	2	0	17	329	7	697	61	27	1278
Urban	97	33	64	3	12	39	19	14	83	11	375
B: By 8 aggregated categories (sq km)											
Cropland	4358	3289	1028	3520	2258	464	2276	2609	2561	603	22966
Grass with crop	856	830	531	266	36	133	19	247	282	90	3290
Shrub with crop	1231	1254	436	2571	721	2239	459	3443	3709	1234	17297
Grass	26189	14334	7408	4991	1006	4039	5409	8688	4399	20270	96733
Shrub and tree	31781	80193	14962	14279	19046	75699	28714	63804	31465	47027	406970
Tree, shrub and other vegetation on flood land	8505	25213	14125	10753	6902	12795	8487	1354	2253	4186	94573
Water and rock	444	811	301	83	717	865	201	818	173	264	4677
Urban	97	33	64	3	12	39	19	14	83	11	375
Total	73461	125957	38855	36466	30698	96273	45584	80977	44925	73685	646881
C:% of total national land by state (18 types of land use categories)											
Rainfed crop	19.1	14.5	4.4	15.6	9.0	2.0	9.8	11.6	11.3	2.6	100
Irrigated crop	93.5	2.6	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0	100
Rice on floodland	0.0	0.0	0.0	1.4	98.6	0.0	0.0	0.0	0.0	0.0	100
Fruit crop	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100
Tree crop, plantation	0.0	0.0	0.0	0.0	0.0	2.8	0.0	38.0	59.2	0.0	100
Rainfed crop with temporarily flooded land	1.7	19.2	17.9	11.1	14.4	4.7	20.6	1.0	5.1	4.4	100
Rainfed crop on post flooding land	0.0	6.1	0.0	11.5	56.1	0.3	18.2	0.0	2.1	5.8	100
Grass with crop	26.0	25.2	16.1	8.1	1.1	4.0	0.6	7.5	8.6	2.7	100
Shrub with crop	86.1	0.0	0.0	0.0	0.0	0.0	0.0	2.0	11.9	0.0	100
Shrub or tree with crop	6.9	7.3	2.5	14.9	4.2	13.0	2.7	20.0	21.5	7.2	100

Grass	27.1	14.8	7.7	5.2	1.0	4.2	5.6	9.0	4.5	21.0	100
Shrub	10.2	31.1	6.4	3.9	1.8	2.9	6.6	10.9	8.1	18.1	100
Tree with shrub	5.8	8.7	1.0	2.9	8.6	34.2	7.9	17.7	7.8	5.5	100
Woodland with shrub	1.7	3.8	0.1	4.6	0.0	38.0	5.3	41.7	4.1	0.8	100
Tree, shrub and other vegetation on flood land	9.0	26.7	14.9	11.4	7.3	13.5	9.0	1.4	2.4	4.4	100
Water	9.3	23.6	8.8	2.4	20.6	15.8	5.7	3.6	3.3	7.0	100
Rock	10.0	0.7	0.1	0.0	1.3	25.7	0.5	54.6	4.8	2.1	100
Urban	25.8	8.8	17.1	0.9	3.2	10.4	5.1	3.7	22.1	2.8	100
D: of total national land by state (8 aggregated land use categories)											
Cropland	19	14.3	4.5	15.3	9.8	2.0	9.9	11.4	11.2	2.6	100
Grass with crop	26	25.2	16.1	8.1	1.1	4.0	0.6	7.5	8.6	2.7	100
Shrub with crop	7.1	7.3	2.5	14.9	4.2	12.9	2.7	19.9	21.4	7.1	100
Grass	27.1	14.8	7.7	5.2	1.0	4.2	5.6	9.0	4.5	21.0	100
Shrub and tree	7.8	19.7	3.7	3.5	4.7	18.6	7.1	15.7	7.7	11.6	100
Tree, shrub and other vegetation on flood land	9	26.7	14.9	11.4	7.3	13.5	9.0	1.4	2.4	4.4	100
Water and rock	9.5	17.3	6.4	1.8	15.3	18.5	4.3	17.5	3.7	5.6	100
Urban	25.8	8.8	17.1	0.9	3.2	10.4	5.1	3.7	22.1	2.8	100
Total	11.4	19.5	6.0	5.6	4.7	14.9	7.0	12.5	6.9	11.4	100

