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THE IMPACT OF FINANCE AND FUNDING ON TECHNOLOGY ADOPTION IN AFRICA

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Although Sudan is a predominately agricultural economy, crop productivity is extremely low and does not exceed 30% of the level attained in research farms. Even though most farmers acknowledge the great benefits of technologies provided by research and academic institutions, they argue that most of these technologies are very expensive to adopt, and there is no source of funds to adopt them even if they were not expensive in the first place. Therefore, the aim of this paper is to address the impact of finance and funding on the adoption of agricultural technologies in the Sudan. This paper attempts to demonstrate how limitations of finance and funding could explain the failure of Sudanese farmers to adopt the available technology and raise productivity. Finally, a number of findings emerge regarding the government policies and strategic planning that will effectively help and support small farmers. These findings may help policy makers take appropriate and immediate measures to improve agricultural productivity in the Sudan.

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I. Introduction

The process of agricultural technology and growth has remained outside the concern of most development economists (Hayami and Ruttan 1985). For Schultz, the critical factor in raising productivity is “technical change” and the role of the government is to promote it (Schultz 1964). Schultz’s policy prescription was for government to invest in agricultural research stations and provide agricultural extension services. Schultz argues that the process of agricultural development can be accelerated through provision of new and improved inputs and technologies (particularly improved seeds, fertilizers, pesticides and irrigation systems). What farmers need are new high-payoff inputs and technologies to increase their productivity. Negatu and Parikh (1999) examine the conventional (traditional) factors which influence farmers’ adoption decision and identify the following as key factors: resource endowments (as the availability of funding greatly influences the transfer of technology), socio-economic status, demographic characteristics and access to institutional services such as extension, input supply and markets. Studies on the effect of these conventional factors on adoption are extensive and numerous (see Ahmed 2003 and 2004; Feder and Zilberman 1985; Feder and Umali 1993). Therefore, the purpose of farmer participation in agricultural technology development is to involve small farmers as active decision-makers in the development and transfer of new technology. The result is they get the technology they want and are able to adopt. Bureaucratic public sector agricultural research systems consistently fail to serve the majority of small farmers effectively—especially in African countries. If agricultural technologies can be improved, additional resources mobilized and appropriate policies adopted in most African countries, then faster agricultural growth will be achieved. Economic

development, particularly of the poorer countries like Sudan, will speed up and poverty will be reduced. Therefore, the main objective of this paper is to examine the determinants of technology adoption among Sudanese farmers with emphasis and focus on the impact of finance and funding.

While technology transfer typically “refers to the development of a technology in one setting which is then transferred for use in another setting” (Markert 1993), technology diffusion is used to describe the “spreading” or use of a technology within a society, organization, or group of individuals (Rogers 1995). Technology transfer tends to focus on the producer of the technology while much of the focus of diffusion relates to the end user of the technology. Viewed from the holistic perspective of technology development and utilization, these two areas are closely interrelated and must be considered together. Therefore, in this paper, the term technology transfer will be defined to include both the movement of technology from the research and/or academic institutions (site of origin) to the farmers (site of use) and the issues concerning the ultimate acceptance and use of the technology by the farmers.

II. Sudan

With an area of 2.5 million square kilometers, Sudan is the largest country in Africa and 9th largest in the world, and contains the longest river in the world. Sudan has boasted the largest farm in the world in the Gezira irrigated cotton scheme and the world’s largest sugar-producing complex in the Kenana project (Yousif 1997). It was also until recently the biggest producer of gum arabic in the world (Food Matters Worldwide 1991). Sudan was optimistically referred to as an “awakening giant” by the hype merchants

of the 1970s, and its vast plains were seen by development experts as a potential “bread-basket”—either for Africa or for the Arab world across the Red Sea (O’Brian 1981). According to the IMF, Sudan’s real GDP increased by 4.4% and 4.5% in 1995 and 1996 respectively and as of 2003, the GDP per capita is \$1,878 (IMF 1999; Salopek 2003). In the international wealth scale, measured by gross national product (GNP), Sudan held place 115 at the beginning of the 1990s and according to the Human Development Index,¹ Sudan has been ranked even lower, at position 145 among 160 countries covered by UNDP (Grawert, 1998; UNDP, 1992). Economic development indicators describe Sudan as a country in which the majority of people depend on agriculture, with a low degree of industrialization, a disproportionately large and costly public sector, a high rate of consumer price inflation and a state budget hit by soaring foreign debt and immense war expenditure.

