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Potatoes Value Chain Analysis and Development in River Nile State of Sudan

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ABSTRACT

Now days worldwide increased concern about developing the major food-cash crops production to meet the demand of population growth and farms sustainability. Potato crop is one of the most potential crops in River Nile State that can achieve this purpose. This research aims to describe the potatoes value chain analysis and development. It depends on primary and secondary data. The study applied an approach dependent on compiling theoretical knowledge of value chain analysis basics along with intensive fieldwork and includes comprehensive interviews with a total of 44 producers, 19 wholesalers, 35 retailers, 2 cold storages managers and 34 consumers were interviewed. The actors in the crop chains to present an integrated detailed of all the key actors and players along with the vertical correlations and relations that control the operation and process inside potatoes chains. The field survey in area of the study undertook four major districts along the State specializing in production of potatoes. The value chain analysis showed that, at the level of marketing, there are inadequate cold storages for preserving potatoes, poor extension services at different levels of the crop chain. However, to tackle these constraints, cooperation of stakeholders implying national and international agricultural organizations, governmental institutions and private sector would enhance farming system sustainability of the crop.

KEYWORDS: potatoes, value chain, River Nile State, Sudan

1. INTRODUCTION

Potatoes (*Solanum tuberosum L.*) are tubers that are a staple food in many parts of the world, particularly Europe and the West. Potato is a major vegetable crop and the third most important after wheat and rice in terms of production and consumption worldwide (FAO, 2012). They are commonly categorized according to when they're harvested (early, mid-season and late) as well as their characteristics (whether waxy in appearance, or floury once cooked). All-rounder varieties include King Edward, Maris Piper, Romano and Desirée potatoes, which are suitable for every type of cooking except for salads and steaming. In Sudan potatoes production is a relatively recent agricultural activity, starting in Khartoum and later spreading to other parts of the country. The most potent states of potatoes production might include River Nile, Northern, Kassala and Gezira (Algizouli, 2000). The country witnessed that the majority of the population is living under poverty line. Due to predominant of poverty incident, the major portion of population is unaffordable to purchase and consume quality nutritious food items. Malnutrition and poor health are dominated among people, resulting low productivity of labor force and less development. Accordingly, the crop is considered as one of the most important food and cash crop. It contributes significantly to the daily diet of Sudanese people. Moreover, it plays an important role in sustaining the farming systems through its high returns. Among short duration crops, potatoes farming are considered one of the most feasible ventures. The selection of this state was based on the crop pattern and crop combinations represented by seasonal field crops as well as it large arable acreages endowments that occupied by high number of tenants. The location of the state is about 300 kilometers north Khartoum, the district has chosen rather than whole of the State to restrain time and money. Potatoes in River Nile State depend mainly on surface irrigation from River Nile. The climate there is relatively cool in winter that extends from October to March. The state is enjoyed with alluvial fertile soils, while the environment is rather favorable for producing relatively high-value crops compared to other states of the country. The crop is grown in the state in the winter season, it begins in November and continues into March, it

prevailed along the River Nile banks as well as in the islands existed along the River Nile. Potato crop in the State is commonly produced under irrigated sector from the River Nile. Generally, demand and consumption of potatoes increase during the post-harvest where the crop prices often low with high crop supply resulting demand increase for annual cool storage. Bearing in mind the importance of potatoes in rural economy, the present research was carried out to present a clear mapping and analysis of potatoes sub-sector value chains and development in River Nile State, North Sudan. Specifically it aims to investigate the challenges and the main factors constraining the potatoes value chains from achieving increased yield and full commercialization, also to examine routes for sustainable change in potatoes farming system and that increase market opportunities along the crop value chains, in addition to identify opportunities and advantage points in the potatoes market system for interventions and development.

2. MATEREALS AND METHODES

This research carried-out in the River Nile State (RNS) of North Sudan. The climatic conditions of the State allow the production of a wide range of annual crops. The total area of the River Nile State is estimated at 129.744 km^2 (30 million fed) out of which about 9,500,000 feddan is a categorized as agricultural arable land, while the current invested land is about 1,200,000 feddan and 3,249,000 fed is certified land for agricultural investment and suitable for multi agro-activities and crop production (see Table 2). On the other hand, the State is one of the relatively rich states in the country in water resources. The main direct resources of irrigation water in RNS are the River Nile, Atbara River, underground water and rains as shown in Table 2 (see Figure 1).

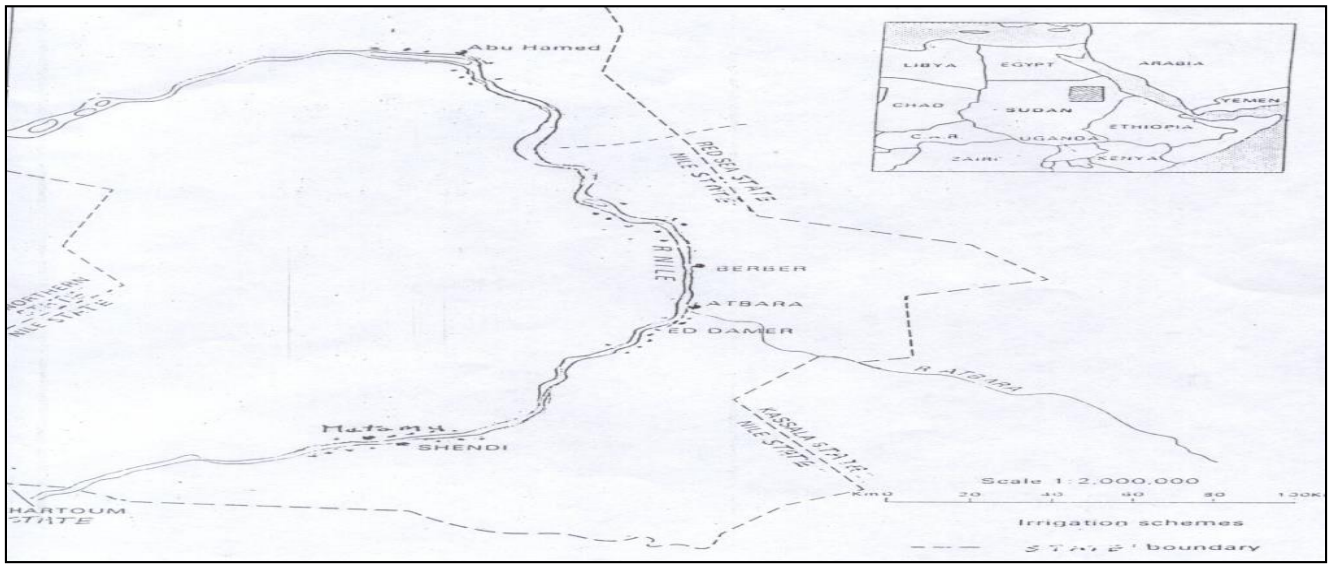


Figure 1. Map of the River Nile State of North Sudan

Source: Ahmed 2004

The primary data collected by using structural questionnaires, it was largely qualitative, using key informant interviews and observations. The primary data covered technical, social and economic aspects of potatoes production in area of the study. While the secondary data and literature review emphasized on an analysis of the market system supporting the core value chain at different levels. FAO (2015) defined these various levels of value chain and the market system that including the micro-level: core value-chain actors as well supporting suppliers of goods and services at production and post-production levels, macro-level: people facilitating polices, laws and regulations governing business in the sector), meta-level: people influencing other people's views about potatoes, and the. This process also helped identify data gaps during the field research, which targeted people growing, trading, processing, wholesaling, retailing and consuming potatoes as well as those providing various services to all these value chain actors.