Annex 3: Type of land use by livelihood zone

A: By 18 types of land use categories (sq km)	**Eastern Flood Plains**	**Greenbelt**	**Hills & Mountains**	**Ironstone Plateau**	**Nile-Sobat Rivers**	**Pastoral**	**Western Flood Plains**	**National total**
Rainfed crop	5861	3957	924	1527	2170	181	7426	22046
Irrigated crop	102	5	0	0	4	0	0	111
Rice on floodland	0	0	0	0	0	0	62	62
Fruit crop	0	0	1	0	0	0	0	1
Tree crop, plantation	0	59	1	4	0	0	0	64
Rainfed crop with temporarily flooded land	4	0	20	23	105	0	109	261
Rainfed crop on post flooding land	18	0	19	42	0	4	210	293
Grass with crop	1610	454	136	183	357	147	388	3275
Shrub with crop	39	6	0	0	0	0	0	45
Shrub or tree with crop	1368	4848	1793	3121	841	731	4598	17300
Grass	34136	8071	8327	10144	5092	19529	11583	96882
Shrub	57811	23240	34503	20270	13853	32804	22907	205388
Tree with shrub	16405	31565	9679	86222	7827	8883	17371	177952
Woodland with shrub	420	7901	775	13653	179	104	659	23691
Tree, shrub and other vegetation on flood land	13648	1106	3312	15917	29004	6188	25384	94559
Water	281	157	113	573	1202	215	846	3387
Rock	129	687	42	314	1	16	3	1192
Urban	123	15	85	52	33	4	67	379
B: By 8 aggregated categories (sq km)								
Cropland	5984	4022	966	1595	2278	185	7807	22837
Grass with crop	1610	454	136	183	357	147	388	3275
Shrub with crop	1406	4854	1793	3121	841	731	4598	17344
Grass	34136	8071	8327	10144	5092	19529	11583	96882
Shrub and tree	74636	62706	44956	120144	21858	41792	40937	407029
Tree, shrub and other vegetation on flood land	13648	1106	3312	15917	29004	6188	25384	94559
Water and rock	409	844	154	887	1203	231	849	4577
Urban	123	15	85	52	33	4	67	379
Total	**131953**	**82073**	**59728**	**152042**	**60666**	**68807**	**91613**	**646882**
C:% of total national land by state (18 types of land use categories)								
Rainfed crop	26.6	17.9	4.2	6.9	9.8	0.8	33.7	100
Irrigated crop	92.0	4.8	0.0	0.0	3.2	0.0	0.0	100
Rice on floodland	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100
Fruit crop	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100
Tree crop, plantation	0.0	93.1	1.4	5.5	0.0	0.0	0.0	100
Rainfed crop with temporarily flooded land	1.7	0.0	7.8	8.8	40.1	0.0	41.7	100
Rainfed crop on post flooding land	6.0	0.0	6.7	14.2	0.0	1.2	71.9	100
Grass with crop	49.2	13.9	4.1	5.6	10.9	4.5	11.8	100
Shrub with crop	86.1	13.9	0.0	0.0	0.0	0.0	0.0	100
Shrub or tree with crop	7.9	28.0	10.4	18.0	4.9	4.2	26.6	100
Grass	35.2	8.3	8.6	10.5	5.3	20.2	12.0	100

Shrub	28.1	11.3	16.8	9.9	6.7	16.0	11.2	100
Tree with shrub	9.2	17.7	5.4	48.5	4.4	5.0	9.8	100
Woodland with shrub	1.8	33.4	3.3	57.6	0.8	0.4	2.8	100
Tree, shrub and other vegetation on flood land	14.4	1.2	3.5	16.8	30.7	6.5	26.8	100
Water	8.3	4.6	3.3	16.9	35.5	6.4	25.0	100
Rock	10.8	57.7	3.5	26.4	0.1	1.3	0.2	100
Urban	32.4	4.0	22.5	13.7	8.8	0.9	17.6	100
D: of total national land by state (8 aggregated land use categories)								
Cropland	26.2	17.6	4.2	7.0	10.0	0.8	34.2	100
Grass with crop	49.2	13.9	4.1	5.6	10.9	4.5	11.8	100
Shrub with crop	8.1	28.0	10.3	18.0	4.8	4.2	26.5	100
Grass	35.2	8.3	8.6	10.5	5.3	20.2	12.0	100
Shrub and tree	18.3	15.4	11.0	29.5	5.4	10.3	10.0	100
Tree, shrub and other vegetation on flood land	14.4	1.2	3.5	16.8	30.7	6.5	26.8	100
Water and rock	8.9	18.4	3.4	19.4	26.3	5.1	18.5	100
Urban	32.4	4.0	22.5	13.7	8.8	0.9	17.6	100
Total	**20.4**	**12.7**	**9.2**	**23.5**	**9.4**	**10.6**	**14.2**	**100**

Annex 4: Population density and share of cropland by agricultural potential-population density typologies by state