Agriculture employs 80% of the Sudan’s labor force and the industry contributes about 42% of the country’s GDP. It is the largest of all sectors, representing over 90% of the exports and foreign cash earnings. Moreover, it produces over 90% of the national food requirements (IMF 1999; Salopek 2003; The Europa World 1998). Therefore, productivity and efficiency of the agricultural sector are central to any program of economic recovery. According to the recent FAO Crop Assessment Mission to Sudan (FAO 2000), Sudan is facing serious food shortage problems *vis-à-vis* socio-economic development. The FAO has estimated that wheat and sorghum output is about 60% and 24% below the previous five years’ average respectively and that the overall aggregate production of cereals, estimated at 3.14 million tons, represents a drop over last year and the previous five years of some 39% and 24% respectively.

The remarkable agricultural feature in Sudan is the Gezira Scheme (SGB). The Gezira Scheme is the largest agricultural irrigated scheme in the Sudan, responsible for the production of almost all the major crops in the country, particularly cotton which is the main export crop produced and supplemented with sorghum, groundnuts, wheat and rice. Any Sudanese government greatly depends on the Gezira Scheme for its hard currency return from exports (Yousif 1997). The main distinctive characteristic of the Gezira Scheme is land acquisition. Initially each farmer was allocated 30 feddans (12.6 hectare)² regardless of the original ownership of the land for which owners were paid an annual rent. The production relations within the Gezira Scheme allowed the administration to evict any tenant who proved to be unable to abide by the set laws and regulations. This agreement was in place until nationalization of the Scheme in 1950, when the tenants were able to enforce an agreement which was then referred to as a joint account or partnership system.

Agricultural research in the Sudan started in 1902 with an overall goal to find ways to increase the productivity of specific crop and livestock species, while maintaining soil, water and vegetation as renewable resources (Ageeb and Hamdoun 1997). The major National Agricultural Research Institutions (NARIs) include the Agricultural Research Corporation (ARC), Animal Resources Research Corporation (ARRC), Environment and Natural Resources Research Institute (ENRRI) as well as academic institutions. The Agricultural Research Corporation (ARC) is the oldest agricultural research institution in Africa and the major research institution in the Sudan and accounted for nearly half the country's agricultural research capacity in terms of full-time equivalent researchers (Yousif 1997; ISNAR 1995). The ARC mission is to provide attractive and realistic technologies to

improve and sustain productivity in agriculture with a particular focus on the Gezira Scheme. However, despite all the work of the ARC during the last 100 years in providing new technologies to improve farmers productivity up to 100%, crop productivity is still extremely low and does not exceed 30% of the level attained in research farms. Given this low productivity in the Gezira Scheme a number of fundamental research questions are addressed:

- What are the roles of finance and funding in technology adoption?
- What other factors determine the adoption of new technology among Sudanese farmers?
- What are the policy implications of the answers to the above-stated questions?

III. Research Method

A. *Questionnaire Design*

A series of detailed (interview-based) surveys were implemented in order to generate the data required to measure the economic and technical variables associated with the finance and funding determinants of technology adoption within the Gezira Scheme, the spatial focus of most agricultural research in Sudan. The study used multiple choice and scale-type questions in order to identify and assess farmers' access to, for example, finance, funding sources, accessibility of information and marketing of their produce. Most of the questions in the study compared the traditional farming practices to the modern agricultural practices in the research and academic institutions. However, examples of the questions asked within the questionnaire include:

- Is farming the only job you do?

- Do you own this farm?
- Where is your farm located relative to the main irrigation canal?
- What crop(s) do you grow?
- What agricultural operation(s) do you do each month of the year?
- How many labour/day/feddan do you use each month of the year?
- What is your cost of production (Ls/fed)?
- From where do you finance all these farming expenses?
- Do you have any problem with finance?
- Are you member of the Farmers' Union?
- Have you ever lost your produce?
- How do you market your produce?

B. *Sampling Structure*

Within the Gezira Scheme, the centre group was chosen for the study because it has the same average yield (1498 kilogram/hectare) as the whole scheme for cotton. Moreover, the centre group is accessible by roads and has varied socio-economic characteristics and resource endowments. Since the distance of households from a town, a neighboring village or from the main roads connecting villages within the blocks (a block is an administrative region designed by the Scheme for management purposes) is considered to be a possible important factor influencing farmers' access to information, inputs and markets, it was used as a stratifying criterion to select the different administrative regions (blocks) within the centre region. Thus four blocks were chosen from the centre group: Barakat, Hamad Elnile, Abdel Hakam and Elkomor. Thirty tenants were drawn from each selected block at random. These selected tenants within each block were categorized into three strata: high, medium and low. This

stratification was based on cotton yield variability from the (1998/1999) season, where those who achieved more than (2043 kg/ha) were considered high, (1498-2043 kg/ha) were considered medium and less than (1498 kg/ha) were considered low. Therefore, the total sampling unit is 120 tenants chosen from four blocks.