2.1. Analytical techniques

Qualitative analysis was used, it was chosen because there is little quantitative data about the potatoes marketing in the area of the study. Generally, a set of techniques were applied to achieve the goals of the study. Descriptive statistical analysis and partial

budget analysis were used. In this part of the analysis, graphical, frequency distribution and statistical analysis was applied. This research is based on in-depth respondents conducted in River Nile State in Feb. 2018. The surveyed potatoes growers and actors took place in four localities in the State, namely Shendi, Eddamar, Atbara and Berber. The selection of potatoes actors was based on their involvement and expertise in potatoes production and business.

The applied statistical analysis used the collected data from the field survey and other relevant formal sources. They were found to be relevant to attain the objectives of the study and they enabled interpretation and discussions on the research topics and themes. To achieve the proposed fieldwork, a team of five persons was formed from the State Ministry of Agriculture who use to participate in various researches and similar studies of crop value chains, based on their experiences and backgrounds as agricultural economists and field researchers. The surveyed respondents were contacted first by the team and inform them briefly about the purpose of the study and informed how the research policy recommendation would be used and benefit, and concluded by setting up an interview. The venue for the meetings was often the workplace of the interviewers; this will make the respondents feel comfortable to talk and provide the required information. The surveyed respondent consisted of potatoes growers, wholesalers, retailers, managers of cool storages, and consumers as illustrated in Table 1. All of the respondents were from the area of the study.

Table 1. The actors and respondents of the field survey

Actors	Number of Actors
Potatoes growers	44
cold storages managers	2
Wholesalers	19
Retailers	35
Consumers	34

3. RESULTS AND DISCUSSION

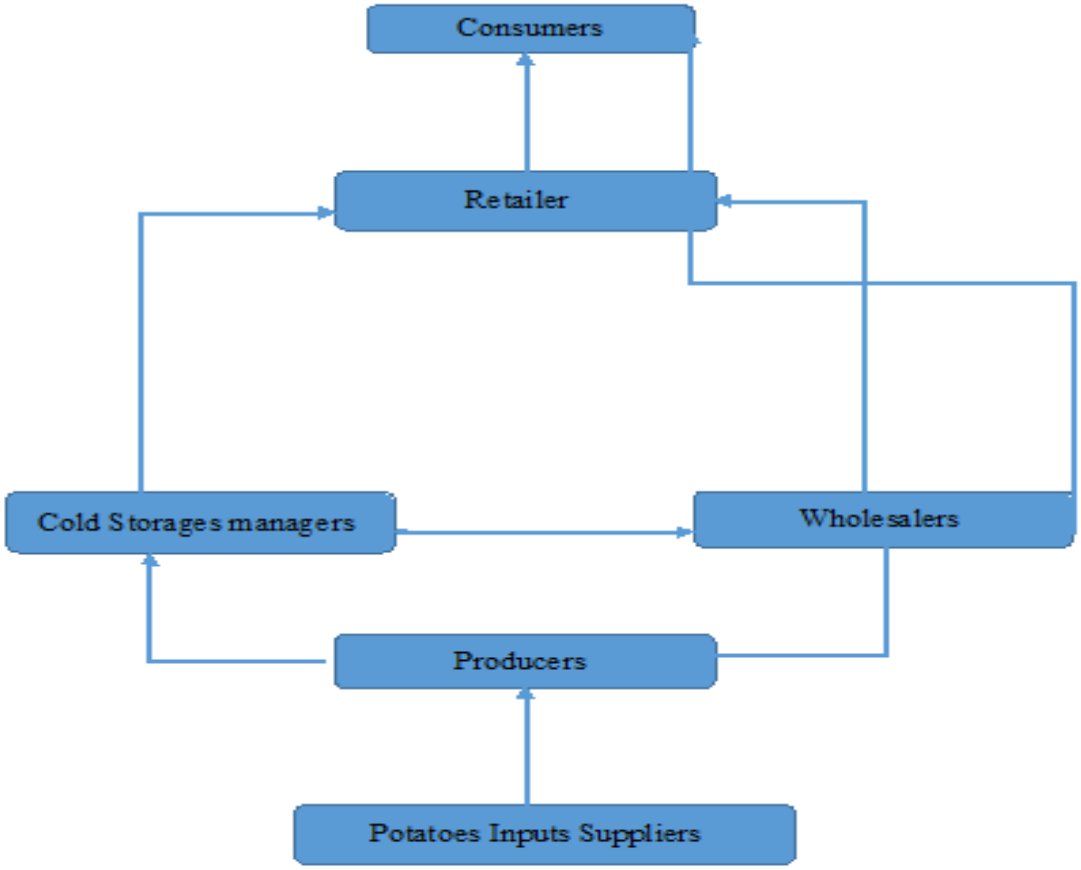
The value chain of potatoes like any value chain of strategic crops, it implies production inputs suppliers and banks and financial institutions. These institutions are represented in the area of the study mainly by the Agricultural Bank of Sudan (ABS), the Ministry of Agriculture and Ministry of Finance. They have continually provided financial and technical support to rural agriculture in these areas such as agricultural credit provision, production inputs, machineries, access to markets, rehabilitation of irrigation sector and others. In spite of this efforts and progress observed in the last decades, the technological gap between private and public sector as well as large-scale and small-scale farmers persists.

The farmers in the agricultural schemes of RNS seek every season to develop their farming system and to adopt new relevant agricultural technologies. They aim to manage a suitable crop rotation that contributes to irrigation water and land use efficiency and soil conservation. In addition, they look to apply advance technologies to manage a reliable crop combination based on legumes crops (i.e. alfalfa, broad bean) and grains (i.e. wheat). The agricultural production in the State faced by some hindrances includes inadequate finance, lack of information and awareness, and poor agricultural policies; they constrain the application of agricultural advance technologies and cause the slow adoption process among public irrigated schemes and small farmers. Bardhan and Udry (1999) reported that, lower adoption rates are generally associated with imperfections in credit markets, information, agro-ecological characteristics, input and output markets as well as inadequate incentives associated with farm tenure arrangements, problems mainly observed in developing countries.

3.1. Potatoes Value chain mapping in River Nile State

The study covers the technical, financial, marketing and processing aspects of potatoes value chain, performance about production aspects, potatoes quality, and gained profits among different actors of potatoes value chain in the State. The State policies are also a fundamental part of the enabling environment of the crop value chain, and from that section a few data was collected about government policies from some annual reports. It is the results of a fieldwork and a documentation review. This research focuses on potatoes value chain analysis, development and mapping of the crop chain, and identifying the production constraints, bottlenecks as well as the opportunities for potential areas of intervention for value chain development that could be addressed in the future. The study provides a complete value chain analysis for potatoes starting from production inputs to the stage of consumption. It also emphasizes and evaluates the different potatoes chains and provides a market analysis of the product flow. The study addressed the value chain mapping of the crop to enables us to visualize the flow of potatoes product from inputs companies (i.e. Seed Company) to end consumers along the different actors of the crop.

Figure 3: Potatoes Value Chain Mapping in River Nile State



Source: Field survey, 2019.

Fig.3 shows the value chain mapping of potatoes in River Nile State. It presents the different actors in the value chain including inputs suppliers, potatoes growers or producers, wholesalers (in rural areas and central cities), cold storage owners, retailers and consumers. From the structure aspect of potatoes value chain, the information enlightens potatoes product differentiation and the dominant vertical coordination. The conduct of the potatoes industry in area of the study was perhaps the absent part to be examined may be due to dominant conventional use, but other information regarding pricing behavior, and actors' performance was gathered.

3.2. Socio-economic characteristics of potatoes VC actors in the State

The study undertook an analysis of some socioeconomic characteristics including mainly locality, occupation, age, education level and experiences for the surveyed potatoes actors. Table 3 and Table 4 represent these characteristics.