Population density (person/km^2)	High agricultural potential		Medium agricultural potential		Low agricultural potential		Total
	High/medium population density (Type HH)	Low population density (Type HL)	High/medium population density (Type MH)	Low population density (Type ML)	High/medium population density (Type LH)	Low population density (Type LL)	
Upper Nile	0	0	46	5	65	3	12
Jonglei	48	4	42	7	47	6	11
Unity	0	0	58	5	49	5	15
Warrap	0	0	50	7	51	4	22
N. Bahr el Ghazal	0	0	87	3	42	4	24
W.Bahr el Ghazal	46	1	101	2	25	0	3
Lakes	30	3	59	4	0	0	16
Western Equatoria	68	3	46	3	0	0	8
Central Equatoria	89	5	38	5	0	0	25
Eastern Equatoria	51	5	29	3	19	3	12
National	**66**	**3**	**54**	**4**	**51**	**3**	**13**
Cropland share (%)							
Upper Nile	0.0	0.0	1.3	0.7	7.6	15.1	24.7
Jonglei	0.4	0.4	3.6	3.1	2.9	2.3	12.8
Unity	0.0	0.0	0.8	0.4	1.4	1.4	4.1
Warrap	0.0	0.0	8.8	4.0	1.1	0.2	14.1
N. Bahr el Ghazal	0.0	0.0	3.6	1.1	3.5	0.4	8.6
W.Bahr el Ghazal	0.0	0.0	0.6	1.6	0.0	0.4	2.6
Lakes	0.1	0.1	5.7	2.7	0.0	0.0	8.6
W. Equatoria	5.4	5.4	0.1	0.2	0.0	0.0	11.0
C. Equatoria	7.1	3.8	0.0	0.0	0.0	0.0	10.9
Eastern Equatoria	1.2	1.5	0.0	0.0	0.0	0.0	2.7
National	**14.1**	**11.1**	**24.7**	**13.7**	**16.6**	**19.7**	**100**

Source: Authors' estimates based on NBHS (2009) and LandScan (2009).

Annex 5: Population density and share of cropland by agricultural potential-population density typologies by livelihood zone

	High agricultural potential		Medium agricultural potential		Low agricultural potential		
Population density (person/km²)	High/medium population density	Low population density	High/medium population density	Low population density	High/medium population density	Low population density	Total
Eastern Flood Plains	28	5	38	6	45	3	11
Greenbelt	77	3	20	1	0	0	14
Hills and Mountains	63	4	0	4	0	0	17
Ironstone Plateau	41	3	75	2	25	0	5
Nile-Sobat Rivers	112	8	66	6	85	5	18
Pastoral	59	4	41	5	16	3	6
Western Flood Plains	34	5	59	6	41	5	26
National	66	3	54	4	51	3	13
Cropland share (%)							
Eastern Flood Plains	0.0	0.0	4.1	3.2	8.0	15.8	31.2
Greenbelt	11.2	5.9	0.0	0.0	0.0	0.0	17.1
Hills and Mountains	1.5	2.7	0.0	0.0	0.0	0.0	4.2
Ironstone Plateau	0.8	1.7	1.6	2.5	0.0	0.4	7.0
Nile-Sobat Rivers	0.3	0.2	1.7	1.1	2.8	2.7	8.8
Pastoral	0.2	0.6	0.0	0.1	0.0	0.0	1.0
Western Flood Plains	0.1	0.0	17.2	6.9	5.7	0.9	30.7
National	14.1	11.1	24.7	13.7	16.6	19.7	100.0

Source: Authors' estimates based on NBHS (2009) and LandScan (2009).

Annex 6: Share of food consumption by aggregated items for all households

	Cereals	Roots	Pulse & oil seeds	Other crops	Livestock	Fish	Per HH (US$/yr)	Per capita (US$/yr)
National total	**48.0**	**1.8**	**3.8**	**12.8**	**29.7**	**4.0**	**377**	**58**
Upper Nile	26.7	2.0	6.1	31.3	30.8	3.0	466	61
Jonglei	55.1	0.2	1.5	3.5	38.8	0.9	415	65
Unity	76.7	0.8	1.4	11.6	8.3	1.1	242	31
Warrap	74.7	0.0	6.4	3.7	11.6	3.5	306	43
Northern Bahr el Ghazal	60.3	0.2	2.6	5.6	23.2	8.2	310	50
Western Bahr el Ghazal	24.0	1.2	5.3	17.4	40.3	11.7	255	47
Lakes	68.5	1.2	2.6	4.9	12.9	9.9	344	46
Western Equatoria	34.6	5.5	6.8	16.9	27.8	8.4	331	60
Central Equatoria	35.8	4.6	3.8	21.4	31.8	2.5	439	70
Eastern Equatoria	43.2	0.9	2.1	7.9	44.0	1.9	477	84
Rural total	**51.9**	**1.4**	**3.5**	**9.8**	**29.4**	**4.0**	**341**	**53**
Upper Nile	27.9	1.1	5.6	29.0	32.4	3.9	408	55
Jonglei	55.0	0.2	1.5	3.2	39.2	0.9	405	64
Unity	80.9	0.4	1.3	9.2	7.1	1.2	225	29
Warrap	77.3	0.0	6.3	2.7	10.3	3.5	293	42
Northern Bahr el Ghazal	63.0	0.0	2.5	4.3	21.4	8.8	281	46
Western Bahr el Ghazal	31.6	0.5	2.4	8.3	42.3	14.9	176	34
Lakes	68.0	1.2	2.5	4.5	13.5	10.2	320	43
Western Equatoria	37.0	6.6	7.8	17.0	22.3	9.3	286	53
Central Equatoria	40.7	5.6	3.4	17.5	30.7	2.1	322	53
Eastern Equatoria	43.0	0.6	1.8	6.3	46.9	1.4	469	83
Urban total	**34.7**	**2.9**	**4.9**	**23.0**	**30.6**	**3.9**	**594**	**84**
Upper Nile	23.8	4.1	7.2	36.6	27.2	1.0	694	83
Jonglei	56.1	0.3	1.2	7.2	34.3	1.0	622	82
Unity	50.7	3.7	2.5	26.5	15.9	0.6	446	45
Warrap	54.1	0.2	7.9	11.9	22.1	4.0	454	56
Northern Bahr el Ghazal	44.9	1.1	3.1	13.1	33.3	4.5	731	102
Western Bahr el Ghazal	19.3	1.7	7.1	23.1	39.1	9.7	351	62
Lakes	71.9	0.5	3.0	7.7	8.9	8.0	660	70
Western Equatoria	28.5	2.7	4.3	16.9	41.5	6.1	549	89
Central Equatoria	30.8	3.6	4.2	25.4	33.0	3.0	697	103
Eastern Equatoria	44.7	3.5	4.5	20.3	20.7	6.3	548	89