C. Data Collection

Building on a comprehensive review of the relevant literature, the secondary data collection focused on the derivation of appropriate testable hypotheses linked to the research questions above. A number of key databases were used to extract published and comparative data focused on agricultural productivity, agricultural research and extension services. The primary data collection is based on field work undertaken in Sudan over a period of three months (June through August 2000) consisting of participant observation, interviews with farmers and staff in the agricultural research institutions and the academic institutions, visits to the Gezira Scheme and other agricultural projects' sites and administration offices and meetings with officials and relevant focus groups.

The Agricultural Extension Section of the Faculty of Agricultural Sciences, University of Gezira was chosen as a meeting point where meetings and discussion sessions were conducted with the six enumerators³ on the aim and content of the survey questionnaire. During the study, time was allocated from each survey day for checking and clarifying the completed questionnaires, correcting any information or descriptions while they were fresh in the subjects' memory as well as gathering all relevant literature. After incorporating

corrections, twelve farmers (three from each block) were interviewed for pre-testing of the questionnaire. The final version of the questionnaire was produced in English and then translated into Arabic and data was gathered from the selected 120 farmers as designed.

D. Data Analysis

Non-parametric statistical methods were applied to the large data set in order to produce deeper insights into the economic, technical and social variables generated in the survey. Results of the surveys were transcribed and analyzed using the Statistical Package for the Social Sciences (SPSS). This computer software conducted data analysis using an approach similar to factor analysis for organizing and identifying qualitative data by frequencies, means, variables, cross-tabulations, commonality and other linear regression modeling considerations.

E. Limitations of the Research Method

The sampling unit of the farmers' survey, 120 farmers, is relatively small compared with the 114,000 total farmers in the whole Gezira Scheme. In addition, the data gathered is only for one year, making it difficult to generalize the conclusions of the study to Sudan as a whole. As discussed earlier, the sheer size of the Gezira Scheme (and the variety of agro-climatic zones and resources limitations) combined with the sensitivity of the data gathered under the current administration's security procedures contribute to the sample's small size. In connection with these difficulties the data regarding labor inputs and costs of production could not be acquired. Another limitation of the study is that sampling is based on cotton yield only while it would be a more representative sample if based on all (or more than one) crops since the

farmers' perception of technology might be different. The data gathering period is also considered another limitation as a longer period would enable researchers to build trust with the farmers, leading to better and more reliable data collection. Furthermore, selecting areas of different distances from information sources would also improve the quality of the data and make it more representative than the study data, which is collected from areas which are generally considered nearer to the information and finance sources.

IV. Results and Discussion

The results of the analysis are presented and discussed in the context of the three research questions posed at the beginning of the paper.

A. Roles of Finance and Funding in Technology Adoption

Finance is the major constraint facing farming in Sudan where 88% of the farmers have serious problems with finance, often arguing that the government creates these financial problems. The remaining 12% for whom finance is not a problem either have their own businesses (trade) or receive substantial support from other family member(s) or relative(s) working abroad (mainly in the Middle East). Meanwhile, farmers with inadequate funding are forced either to rent part of their land or sell part of their fertilizers to other wealthier farmers. Consequently, the majority of poor farmers get poorer and the farmers with available funding get richer. The impact of finance and funding availability on farmers' productivity is clearly illustrated in Figure 1 (Adopted from El Siddig 1997).