Locality: The study revealed that 54.5% of potatoes growers of the crop value chain live in Shandi locality, while Elddamr showed 34.1% and Barbr just 11.4%. But in Table 4 the majority of the wholesalers and retailers live in Atbara and Elddamr (68.4 and 62.9 respectively), 52.9% of the consumers live in Elddamr. Occupation: Table 3 unveiled that 81.8% of the producers mentioned that their basic occupation is agricultural activities and 18.2% of them have additional work. On the other hand, wholesalers and retailers reported that their basic occupation is trade of the potatoes (94.7% and 74.3% respectively).

Table 3. Distributions of producers and cold storage owner according to Socio-economic characteristics

Variable		Producers		Cold storage owner	
Locality	Items	Frequency	Percent	Frequency	Percent
	Shendi	24	54.5	-	-
	Aldamr	15	34.1	1	50.0
	Brbr	5	11.4	1	50.0
	Total	44	100.0	2	100.0
Your Occupation	Yes	36	81.8	2	100.0
	No	8	18.2	-	-
	Total	44	100.0	2	100.0
Age	Less than 20	0	0	-	-
	21 - 30	3	6.8	2	100.0
	31- 40	11	25.0	-	-
	41 - 50	10	22.7	-	-
	51 - 60	12	27.3	-	-
	More than 60	8	18.2	-	-
	Total	44	100.0	2	100.0
Education Level	Khalowa	3	6.8	-	-
	Primary	16	36.4	-	-
	Basic	7	15.9	-	-
	Secondary	18	40.9	-	-
	University	-	-	2	100.0
	Total	44	100.0	2	100.0

Source: field survey, 2020

Table 4. Distributions of wholesalers, retailers and consumers according to Socio-economic characteristics

Variable		Wholesalers		Retailers		Consumers	
Locality	Items	Frequency	%	Frequency	%	Frequency	%
	Abdra	13	68.4	22	62.9	16	47.1
	Aldamr	6	31.6	13	37.1	18	52.9
	Total	19	100.0	35	100.0	34	100.0
Occupation	Yes	18	94.7	26	74.3	-	-
	No	1	5.3	9	25.7	-	-
	Total	19	100.0	35	100.0	-	-
Age	Less than 20	1	5.3	3	8.6	1	2.9
	21 - 30	4	21.1	8	22.9	9	26.5
	31- 40	3	15.8	16	45.7	12	35.3
	41 - 50	5	26.3	5	14.3	9	26.5
	51 - 60	4	21.1	3	8.6	2	5.9
	More than 60	2	10.5	0	0	1	2.9
	Total	19	100.0	35	100.0	34	100
Education Level	Khalow	2	10.5	3	8.6	4	11.8
	Primary	4	21.1	6	17.1	3	8.8
	Basic	6	31.6	12	34.3	1	2.9
	Secondary	4	21.1	9	25.7	3	8.8
	University	3	15.8	5	14.3	19	55.9
	University+	0	0	0	0	4	11.8
	Total	19	100.0	35	100.0	34	100

Source: field survey, 2020

Age: The research unveiled that the majority of producers were under age groups 31 – 40 and 51 – 60 which are the most active group while the others were found as less than 20 and more than 60 represented

less share. In the Table 4 wholesalers were dominant under age groups 41 – 50 and 51 – 60 that is refer to the experiences while the retailers were dominant under age groups 21 – 30 and 31 – 40.

Education level: Table 3 shows that 40.9% of the producers have attended secondary school and 36.4% basic school, it's noticed that only 6.8% were "khalowa" that indicated high awareness of the producers in cultivation potatoes in the State, while Table 4 shows that the majority of wholesalers and retailers were educated.

Experiences: From Table 5 the average experience years for producers, wholesalers and retailers were 12.2, 18.0 and 14.6 years respectively.

3.3. Value chain actors of potatoes in River Nile State

The crop value chain process begins usually by contacting financial institutions in case of looking for agricultural finance otherwise the crop grower will communicates with input suppliers who normally supplying chemical (i.e. pesticides, fertilizers), seedlings, farm tools and equipments and others. Private firms are active in providing chemical inputs and packing material. The value chain of crops might include numerous types of actors beside financial institutions and input suppliers namely producers, traders, retailers, wholesalers, processors and exporters, in this research the main actors are producers, retailers, wholesalers and cold storages owners (see Table 5).

Table 5. Distributions of potatoes actors according to the experiences years

Variable	Experiences of years	
	Mean	SD
Producers	12.22	10.912
Wholesalers	18.00	11.728
Retailers	14.05	9.959
Cold storages owners	6.00	5.656

Source: field survey, 2020

3.4. Traders

The traders play a significant role in the crops value chains, they usually buy from producers on a short-sell basis (i.e. they book the crop around the start of the season and pay cash). They procure the crop and pass the marketable surplus of that crop up to wholesalers, retailers, and processors.

Wholesalers could perform purchase from producers through agents. There are numerous stakeholders working in developing potatoes sub-sector in Sudan. Most of them are considered as private sector and the international organizations also took place in upgrading potatoes sub-sector. The main stakeholders that active in the potatoes sub-sector in the country are Agricultural Research Corporation (ARC) of Central Ministry of Agriculture and Forestry, the Agricultural Development Corporation of Merowe Dam and the Food Research Center of Central Ministry of Agriculture and Forestry. The mentioned stakeholders are carrying out different types of activities comprise processing. Agricultural Research Corporation (ARC) and the Technology Transfer administration of Central Ministry of Agriculture and Forestry provide extension services to producers related to research studies on potatoes seeds and new varieties, potatoes pests and diseases, agro-technical packages, as well as related extension services.

3.5. Producers

Small-, medium- and large-scale privates producers and big companies; tenants in quasi-government schemes; mostly traditional production concentrated along the River Nile banks as well as in eastern, central and western States of the country. Potatoes are grown mainly by vegetables farmers, average allocated area for potatoes is found as 17.43 fed per producer of the State. The most famous areas of producing potatoes in River Nile State were namely, Altragma, Alkityab, Almtama, Alsnahir Alnyha island, Almosiab and Alzidab, while the most common variety grown called Zafera and Bilina and the average yield of potatoes achieved by the crop growers was about 166.43 sack/fed. Table 6 shows some of essential inputs of potatoes including land tenure type, potatoes seeds input, sources of finance, sources of potatoes seeds.

Land tenure type: according to Table 6 that 70.5% of land was rented and 27.3% was owned, while only 2.3% of the land was shared.

Type of potatoes seeds input: The research revealed that the greatest portion of producer's (45.5%) preferred local seeds varieties from market, while about 43.2% of them planted local seeds mixed with imported seeds, and the minority of the producers

(11.4%) planted imported seeds, due to high price of the imported seeds (see Table 6).

Sources of potatoes seeds: From Table 6, about 38.6% of the potatoes producers obtained their seeds from the local and central markets, while 31.8% of them have obtained it from Seeds Companies and a few of them obtained it either from cold storage owners or Agricultural Bank of Sudan (ABS) for 20.5% and 6.8% respectively (see Table 6).

Table 6. Distribution of producers according to type of land, seeds and finance

	Variables	Producers	
Land tenure type	Items	Frequency	Present
	Owner	12	27.3
	Rent	31	70.5
	Share	1	2.3
	Total	44	100.0
Type of Potatoes seeds input	Local	20	45.5
	Imported	5	11.4
	Local & Imported	19	43.2
	Total	44	100.0
Sources of potatoes seeds	From market	17	38.6
	Freezing owner	9	20.5
	Seeds company	14	31.8
	Wholesalers	1	2.3
	Agricultural Bank	3	6.8
	Total	44	100.0
Sources of finance	Self-funding	26	59.1
	Share	10	22.7
	Agricultural company	2	4.5
	Agricultural Bank	4	9.1
	Friends and relative	1	2.3
	Other	1	2.3
	Total	44	100.0

Sources: field survey, 2020

Sources of finance: The study unveiled that 59.1% of the producers under the study were reported as self-finance while 9.1% of them have received finance from the Agricultural Bank of Sudan (ABS) due to complicated procedures at financial institutions in the country.