Source: Authors' estimates based on NBHS (2009).

Annex 7: Type of rural households, with and without cereal consumption

States	Cereal consuming households: Total	Subsistence	Buyers	In-between	Without cereal consuming households: Total	With root/tuber consumption	Without root but with livestock/fish consumption	Without root or livestock/fish consumption
Number of rural households								
Total rural	850897	289542	411699	149656	249221	59881	127004	62337
Upper Nile	72561	16243	50248	6071	38595	2212	35876	507
Jonglei	150249	59141	71806	19303	28951	849	21673	6429
Unity	52553	20513	25873	6168	11074	1110	8892	1072
Warrap	119752	25144	69904	24704	35117	3182	14274	17661
N. Bahr el Ghazal	116450	27422	57996	31033	6137	300	4835	1002
W. Bahr el Ghazal	19838	6312	10785	2741	11931	1203	7855	2873
Lakes	53923	10953	25672	17298	29916	1174	15673	13069
Western Equatoria	62431	34955	17905	9572	33417	28233	2534	2650
Central Equatoria	78549	14207	51357	12985	42453	20656	7316	14481
Eastern Equatoria	124591	74655	30153	19783	11632	962	8076	2594
% of total rural households (total rural households =100)								
Total rural	77.3	26.3	37.4	13.6	22.7	5.4	11.5	5.7
Upper Nile	65.3	14.6	45.2	5.5	34.7	2	32.3	0.5
Jonglei	83.8	33.0	40.1	10.8	16.2	0.5	12.1	3.6
Unity	82.6	32.2	40.7	9.7	17.4	1.7	14	1.7
Warrap	77.3	16.2	45.1	16.0	22.7	2.1	9.2	11.7
N. Bahr el Ghazal	95.0	22.4	47.3	25.3	5.0	0.2	3.9	0.8
W. Bahr el Ghazal	62.4	19.9	33.9	8.6	37.6	3.8	24.7	9.0
Lakes	64.3	13.1	30.6	20.6	35.7	1.4	18.7	15.6
Western Equatoria	65.1	36.5	18.7	10.0	34.9	29.5	2.6	2.8
Central Equatoria	64.9	11.7	42.4	10.7	35.1	17.1	6	12.0
Eastern Equatoria	91.5	54.8	22.1	14.5	8.5	0.7	5.9	1.9
% of different types of households (type of rural households = 100)								
Total rural	100	34.0	48.4	17.6	100	24.0	51.0	25.0
Upper Nile	100	22.4	69.2	8.4	100	5.7	93.0	1.3
Jonglei	100	39.4	47.8	12.8	100	2.9	74.9	22.2
Unity	100	39.0	49.2	11.7	100	10.0	80.3	9.7
Warrap	100	21.0	58.4	20.6	100	9.1	40.6	50.3
N. Bahr el Ghazal	100	23.5	49.8	26.6	100	4.9	78.8	16.3
W. Bahr el Ghazal	100	31.8	54.4	13.8	100	10.1	65.8	24.1
Lakes	100	20.3	47.6	32.1	100	3.9	52.4	43.7
Western Equatoria	100	56.0	28.7	15.3	100	84.5	7.6	7.9
Central Equatoria	100	18.1	65.4	16.5	100	48.7	17.2	34.1
Eastern Equatoria	100	59.9	24.2	15.9	100	8.3	69.4	22.3

Source: Authors' calculation based on NBHS (2009)

Subsistence households are those were more than 90% of cereals consumed are from own produce
Cereal buyers are households were less than 10% of cereals consumed are from own produce
In-between households are those that are neither subsistence nor buyers