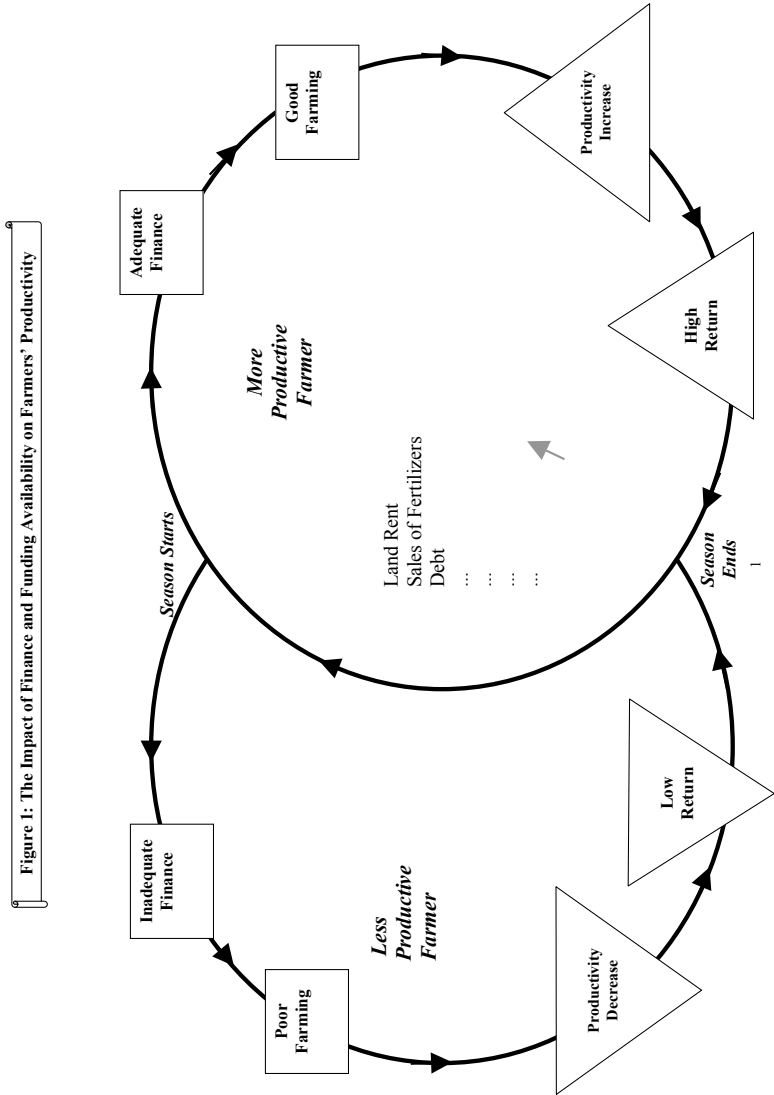


Figure 1: The Impact of Finance and Funding Availability on Farmers' Productivity

The problems associated with finance and funding can be summarized in the following:

- The government delays previous payments, which result in deficit in the next season, or payments are not made at the time needed.
- Low profitability of the different crops grown.
- High taxes.
- High water charges.
- The government normally provides fertilizers with prices above the market prices or does not provide fertilizers at all, meaning farmers have to pay the black market price.
- Hybrid seeds are very expensive and not included in the credit package provided by the government.
- Low productivity in the previous season(s).
- Banks and village traders refuse to provide farmers with loans that results in financial difficulties for farmers. Due to the difficult economic situation in the country and the high inflation rate, businesses including banks have become very sensitive to the daily speculations about prices change and uncertainty particularly farm products. Furthermore, banks lack confidence in farmers' returns as the government pays farmers only after a long period of time.

76% of the farmers surveyed depend mainly on their own personal financing since they receive no support from SGB for their sorghum, groundnuts, vegetables and other crops. However, very little financial support is provided by SGB for the cotton and wheat crops, so farmers have to find other sources of finance such as partnership arrangements for their groundnuts and sorghum or the sale of household items, animals or even part of their government-supplied fertilizer to finance important timely operations like cotton cultivation.

Few farmers have received bank loans or loan(s) from merchants, friends or relatives.

The Gezira Scheme accounts system started as a Joint Accounts System (JAS) based on the agreement that 40% of the annual net profit should go to the tenant and the rest should be spent on research, social services, business profit tax and loan interest and, if there is surplus, a reserve fund. The JAS was then abolished and replaced by the Individual Account System (IAS) in June 1980. The IAS is aimed at motivating tenants to increase crop production. According to the IAS, farmers are responsible for all costs including certain land and water charges owed to the government. Different components were included in these charges including irrigation costs, administration costs, depreciation and interest on capital. Table 1 below shows all costs of production for a typical farmer in the Gezira Scheme.