Type of potatoes fertilization in the State: Figure 4 illustrates some type of the fertilizer to be used by potatoes growers in the State

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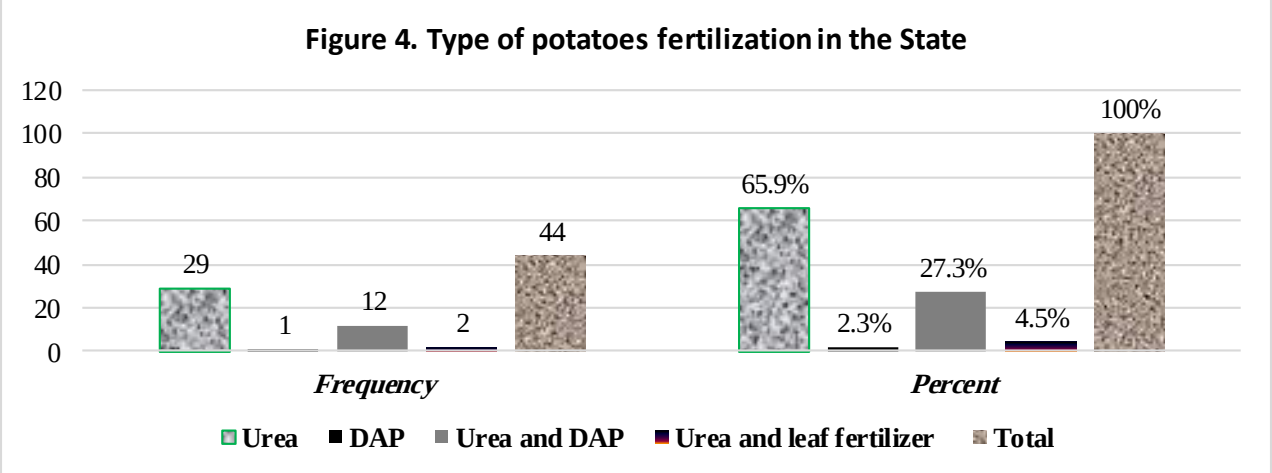


The figure shows that the majority of producers (65.9%) were used Urea while 27.3% of them used Urea mixed with DAP and 4.5% of them used Urea with leaf fertilizer and only 2.3% of them used DAP.

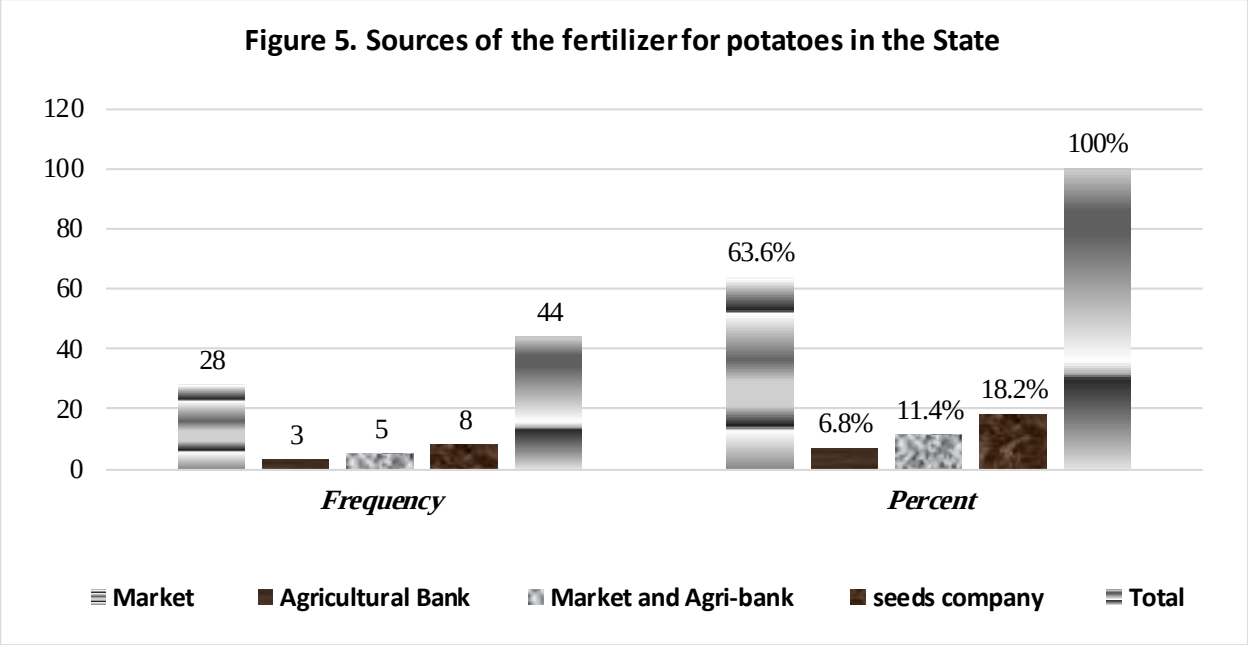
Sources of the fertilizer for potatoes: From the Figure 5 that 63.6% of the potatoes producers obtained fertilizer for potatoes from local and central cities markets, while 18.2% them brought it from seeds companies, and 11.4% from the market with agricultural bank and only 6.8% of them obtained it Agricultural Bank.

On the other side Table 7 depicts the distribution of fertilization for potatoes crop according to quantity and prices (sack/fed) in River Nile State.

Table 7. Distribution of the fertilization of potato according to quantity & prices (sack/fed)

Variable	Fertilization	
	Mean	SD
Quantity (sack)	4.06	1.917
Prices (SDG)	1566.27	289.000

Sources: field survey, 2020



Sources: field survey, 2020

From Table 8 that the highest cost component recorded was for obtained seeds which was accounted for 59.79% of the total costs for one fed, while 10.01% for the fertilizer and 9.22% for the cost of land rents for cultivation of fed of potato.

3.6. Cold storage owners

Table 9 illustrates the distribution of the cold storage ownership according to the type storage ownership and locations of potatoes crop production, in addition it represents the suitable markets that intake the surplus of potatoes as well as sources of crop purchase and showed who sell the crop and who provide finance to potatoes growers to obtain their crops after harvest.

Type of cold storage ownership: For the cold storage ownership in the area of the study, the results show that 100% of the cold storage owned by wholesalers of potatoes in the State. The research revealed locations for production potato crop: it shows that 50% of the cold storage owners from Almhmia and Barbr locality, and 50% of them same percentage from Shendi and Elddamr, while the markets of potatoes in the State were included cold storage owners who obtained potatoes directly from potatoes producers as well as from central markets of the State such as Almhmia, Barbr, Shendi and Elddamr of the State.

Table 8. Costs and returns potatoes production obtained by the producers (SDG/fed)

Revenues and costs	Mean (sack/fed)	(%)	Mean (for one ton)
Revenues:			
Productivity (sack/fed)	166.43		1.00
Prices of potato (SDG/ sack)	600.11		12,000
Return of potato (SDG/fed)	**99,876.30**		12,000
Total of revenues (SDG/fed)	**99,876.30**		**12,000**
Costs:			
Rent	5854.54	9.22	p.
Seeds	37982.81	59.79	p.
Fertilizer	6359.05	10.01	p.
Tilling	1271.48	2.00	p.
Total production cost	**51467.88**		**6185**
Prepare	1131.73	1.78	o.
Cultivation	1757.73	2.77	o.
Weeding	1619.68	2.55	o.
Irrigation	757.73	1.19	o.
Harvesting	3008.95	4.74	o.
Transport	3072.27	4.84	o.
Load	684.20	1.08	o.
Taxes	30.57	0.05	o.
Total operation cost	**12062**		**1450**
Total costs	**63,530.74**		**7,634.529**
(as a proxy for purchase price)			**(**Total costs for one ton)
Net Returns	**36,345.56**		**4,365.471**