Annex 8: Livestock population by state: SSCCSE computed estimates, 2008

	Population (head)				Share in national total (%)			
	Cattle	Goats	Sheep	Total	Cattle	Goats	Sheep	Total
Upper Nile	1,609,631	999,985	1,108,949	3,718,565	4.6	4.9	4.2	4.5
Jonglei	8,487,911	3,430,424	4,016,443	15,934,778	24.1	16.7	15.2	19.4
Unity	1,828,848	872,765	1,031,150	3,732,763	5.2	4.3	3.9	4.5
Warrap	3,065,690	1,377,243	1,977,304	6,420,237	8.7	6.7	7.5	7.8
N. Bahr el Ghazal	894,005	621,693	783,539	2,299,237	2.5	3.0	3.0	2.8
W. Bahr el Ghazal	241,920	82,066	206,902	530,888	0.7	0.4	0.8	0.6
Lakes	1,777,980	530,298	846,906	3,155,184	5.0	2.6	3.2	3.8
Western Equatoria	71,665	50,272	303,772	425,709	0.2	0.2	1.2	0.5
Central Equatoria	1,333,768	757,960	1,406,283	3,498,011	3.8	3.7	5.3	4.3
Eastern Equatoria	15,964,247	11,793,401	14,690,631	42,448,279	45.3	57.5	55.7	51.7
National total	35,275,665	20,516,107	26,371,879	82,163,651				
% of FAO								
Upper Nile	164	227	173	180				
Jonglei	580	284	287	391				
Unity	155	50	69	84				
Warrap	201	101	153	153				
N. Bahr el Ghazal	57	38	61	51				
W. Bahr el Ghazal	19	7	16	15				
Lakes	136	36	69	79				
Western Equatoria	11	4	26	14				
Central Equatoria	152	66	111	106				
Eastern Equatoria	1,797	1,041	1,433	1,394				
National total	301	165	219	227				

Source: Table 2.6 in Musinga *et al*. (2010).

Annex 9: Quantity of crop production by state (tons)

Category	Crop	National	Upper Nile	Jonglei	Unity	Warrap	N. Bahr el Ghazal	W. Bahr el Ghazal	Lakes	Western Equatoria	Central Equatoria	Eastern Equatoria
Cereals	Maize	181292	84787	39194	3424	28622	4676	2216	27098	7252	22009	31314
	Millet	40445	4618	692	10	649	1542	35	2330	9892	817	19861
	Rice	8560	1110	2608	198	116	103	15	1064	1886	912	548
	Sorghum	784391	48729	150892	7261	110558	94794	14001	82353	49353	48200	158249
	Wheat	4653	1475	424	823	743	246	64	127	80	503	169
Roots and Tubers	Cassava	1253367	243	2882	500	1027	0	20453	37765	692223	453829	44445
	Plantain	4994	0	0	0	0	0	0	0	4072	550	373
	Potatoes	4773	1344	143	192	11	121	280	31	0	1725	925
	Sweet potato	10821	2377	321	37	33	116	145	1272	2231	1931	2357
	Yams	334	57	0	0	43	0	0	0	0	0	233
Groundnuts and Pulses	Beans/pulses	11574	1795	908	133	1570	110	482	259	944	4142	1231
	Chick pea	2616	11	31	21	10	0	18	20	30	2475	0
	Groundnuts	40853	393	1281	72	9325	1893	1393	11507	10663	3215	1112
	Lentils	17343	4231	2861	835	2007	1054	770	268	467	1351	3500
Fruits	Apples	264	77	0	6	14	8	8	60	4	118	25
	Avocado	1092	0	14	0	0	0	0	0	0	948	130
	Local banana	6868	2165	50	147	14	8	316	116	1745	1761	545
	Dates	2377	1162	72	350	112	83	115	23	14	89	358
	Mangoes	145276	2018	376	780	700	266	1645	2635	88430	39065	9362
	Oranges	4131	1212	48	10	86	9	66	178	318	1451	752
	Pineapples	5392	236	0	9	0	16	43	55	2396	2306	331
	Papaya	9603	404	939	60	266	0	174	62	3806	3052	839
Vegetables	Cabbages	7042	30	34	0	19	0	0	80	55	3404	3420
	Carrots	122	3	0	0	0	7	0	0	0	102	10
	Cucumber	748	167	0	23	5	1	10	7	8	82	445
	Okra	25205	6637	1739	290	598	705	1061	1848	2031	5893	4403
	Onions	28495	10582	222	1547	482	1290	1480	222	1761	7157	1750
	Pumpkins	6299	474	1889	0	2593	653	0	516	0	113	62
	Tomatoes	4883	1421	20	62	40	131	118	6	157	2161	767
Other high value crops	Cocoa	5	5	0	0	0	0	0	0	0	0	0
	Local coffee and tea	6343	2048	404	244	148	379	161	730	709	1506	15
	Sesame	837	88	29	20	112	37	66	55	75	275	81
	Sugar	7070	1685	549	102	181	0	35	24	308	2412	1775
	Tobacco	1475	759	110	153	85	41	3	19	0	76	230

Source: Authors' estimates based on NBHS (2009).