Table 1
A Typical Farmer's Production Cost in the Gezira Scheme, 1997
(Ls*/12.6 Ha)

Components	Cotton	Wheat	Sorghum	Groundnuts
Land Preparation	8.59	7.53	4.30	4.20
Agricultural Operations	20.61	6.56	10.51	13.10
Harvesting	21.48	12.91	10.79	21.46
Material Inputs	112.09	56.44	14.86	17.07
Services	1.15			
Land and Water Charges	11.90			
Transport	7.92	2.49		
Other Expenses		650		
Total Cost	183.74	86.55	40.46	58.97

1999 Exchange Rate to £was 3844. Source: Adopted from Yousif 1997.

The charges were made according to the number of irrigation intakes for each crop in the agricultural rotation. The land and water charges as well as cotton and wheat

prices were fixed by a technical committee set up by the Ministries of Agriculture and Finance and include membership of the Gezira Scheme, Rahad Scheme and the Agricultural Research Corporation. The net profit would go to the tenant after the deduction of all individual costs and accountability would be in accordance with the purchasing system proclaimed by the State. However, in addition to the land and water charges, other costs of production for a typical tenant farmer in the Gezira Scheme include land preparation, agricultural operations, harvesting, material inputs, services and transport.

The study reveals that farmers found the technologies transferred do not afford significant improvement over their traditional practices and priority is always given to cotton rather than other crops. The government argues that to meet national needs, such as earning foreign exchange, farmers are encouraged to grow cash crops such as cotton for export. Hence the need to disseminate becomes a need to be selective in dissemination, steering farmers in a particular direction. Almost all farmers surveyed agree that the technologies provided are very expensive to adopt and that they have no source of funds even if the technologies were not expensive in the first place. Moreover, farmers' returns from their produce as per the IAS are found to be very low. Farmers bear the risk that their crops might be harmed due to reasons beyond human control, such as unfavorable weather conditions (see Table 2). Therefore, 34% of the farmers perform other jobs in addition to farming to earn extra income. Additional roles farmers play include local village traders or businesses, local school teachers or employees in the nearest big towns or in their villages. However, for most farmers, farming is just a tradition they inherited and they cannot think of themselves doing anything else.

Table 2
Overall Farmer Crops Returns in the Gezira Scheme 1997
(Ls*/12.6 Ha)

Crops	Production Cost	Net Returns
Cotton	1,837,739	1,623,150
Wheat	865,520	826,280
Sorghum	404,550	349,970
Groundnuts	589,680	385,950

1999 Exchange Rate to £was 3844. Source: Adopted from Yousif 1997.

More than 91% of the farmers have lost their produce during the last period for a variety of reasons, many of which are listed in Table 3.

Table 3
Reasons for Lost Produce

Reasons	Percentage
Diseases	24%
Bad Management	27%
Theft	01%
Inputs Shortage	01%
Performance	05%
Inferior Seeds	06%
Other Reasons	36%

Source: Field Survey Data

wheat and sorghum due to the unavailability of pesticides. The absence of the entomologists and/or extensionists made the situation more severe. Other important factors mentioned by many farmers include the fact that some irrigation canals are not fully opened, full of weeds or not completed to the end of the block, resulting in water shortage or uneven distribution of water and flooding during the raining season. Farmers claim that they have been complaining about this problem for years but nothing has been corrected. According to some farmers, the nearest farms normally receive about

Disease, caused by inefficient pesticide delivered by the government, bad pesticide recommended for cotton in particular and the lack of compensation given by the government to remedy such problems is found to be the most important factor in produce loss. Weeds (e.g. adar, puda, etc.) destroyed the

twenty irrigation units, three for the moderately near and just one for the farms located further away.

Some farmers lost their produce due to poor fertility while others lost produce because of animal invasion of their farms despite the presence of government security guards. The difficult climatic conditions prevailing during the growing season, particularly the very hot weather, is also considered one of the factors causing loss of produce. Inefficient management resulted in some farmers failing to perform the different agricultural operations on time. Some farmers' fields receive bad or delayed land preparation and/or delayed wheat plantation (sowing date). Some farmers attributed the loss of their produce to the bad or inferior seeds supplied, particularly wheat seeds. A few farmers related the loss of their produce to the shortages of input materials or theft of the crops, while some farmers could not say exactly why they lost their produce.

B. Other Factors that Determine the Adoption of New Technology

Farm productivity varies in relation to the proximity of urban-industrial centers and to the quantity and quality of transportation systems. Closeness to cities and transport matters because of differences in transportation and marketing costs, the effects on labor and capital market, the ease of obtaining new and more productive inputs and the ease of information flows. The study reveals that farms located near the irrigation canal are most likely to be visited by extensionists, researchers and other officials and are also more likely to receive enough irrigation water. Moreover, according to the government regulations nearest farms should be cultivated with vegetables, which farmers prefer for their quick and direct return. Vegetables need adequate irrigation water at regular intervals; therefore, they should be grown in

the farms near the main irrigation canals to avoid any water shortages. Farmers normally prefer vegetables over other crops (like cotton) as they are allowed to sell them directly in the market under their full control, unlike cotton where the government collects the crop immediately after harvesting and sells through certain official channels. Strong linkages between agriculture and markets for inputs and outputs can help stimulate the local economy (see Dickinson 1969, Grigg 1982, Norton 1993, Rogers 1976 and Schultz 1953).