Sources: field survey, 2020

Table 9. Distribution of the cold storage ownership according to the type and locations

Variable		Freezing wholesalers	
Type of cold storage ownership	Items	Frequency	Percent
	Owner	2	100.0
	Rent	0	0
	Total	2	100.0
Locations for production potato crop	Almhmia and Brbr	1	50.0
	Shendi and Aldamr	1	50.0
	Total	2	100.0
Markets which is obtained potato in this season.	Almhmia and Brbr markets	1	50.0
	Shendi and Aldamr markets	1	50.0
	Total	2	100.0
Sources of potatoes crop purchase.	Trader	1	50.0
	Other farmers	1	50.0
	Total	2	100.0
For who sell the crop	Wholesalers	2	100.0
	Total	2	100.0
Do you finance the potatoes producers to obtain the crop	Yes	1	50.0
	No	1	50.0
	Total	2	100.0

Source field survey, 2020

The study unveiled that the main sources of potatoes crop to be purchased by cold storage owners in the River Nile State were found that 50% of the cold storage owners purchase the crop from trade in the markets, while 50% of them purchase from other producers. It's clear that there are different sources for purchasing the crop in the area of the study. In addition, the research depicted the main buyers of potatoes were illustrated in Table 9 that 100% of the cold storage owners sell the crop to the potatoes

wholesalers. This means that the cold storage owners deal with the high quantity and big sizes of potatoes marketable surplus. The research also evaluated the impacts of actors finance on potatoes marketing, it showed that 50% of the cold storage owners finance producers under the condition of obtaining the crop after harvest, while 50% of the cold storage owners did not support or provide any finance to the potatoes growers.

Table 10 depicts the distribution of cold storage owners for capacity of their cold storages (sack), and also it shows the withdrawn quantity during a month per sack in River Nile State.

Table 10. Distribution cold storages capacity and withdrawn quantity per month (sack**)**

Variable	**cold storage owners**	
	Mean	SD
Capacity of cold storages (sack)	1250.00	353.553
Withdrawn quantity during a month (sack)	300.00	282.843

Sources: field survey, 2020

Table 11. costs and returns freezes potatoes stored by cold storage owners in RNS

Costs and benefit per unit	Mean (sack/fed)	%	Mean (for one ton)
Revenues			
Average quantity purchased (sack/year)	5500		1.00
Average purchase price (kg=SDG45)- (SDG/sack)	600		12,000
Average quantity sales (per/year)	5500.00		1.00
Average selling price (kg=SDG80)- (SDG/sack)	950		23020
Total of revenues (SDG/year)	**5225000**		**19000**
Costs			
Cost of transport	34000		487.2
Cost of load	2750		120
Cost of rent during period of storage (5000*5)	25,000		109
Cost of electricity (1000*5)	5,000		22
Cost of government fee	2,500		11
Total operation cost	2,500		11
Total operation cost	**71,750**		**260.9**
Cost of purchase	**3,300,000**		**12000**
Total costs	**3,371,750**		**12,625**
Net Returns	**1,853,250**		**6,375**

Sources: field survey, 2020

3.7. Wholesalers

Wholesalers work as intermediaries between farmers/traders and retailers. Wholesalers usually sell in central or town markets, sometimes they sell on an auction basis and the supplier (farmer or trader) and buyer (retailers) pay a particular fee to the wholesaler. The wholesaler is an intermediary who does not sell to the public. In the State the wholesalers buy potatoes crop from the potatoes growers and central markets of the State then sell it to potatoes retailers and cold storage owners and pass the crop to potatoes processors or/and exporter. Most of the wholesalers attend in the crop markets at production areas at post-harvesting periods aiming to know prices of potatoes.

Table 12 illustrates a set of activities concerning potatoes wholesalers' activities in River Nile State including locations of potatoes production, main markets of potatoes in the State, main buyers of potatoes, determination of potatoes prices in the state, mechanism of determination of potatoes prices in the state, Sources of information about market prices, main actors who willing to buy potatoes in the State markets and Determination of potatoes selling prices.

Table 12, also depicts the main locations of potatoes production in the State were found as 63.2% of the production potatoes in Shendi locality, while the other locations namely, Almhmia and Elddamr recorded 21.1% and 15.8% respectively.

Table 12. Shows some activities of potatoes wholesalers in River Nile State

Variable		Wholesalers		Retailers	
Main locations of potatoes production in the State	Items	Frequency	Percent	Frequency	Percent
	Shendi	12	63.2	22	62.9
	Almhmia	4	21.1	2	5.7
	Elddamr	3	15.8	3	8.6
	Atbra	٠	٠	8	22.9
	Total	**19**	**100.0**	**35**	**100.0**
Main markets of potatoes in the River Nile State	Shendi	7	36.8	5	14.3
	Atbra	2	10.5	22	62.9
	Elddamr	5	26.3	5	14.3
	Almhmia	2	10.5	3	8.6
	Omdurman	3	15.8	0	0
	Total	**19**	**100.0**	**35**	**100.0**
Main buyers of potatoes	Farmers	5	26.3	0	0
	cold storage owners	8	42.1	3	8.6
	Other wholesalers	6	31.6	32	91.4
	Total	**19**	**100.0**	**35**	**100.0**
Determination of potatoes prices in the state	Brokers	3	15.8	0	0
	Farmers	7	36.8	0	0
	cold storage owners	9	47.4	0	0
	Other markets	0	0	1	2.9
	Wholesalers	0	0	34	97.1
	Total	**19**	**100.0**	**35**	**100.0**
Mechanism of determination of potatoes prices in the state	According to market price	10	52.6	22	62.9
	Quality and quantity	9	47.4	13	37.1
	Total	19	100.0	35	100.0
Sources of information about market prices	Wholesalers	12	63.2	26	74.3
	cold storage owners	7	36.8	٠	٠
	Brokers	٠	٠	3	8.6
	Retailers	٠	٠	6	17.1
	Total	**19**	**100.0**	**35**	**100.0**
Main actors who willing to buy potatoes in the State	Other wholesalers	2	10.5	4	11.4
	Retailers	17	89.5	٠	٠
	Consumers	٠	٠	31	88.6
	Total	**19**	**100.0**	**35**	**100.0**
Determination of potatoes selling prices	According to market price	11	57.9	18	51.4
	Quality and quantity	8	42.1	17	48.6
	Total	**19**	**100.0**	**35**	**100.0**

Sources: field survey, 2020.

The study evaluated the main markets of potatoes for wholesalers in the River Nile State were Shendi and Elddamr for 36.8% and 26.3% respectively, while the other markets such as Atbra and Almhmia formed only 10.5%. In addition, the research depicted the main buyers of potatoes were cold storages owners, wholesalers and producers buy potatoes by 42.1%, 31.6% and 26.3% respectively. The mentioned actors contribute in determination of potatoes prices in the state specially the cold storages owners who control the prices by 47.4%, while the rest percentages 26.3% and 15.8% were allocated for producers and brokers respectively. Generally, the mechanism of determination of potatoes prices in the state is based on the marketing prices forces by 52.6% and 47.4% formed by quantity and quality of potatoes crop. The study revealed that the main Sources of information about market prices were distributed as 52.6% for wholesalers and 36.8% for cold storages owners and the wholesalers intend to sell potatoes in markets for retailers by 89.5% that means the majority of the sold potatoes go to the retailers, while only

10.5% of them goes to the other wholesalers. Finally, the determination of potatoes selling prices were found 57.9% determined by marketing prices forces and 42.1% according to quantity and quality of potatoes.