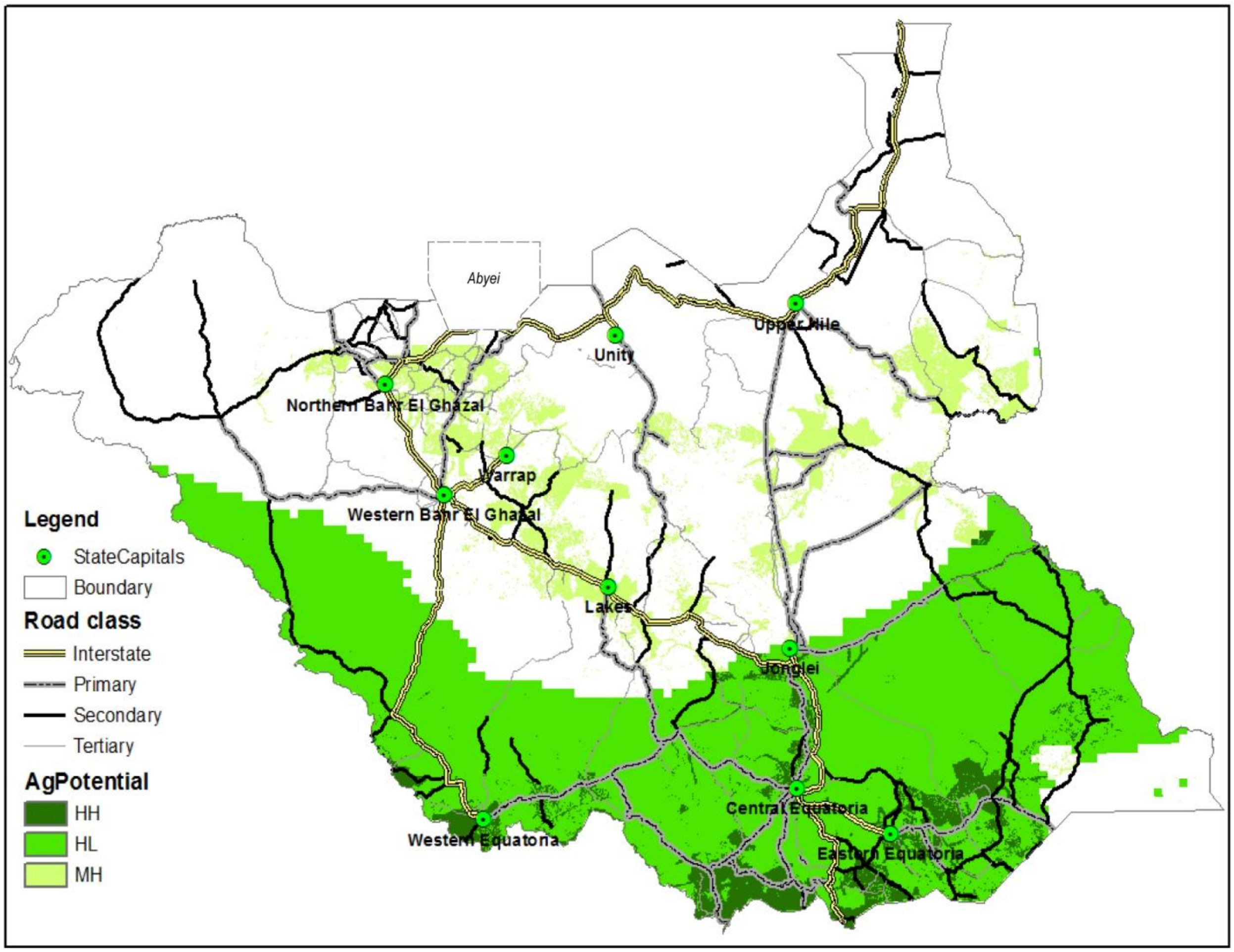
Notes: * Cereal production = consumption from own products + stocks + 55% of rural purchased; other production = consumption from own products + stocks + purchased; ** Cereal flours and cassava flour are converted to corresponding grains and cassava tuber using ratios of 1:1.25 and 1:6, respectively***Grains and roots are further converted from net production to gross production using ratios of 1:1.2 and 1:2, respectively.