The study reveals that almost 85% of the farmers surveyed owned their farms and the remaining 15% the farms either belong to other family members or a close relative. In the survey, there is one partnership arrangement where the farm does not belong to the farmer interviewed. Partnership arrangement is a common subletting contract (mostly verbal) taking place between the farm owner and a third party where the third party cultivates the land and pays all the farming costs. The third party also pays the owner either an agreed share from the produce or rent to be paid at the harvesting period.

The marketing channels for different crops for all farmers surveyed are similar. The government takes cotton and wheat and the farmers have to accept the prices given. The majority of farmers market their sorghum, groundnuts and all other crops personally. They normally keep the sorghum for their families domestic use. According to many farmers, the government charges high prices for fertilizers (above the market price) which makes their produce less profitable. Farmers are forced to take these very expensive fertilizers only because they have no cash to buy fertilizer from the market at low prices; therefore, for many of them it is better to buy the sorghum needed for domestic use from the market rather than grow it on their farms. Farmers store the groundnuts until the price increases as village traders offer only low

prices during the harvesting period. Farmers depend mostly on their groundnuts to pay their debts.

The study also reveals that 40% of the farmers surveyed are full members of the Farmers' Union. The majority of the farmers (83%-100%) stated that the union "played a very negative role in their life and did nothing for them." Almost all the farmers surveyed claim that the Farmers' Union is not helping them with technology diffusion and marketing of their produce. In the past the union used to help farmers with land preparations, playing a vital role in advising them and determining the prices of the different crops (particularly the cotton and wheat) as well as helping farmers purchase subsidized fertilizers and other inputs. The Farmers' Union has established some business activities such as a milling factory and a pharmacy but for many years farmers received their share just once, hence, the farmers' union has a very poor relationship with its members. Furthermore, no support is given with respect to product prices nor is any support given to farmers for credit and/or financial challenges.

V. Policy Implications and Recommendations

The main policy implications and recommendations of this study include:

- Farmers' socio-economic environment plays a key role in improving productivity. Research should consider the characteristics of the labor force and the resources available in the farming community. Researchers should consider the small-scale farmers' requirements: technology must be cheap, easy to understand and require minimal training for successful adoption. However, interventions should include adjustments in resource

allocations to correct imbalances and a range of techniques to improve research-extension-farmer linkages.

- The government must adopt “fair” micro- and macroeconomic policies by changing national policies from very high taxes and very expensive inputs to raise output prices and lower input prices. The government should focus on providing loans to farmers, improved credit facilities and proper funding for all agricultural operations.
- Politicians must refrain from interfering with agricultural policies, but should ensure a stable agricultural and marketing policies. Politicians should formulate a fair production relationship with farmers.
- The government should improve the storage facilities, address key socio-economic issues (such as health problems) and improve infrastructure (irrigation channels, roads and other necessary and vital services).
- The Gezira Scheme needs urgently to improve its management practices and make inputs (fertilizers, chemicals, etc.) available at the needed time. It must fully understand the importance of timely application of these inputs and preparation of land, availability of irrigation water and adoption of mechanization and the recommended technological packages.

VI. Conclusions

In conclusion, this paper has identified some of the key financial and funding constraints facing the adoption of agricultural technology in the Sudan. It has also provided a better understanding of the production system constraints in Sudan within the framework of demographic, socio-economic, technical and cultural variables. This study has suggested

policies aimed at improving the productivity in the future in Sudan. By implementing the recommendations, based on the findings of this study, the future productivity in Sudan can be substantially increased.

Endnotes

¹The Human Development Index (HDI) is an index that combines average life expectancy at birth, literacy rate and purchasing power parity.

²Feddan is a local metric measurement equivalent to 0.42 hectare.

³Six final year students from the faculties of Economics and Rural Development and Agricultural Sciences were used as enumerators to collect the data from the selected blocks. These enumerators were chosen from the selected blocks so as to give full assurance to the farmers regarding the confidentiality of the information given.

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