Table 13. Distribution of costs and returns for potatoes wholesalers in River Nile State

Costs and benefit per unit	Mean (sack/fed)	%	Mean (for one ton)
Revenues			
Average quantity purchased (sack/day)	42.36		1.00
Average purchase price (SDG/ sack)	950		19,000
Average quantity sold (sack/per a day)	34.94		1.747
Average selling price (SDG/ sack)	1144.73		22,894.6
Total of revenues (SDG/day)	**48490.76**		**22,894.6**
Costs			
Cost of transport	26.32		
Cost of load	6.42		
Cost of trade insurance	591.26		
Cost of health insurance	151.58		
Cost of health card	32.11		
Cost of rubbish fee	13.21		
Cost of Zakat	22.21		
Total market costs	**843.11**		**398.06**
Purchase cost	40242		**19000**
Total costs	**41085.11**		**19,398.06**
Net Returns	**7,405.65**		**3,496.54**

Sources: field survey, 2020

3.8. Retailers

Various, ranged from simple small shop and street retailers in village and town markets to modern shops in big towns. Source supplies from wholesalers or directly from production areas in case of some modern retailers. Potatoes retailers are considered as essential actors in potatoes markets of the State. They mainly receive the crops from the crop wholesalers in the central markets of the State namely, Shendi, Atbra, Elddamr and Almhmia, and the next chain for retailer is always the consumers who usually by the crop in a Kilogram unit. The study unveiled numerous results with concern to retailers' activities similar to that of potatoes wholesalers' activities in River Nile State consisting locations of potatoes production, main markets of potatoes in the State, main buyers of potatoes, determination of potatoes prices in the state, mechanism of determination of potatoes prices in the state, Sources of information about market prices, main actors who willing to buy potatoes in the State markets and Determination of potatoes selling prices.

The research revealed that the main locations of potatoes production in the State were found as 62.9% of the production potatoes in Shendi locality, while 22.9%, 8.6% and 5.7% formed by Atbra, Elddamr and Almhmia respectively. The study evaluated the main markets for retailers where they buy the crop in the River Nile State were Atbara central market by 63% and 18.5% recorded for Shendi and Elddamr for each one. In addition, the research depicted the main buyers of potatoes were wholesalers and cold storages owners buy potatoes by 91.4% and 8.6% respectively. The mentioned actors contribute in determination of potatoes prices in the state specially the wholesalers who control the prices for retailers by 97.1%, while only 2.9% percentages were allocated for retailers. This indicates that the retailers depend on wholesalers to determine potatoes prices in the State markets. Generally, the mechanism of determination of potatoes prices in the state according to retailers' response is based on the marketing prices forces by 62.9% and 37.1% formed by quantity and quality of potatoes crop. The study revealed that the main Sources of information about market prices were distributed as 74.3% for wholesalers, while 17.1% and 8.6%% allocated for retailers and brokers respectively. The study found that the retailers intend to sell potatoes in markets mainly for consumers by about 88.6%, while 11.4% of them go to the other wholesalers. Finally, the determination of potatoes selling prices according to the retailers reports were found as 51.4% determined by marketing prices forces and 48.6% according to quantity and quality of potatoes. This confirms that the marketing preference of actors in potatoes markets in the State is predominant.

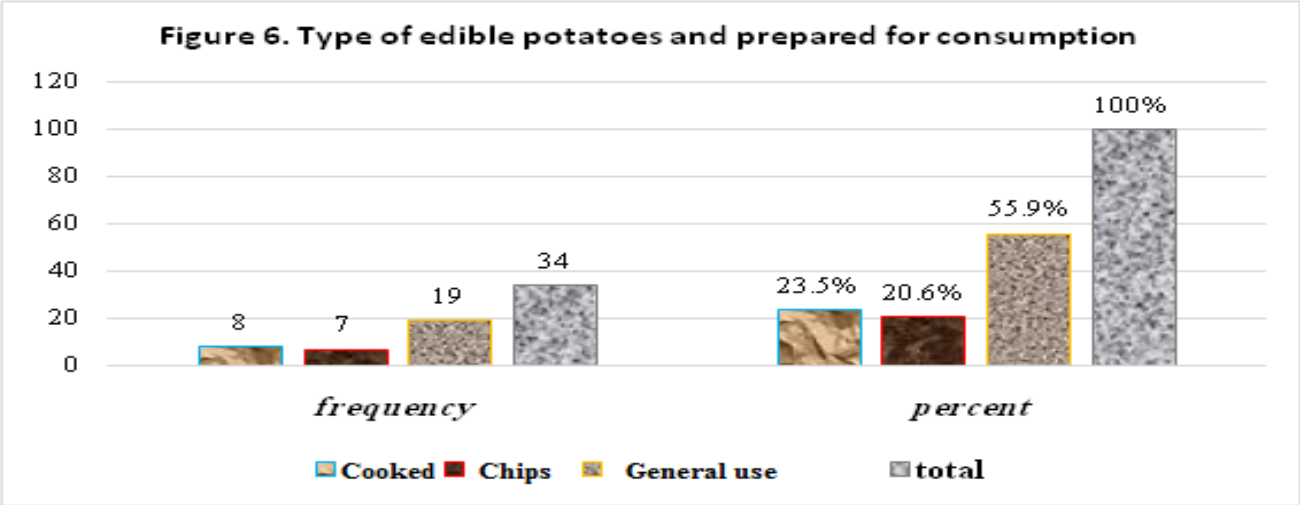
Table 14. Costs and returns for potatoes activities by the retailers in River Nile State

Costs and benefit per unit	Mean (sack)	%	Mean (for one ton)
Revenues			
Average quantity purchased (sack/day)	2.65		1.00
Average purchase price (SDG/sack)	1151.42		23,028.4
Average quantity sold (sack/year)	39.48		1.974
Average selling price (SDG/sack)	1,528.5		30,570
Total of revenues (SDG/day)	**60,345.18**		**30,570**
Costs			
Cost of transport	885.61		
Cost of load	336.19		
Cost of transfer for other market	259.48		
Cost of load for other market	81.23		
Total market costs	**1562.51**		**791.5**
Purchase price	1151.42		
Purchase cost	45,458		
Total costs	**47,020.51**		**23,819.91**
Net Return	**13,324.67**		**6,750.09**

Sources: field survey, 2020

3.9. Consumers of potatoes

Despite this humble tuber's popularity, shoppers have generally been offered very little choice about what types of potato to choose from. Supermarkets and some farmers' markets are increasing their range of old and new potato varieties, with myriad tastes and textures. Whichever you buy, they should be firm and well-shaped with no eyes or green patches. The British tend to prefer white-fleshed tatties, whereas the Dutch and Spanish like yellow-fleshed potatoes, but color makes little difference to the taste. Once cooked the texture of potatoes can range from smooth, waxy-textured flesh perfect for salads to floury-textured flesh ideal for fluffy mashed potato, so it's important to know what type of potato you've bought before you decide how to cook them. Consumers of potatoes mainly use potatoes for fast food or to be prepared as the chips and boiled for the kids. The study results appear that the majority of the consumers purchase potatoes from retailers in local markets. The research also considered the important of the potatoes for you as the house keeper, it shows that 73.5% of the consumers prefer prepared potatoes as fast food, while 26.5% of them reported potatoes crop important for starch benefits for the children. In other words and based on consumers responds, the most preferred type of cooked potatoes, the study revealed that 55.9% of the consumers preferred to use the crop for different kind of food, while 23.5% as boiled potatoes and 20.6% preferred potatoes chips as shown in figure 6.