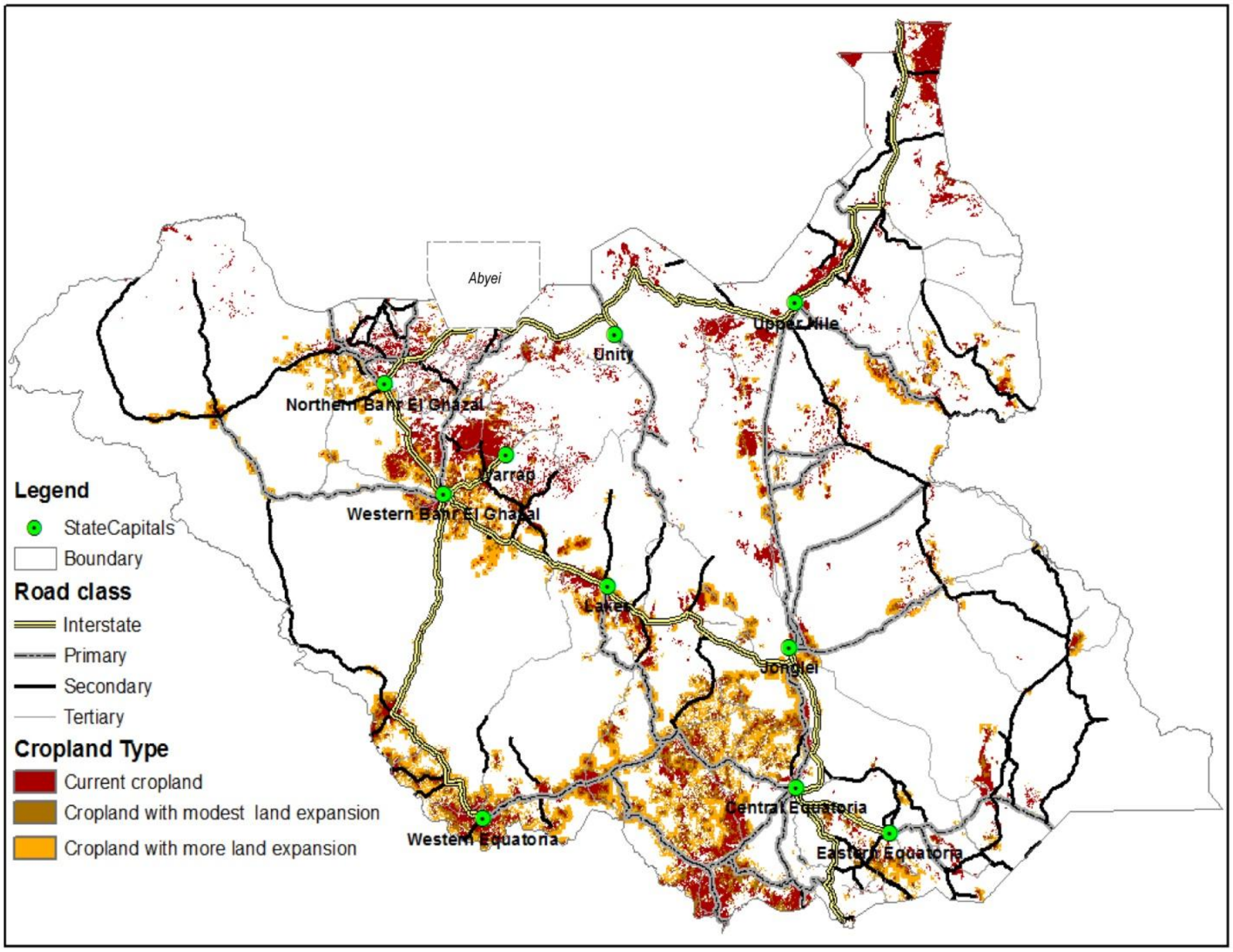
Annex 10: Cropland expansion by livelihood zones and typologies of agricultural potential areas (Scenario 1)

Area (sq km)	Current cropland							Cropland after expansion						
	HH	**HL**	**MH**	**ML**	**LH**	**LL**	**Total**	**HH**	**HL**	**MH**	**ML**	**LH**	**LL**	**Total**
Eastern Flood Plains	0	0	926	712	1,776	3,525	6,940	0	0	1,684	1,494	2,047	4,105	9,330
Greenbelt	3,202	1,665	0	0	0	0	4,867	7,489	8,617	0	0	0	0	16,106
Hills and Mountains	436	792	0	0	0	0	1,228	1,795	3,546	0	0	0	0	5,341
Ironstone Plateau	246	495	472	717	0	111	2,040	1,060	4,563	1,047	4,099	0	121	10,890
Nile-Sobat Rivers	85	51	501	309	836	790	2,572	216	275	812	985	1,061	883	4,232
Pastoral	67	183	4	32	0	0	286	455	680	30	158	0	0	1,323
Western Flood Plains	18	12	4,963	1,988	1,651	245	8,877	84	36	8,277	4,482	2,222	354	15,453
National	**4,053**	**3,198**	**6,865**	**3,759**	**4,263**	**4,671**	**26,809**	**11,098**	**17,717**	**11,850**	**11,218**	**5,329**	**5,462**	**62,674**
Share in national total (%)	**Current cropland**							**Cropland after expansion**						
	HH	**HL**	**MH**	**ML**	**LH**	**LL**	**Total**	**HH**	**HL**	**MH**	**ML**	**LH**	**LL**	**Total**
Eastern Flood Plains	0.0	0.0	3.5	2.7	6.6	13.1	25.9	0.0	0.0	2.7	2.4	3.3	6.5	14.9
Greenbelt	11.9	6.2	0.0	0.0	0.0	0.0	18.2	11.9	13.7	0.0	0.0	0.0	0.0	25.7
Hills and Mountains	1.6	3.0	0.0	0.0	0.0	0.0	4.6	2.9	5.7	0.0	0.0	0.0	0.0	8.5
Ironstone Plateau	0.9	1.8	1.8	2.7	0.0	0.4	7.6	1.7	7.3	1.7	6.5	0.0	0.2	17.4
Nile-Sobat Rivers	0.3	0.2	1.9	1.2	3.1	2.9	9.6	0.3	0.4	1.3	1.6	1.7	1.4	6.8
Pastoral	0.2	0.7	0.0	0.1	0.0	0.0	1.1	0.7	1.1	0.0	0.3	0.0	0.0	2.1
Western Flood Plains	0.1	0.0	18.5	7.4	6.2	0.9	33.1	0.1	0.1	13.2	7.2	3.5	0.6	24.7
National	**15.1**	**11.9**	**25.6**	**14.0**	**15.9**	**17.4**	**100**	**17.7**	**28.3**	**18.9**	**17.9**	**8.5**	**8.7**	**100**

Source: Authors' estimates based on Land Cover Database, FAO (2009).