Sources: field survey, 2020

The research has considered the frequencies of potatoes consumption, it unveiled that 88.2% of the consumers purchase potatoes every week, while only, 5.9% of the consumers purchase potatoes every day and the percentage (5.9%) every two week indicating that the demand for potatoes high and increasing. The study also aimed to identify the relevant markets for consumers, it revealed that 67.5% of consumers purchase potato usually from retailers in the local markets, and17.6% of them purchase potato from retailers in the central markets of the State, this mean consumers usually require small amount of the crop just mainly for household consumptions, while consumers look to buy potatoes from a particular actors where 70.6% of the consumers prefer to purchase potatoes from retailers in the local markets, while 20.6% of them prefer to purchase from retailers in central markets, and only 8.8% of the consumes prefer to purchase potato from shops cross the road. The potatoes consumers justify their selection of the mentioned markets due to some reasons, that 50.0% of the consumers prefer to purchase potatoes for its good quality, while 41.2% of the consumers prefer to purchase potatoes for its cheap price, and only 8.8% of the consumers prefer to purchase potatoes for its near place. The study also found that the consumers look for good quality of potatoes with a certain criteria. It reported that 67.6% of the consumers preferred potatoes based on the form and volume; while 26.5% of the consumers purchase potato according to the variety or type, and there are only 5.9% choose potato for purchase according to the price. The consumers usually prefer fresh potatoes for consumption. The results shows that 73.5% of the consumers don't used cold storages or freezer for saving their potatoes, while 26.5% of the consumers like to use cold storage or freezer for saving potatoes for a long time.

Table 15. Distribution of the consumers according to potatoes criteria, actors and markets

Variables		Consumers	
The frequencies of potatoes consumption	Items	Frequency	Present
	Daily	2	5.9
	Weekly	30	88.2
	Every two week	2	5.9
	Total	34	100.0
Identification of relevant sources and markets for consumers	Retailers in the central markets	6	17.6
	Retailers in the local markets	26	76.5
	Shops cross the road	2	5.9
	Total	34	100.0
Consumers look to buy potatoes from a particular actors	Retailers in the central markets	7	20.6
	Retailers in the local markets	24	70.6
	Shops cross the road	3	8.8
	Total	34	100.0
Potatoes consumers justify reasons of selection of the mentioned markets	Cheap prices	14	41.2
	Good quality	17	50.0
	Near place	3	8.8
	Total	34	100.0
Consumers prefer good quality of potatoes with basic criteria	Form and volume	23	67.6
	Variety or type	9	26.5
	Price	2	5.9
	Total	34	100.0

Sources: field survey, 2020

Table 16 illustrates the distribution of consumers according to purchased quantities (kg) and prices (SDG), and also it shows the withdrawn quantity during a month per sack in River Nile State.

Table 16. Distribution of potatoes consumers according to purchased quantities and prices

Variable	Consumers	
	Mean	SD
Quantity (kg)	1.47	.873
Prices (SDG)	32.64	8.637

Sources: field survey, 2020

Table 17 summarizes and represents gross profit margins (GPM) and gross marketing margins (GMM). The GPM is known as the percentage of revenue that is actual profit before adjusting for operating costs, such as marketing, overhead, and salaries. The two factors that determine gross profit margin are revenue and cost of goods sold (COGS). COGS is what it directly costs the company to make a product, while the gross marketing margins (GMM) is defined as the percentage of revenue that is actual profit before adjusting for operating costs, such as marketing, overhead, and salaries. The two factors that determine gross profit margin are revenue and cost of goods sold (COGS). COGS is what it directly costs the company to make a product. Also the table shows the average purchase prices, selling prices, costs, revenues, and profits for each stage of potatoes production as well as marketing stages among potatoes value chain in the River Nile State.

Table 17. Profits and marketing margins of one ton of potatoes for different actors

Items	Value (SDG/ton)
Producers:	
Purchase price of potatoes	7634.53
Production expenses	1450
Selling price of potatoes	12000
Gross marketing margin (GMM)	4365.47
Gross profit margin (GPM)	4365.471
Cold storage owner:	
Purchase price of potatoes	12000
Operation expenses	260.9
Selling price of potatoes	19000
Gross marketing margin (GMM)	7000
Gross profit margin (GPM)	6375
Wholesalers:	
Purchase price of potatoes	19000
Marketing expenses	398.06
Selling price of potatoes	22894.6
Gross marketing margin (GMM)	3894.6
Gross profit margin (GPM)	3496.54
Retailers:	
Purchase price of potatoes	23028.4
Marketing expenses	791.5
Selling price of potatoes	30570
Gross marketing margin (GMM)	7541.6
Gross profit margin (GPM)	6750.09

Source: Field survey, 2020

From the table it was noticed that the retailers achieved the highest gross marketing margin (GMM) and gross profit margin (GPM) as SDG 7541.6 and SDG 6750.09 respectively, ranked by cold storage owner for one ton potatoes marketing, while the wholesalers were formed the lowest percentages. On the other hand, the producers recorded the highest cost of production for the crop appeared as SDG 1450 compared to potatoes actors of the crop value chain. Figure 7 also illustrates the percentages share of potatoes basic actors among the crop value chain in River Nile State.

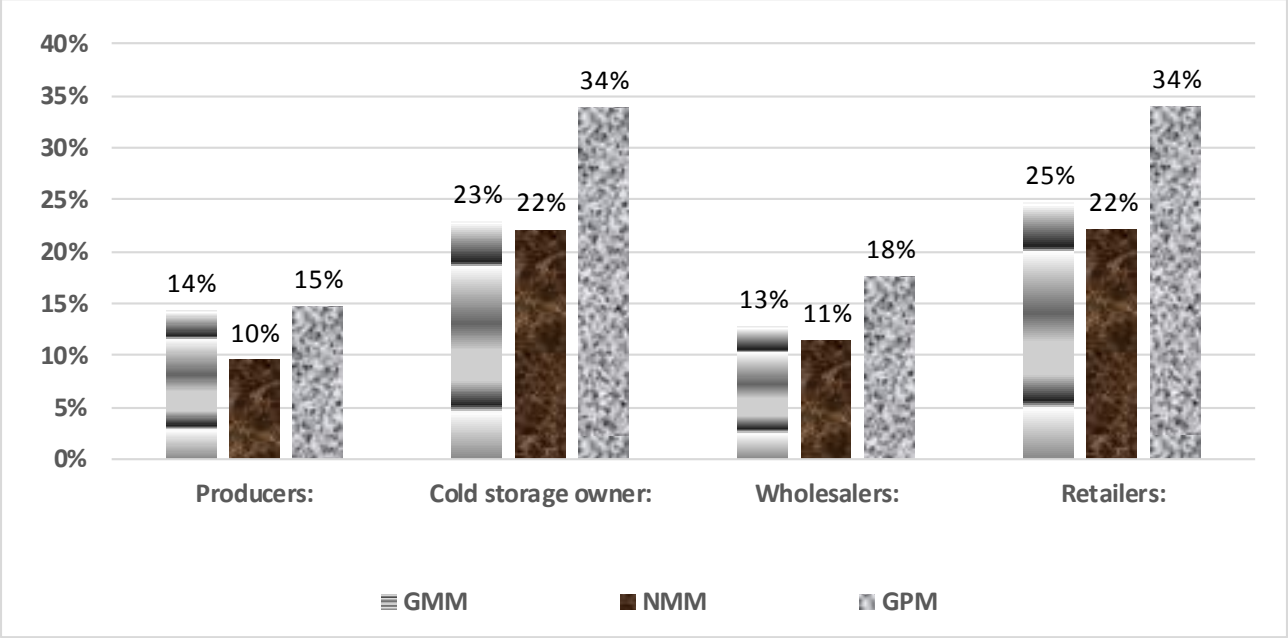


Figure 7. Percentage share of basic actors in potatoes value chain in the State

Source: Field survey, 2020

Table 18 depicts the marketing share and profit margin for potatoes different actors of the crop chain. The author used Excel computer software program to assess the share of gross profit margins (GPM) and gross marketing margin (GMM) for different actors of potatoes value chain per ton, in River Nile State. It's clear that share of benefit is the key factor to create a powerful relationship among the crop actors. The research revealed that the potatoes retailers added the highest share of marketing and profit margin (33%, 32%) to total value, while the share of the other actors were found as (31%, 30%), (19%, 21%), and (17%, 17%) for cold storage owner, producers and wholesalers respectively. The crop retailers gained the highest portion of benefits because they usually purchase the crop directly from potatoes producers as well as from cold storage owners this reason contributes significantly in lowering the expenses and also lead to avoid the other crop brokers. This study also proves that the contribution of the Marketing Efficiency Rate (MER) was high and recorded 75%, while the producer share (PS) was recorded 25%.

Table 18. Share of gross profit margins (GPM) and gross marketing margin (GMM) for different actors of potatoes value chain per ton, in River Nile State.

Items	Producers	Cold storage owners	Wholesalers	Retailers	Total
GMM	4365.47	7000	3894.6	7541.6	22801.67
share of GMM%	19	31	17	33	100
GPM	4365.471	6375	3496.54	6750.09	20987.101
share of GPM%	21	30	17	32	100
TGMM					22801.67
TGPM					20987.101
OE	1450	260.9	398.06	791.5	2900.46
PS			25%		
MER			75%		

Source: Field survey, 2020

4. Conclusion and policy implication

Successful or failure of agricultural sector are related to government policies, thus the most of the root causes to the constraints of the potatoes sub-sectors is related to the State policies which have not expressed a clear agriculture strategy especially for rural areas like north Sudan region. Other hindrances are concerned to certain key actor such as traders and wholesalers in potatoes value chain, who control the whole process along the crop chain by financing the crop growers for all their input materials. In addition, a few constraints are also related to the farmers'

culture that resists application of modern technologies as well as new ideas. Numerous points obtained at the conclusion and policy implication part as follow:

1. Potatoes producers should develop awareness:
   a. Cultural practices suitable to different agro-ecological zones, irrigation supply, pesticides and fertilizers use, and importance of crop rotation.
   b. Appropriate management practices for the control of major pest and diseases in the existing groves and for the protection of new ones.
   c. Provision of facilities for training technician, extension agents and growers' proper pre-and harvest technologies for potatoes production and marketing. Interventions concerning the crop growers should aim to raise their awareness how to think as if as small entrepreneur
   d. Promotion of techniques for the post-harvest handling, processing and making of potatoes and for utilization of by-products.
   e. Identification of superior varieties with emphasis on adoption to non-conventional growing areas and high quality varieties for local consumption as well as exportation.
   f. Encouragement of expansion of potatoes growing at potential areas in the State and by supplying the private sector with suitable planting material and recommendations on appropriate cultural practices.
   g. Importance of working to gather in small groups or cooperative associations in order to reduce share and minimize costs of production (using proper methods of calculating production costs and keeping records and other basic business management), distribution and marketing, protect each other from marketing instability through share of experiences and strengthen the bargaining power within the chain.
   h. Different available options regarding access and process to agricultural finance.
2. Potatoes retailers, wholesalers, and cold storage owners should develop awareness:
   a. Distribution and transportation of the crop, marketing and exhibiting at trade fairs.
   b. The potential of investing in storage facilities of potatoes (cold storages and cold trucks)
   c. For fair trade and ethical trading principles.
   d. Correct and feasible selection for new markets.
   e. Global standards of international trade and methods of adopting them, and
   f. Fair trade and ethical trading principles.
3. Governmental institutions should:
   a. Play a role in providing financial support to the crop growers to gradually break the tight grip of traders and wholesalers over the whole value chain.
   b. Encourage greater facilitation by financial institutions for businesses to access finance and micro credit.
   c. Enforce implementation of an agriculture calendar maximize production, reduce risk, and competitiveness is increased through forming a steering committee with core members who are active key players from the whole value chain.
   d. Establishment of a training centre for specialized crops.
   e. Institutional and human capacity building. To learn them step by step about the way of how to increase the crop yield of their farmland per unit area.
   f. Improvement of techniques for genetics, breeding and propagation (i.e. Potatoes breeding research is required for evolving new varieties which give high yield and should have resistant against disease and pest attacks). The main service provider for this part in Sudan is Agricultural Research Corporation (ARC), the flowing part is concerning with this important institution in the country.

Potatoes research in Sudan is managed mainly by Agricultural Research Corporation (ARC), it addresses a number of issues anticipated to develop the crop sub-sector, and these issues are as follow:

1) Sustainable potatoes production techniques, potential cropping systems and appropriate plant genetic resources explored, identified and conserved in various regions of Sudan in accordance with the comparative advantage and food security requirements.
2) Strengthened national capacity in protection and prevention of potatoes pests and diseases; and

3) Developed potatoes' agricultural research processes, systems and programs.

The key expected results will be achieved through several interventions as follows:

a) Assess and evaluate the present situation of potatoes diversity and production.
b) Review the agro-climatic data of the areas and agricultural resources availability for sustainability of potatoes cultivation.
c) Review and assess the current potatoes research strategies and propose key interventions to enhance development of efficient agricultural practices techniques.
d) Explore the potential areas for cultivation of potatoes in River Nile State and hence at the macro levels.
e) Assess the local potatoes selections and develop standard protocol for identification and regional comparative advantage.
f) Identify key technical production constraints to be overcome.
g) Identify harvest, post-harvest and marketing constraints and develop improved techniques and channels.
h) Identify needs of international technical assistance to support the development of potatoes industry.
i) Assess the local technical support capacity for potatoes development and identify the necessary components of a comprehensive training program aims at providing the technical staff and the stakeholders with the required knowledge.
j) Identify the investments in terms of manpower, equipment, internal and external training that would be required to overcome the technical constraints faced by the relevant regions as related to development of the potatoes industry.

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الملخص العربي

تحليل وتطوير سلسلة القيمة لمحصول البطاطس بولاية نهر النيل في السودان

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مركز البحوث الاقتصادية والسياسات الزراعية ،هيئة البحوث الزراعية – السودان

حاليا وفي جميع أنحاء العالم، يتزايد القلق بشأن تطوير إنتاج المحاصيل الغذائية والنقدية الرئيسية لتلبية الطلب على النمو السكاني وتحقيق استدامة النظام المزرعى. يعتبر محصول البطاطس من أكثر المحاصيل التى يمكن التوسع فيها بولاية نهر النيل والتي يمكن أن تحقق هذا الغرض. يهدف هذا البحث إلى وصف وتحليل وتطوير سلسلة القيمة لمحصول البطاطس. اعتمد البحث على البيانات الأولية والثانوية. طبقت الدراسة نهجًا يعتمد على تجميع المعرفة النظرية لأساسيات تحليل سلسلة القيمة جنبًا إلى جنب مع العمل الميداني المكثف، وتضمن مقابلات مختلفة شملت ٤٤ منتجًا للبطاطس و١٩ تاجر جملة و٣٥ تاجر تجزئة واثنين من مديري المخازن المبرده و ٣٤ مستهلكًا. تقدم العناصر الفاعلة في سلاسل المحاصيل عرضًا تفصيليًا متكاملًا لجميع الجهات الفاعلة والمشاركين واصحاب المصلحة الرئيسيين جنبًا إلى جنب مع الارتباطات والعلاقات الرأسية التي تتحكم في العملية والعملية داخل سلاسل البطاطس. تم تنفيذ المسح الميداني في منطقة الدراسة وفي أربع مناطق رئيسية على امتداد الولاية وهى متخصصة في إنتاج البطاطس. أظهر تحليل سلسلة القيمة أنه على مستوى التسويق، ان المخازن المبرده بالولاية غير كافية لحفظ البطاطس، وان الخدمات الإرشادية ضعيفة على المستويات المختلفة من سلسلة المحاصيل. ومع ذلك، ولمعالجة هذه القيود، فإن تعاون أصحاب المصلحة مما يعني ضمناً المنظمات الزراعية الوطنية والدولية والمؤسسات الحكومية والقطاع الخاص من شأنه أن يعزز استدامة نظام الزراعة للمحصول.

الكلمات المفتاحية: البطاطس ، سلسلة القيمة ، ولاية نهر النيل ، السودان