Annex 11: Agricultural potential zones, areas of potential cropland expansion, and roads




Abyei
Upper Nile
Unity
Northern Bahr El Ghazal
Warrap
Western Bahr El Ghazal
Lakes
Jonglei
Central Equatoria
Eastern Equatoria
Western Equatoria
Legend
StateCapitals
Boundary
Road class
Interstate
Primary
Secondary
Tertiary
Cropland Type
Current cropland
Cropland with modest land expansion
Cropland with more land expansion

Annex 12: Different types of roads across states by agricultural potential (km)

State	Interstate	Other primary	Secondary	Tertiary	Total
Upper Nile					
High potential areas	0	86	172	0	258
Total	506	311	981	0	1,798
Jonglei					
High potential areas	46	553	663	589	1,850
Total	49	1,056	833	589	2,527
Unity					
High potential areas	0	73	14	0	86
Total	326	232	55	0	704
Warrap					
High potential areas	71	129	283	0	482
Total	215	323	559	0	1,096
Northern Bahr el Ghazal					
High potential areas	107	73	125	0	305
Total	130	238	567	0	935
Western Bahr el Ghazal					
High potential areas	155	76	139	0	370
Total	316	364	789	0	1,469
Lakes					
High potential areas	310	70	232	3	614
Total	369	123	357	3	853
Western Equatoria					
High potential areas	317	511	688	538	2,055
Total	335	533	688	538	2,095
Central Equatoria					
High potential areas	312	891	187	561	1,950
Total	312	891	187	561	1,950
Eastern Equatoria					
High potential areas	139	303	1,193	610	2,245
Total	139	312	1,268	610	2,329
Total roads network					
High potential areas	1,456	2,764	3,695	2,303	10,218
Total	2,696	4,475	6,285	2,303	15,759

Source: Authors’ estimates based on LandScan and WFP road maps.

Annex 13: Different types of roads across livelihood zones by agricultural potential (km)

State	Interstate	Other primary	Secondary	Tertiary	Total
Eastern Flood Plains					
High potential areas	20	165	289	258	731
Total	411	647	1,392	258	2,708
Greenbelt					
High potential areas	392	616	1,384	483	2,875
Total	392	616	1,392	483	2,883
Hills and Mountains					
High potential areas	154	499	599	831	2,083
Total	154	509	599	831	2,093
Ironstone Plateau					
High potential areas	161	46	215	433	854
Total	1,027	685	1,341	433	3,485
Nile-Sobat Rivers					
High potential areas	7	50	94	30	182
Total	121	372	475	30	999
Pastoral					
High potential areas	212	642	235	254	1,343
Total	214	840	272	254	1,579
Western Flood Plains					
High potential areas	50	214	174	3	440
Total	289	726	645	3	1,663

Source: Authors' estimates based on LandScan and WFP road maps.

Annex 14: Matrix of distances between states in South Sudan (km)

State	Central Equatoria	Northern Bahr el Ghazal	Unity	Jonglei	Western Bahr el Ghazal	Upper Nile	Lakes	Eastern Equatoria	Warrap	Western Equatoria
City	Juba	Aweil	Bentiu	Bor	Kuajok (Gogrial)	Malakal	Rumbek	Torit	Wau	Yambio
Juba	0	637	923	203	792	2,234	415	133	643	426
Aweil		0	636	994	743	1,947	379	919	153	858
Bentiu			0	706	587	1,313	510	1,050	486	989
Bor				0	946	2,016	618	320	846	629
Kuajok (Gogrial)					0	1,494	330	869	104	809
Malakal						0	1,821	2,362	1,797	2,300
Rumbek							0	544	228	481
Torit								0	770	553
Wau									0	708
Yambio										0

		Central Equatoria	N. Bahr el Ghazal	Unity	Jonglei	W.Bahr el Ghazal	Upper Nile	Lakes	Eastern Equatoria	Warrap	Western Equatoria
Country	**Border City**	Juba	Aweil	Bentiu	Bor	Kuajok	Malakal	Rumbek	Torit	Wau	Yambio
Sudan	Kadugli	1,427	976	343	1,046	523	1,085	850	1,390	827	1,329
Uganda	Nimule	191	991	1,123	388	943	2,433	614	283	842	625

Source: Authors' estimates based on www.google.maps.com.