TRANSFER AND ADOPTION OF THE EGYPTIAN IMPROVED "SAGIYA" IN THE NORTHERN AND KHARTOUM PROVINCES OF SUDAN

By

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ABSTRACT

Lifting of water for irrigation in the Northern and Khartoum provinces of Sudan depends mainly on fuel and electrical pumps, while in Egypt more than 70% of irrigation is done by an animal drawn implement called the "Sagiya".

The shortage of fuel and electricity which started in early seventies has resulted in a sharp reduction of agricultural output in Sudan both vertically and horizontally.

This paper demonstrates the possibility that the transfer of the Egyptian "Sagiya" to Sudan may help increase the agricultural output and/or decrease the cost of production per unit of output.

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TABLE OF CONTENTS

TABLE OF CONTENTS

PART III continued...

LIST OF TABLES

Introduction

The Northern and Khartoum provinces of Sudan are suffering from irrigation problems. The Northern province depends mainly on fuel pumps for irrigation while Khartoum province depends on fuel and electrical pumps. The shortage of fuel, electricity, spare parts and maintenance services has created acute irrigation problems:

- A great deal of perennial and annual crops' output is lost every year due to the water shortage.
- Field crops are prohibited in some public schemes to save water for permanent crops.
- Animals are decreasing in number due to shortage of fodder crops.
- Prices of wheat and sorghum (the staple food), beans, fruits, vegetables, meat and milk have gone very high in the recent years.
- Recently I have received a letter from my father, dated July 26, 1988, saying that the horticultural gardens are almost dead because of the water shortage, and the farmers are asking for compensation from the government.

At the time when this dependency on imported fuel, spare parts and maintenance services is creating such problems in Sudan, more than 70% of the irrigation in Egypt is done by an animal drawn implement, called "Sagiya", which is locally made and locally maintained!

There are a lot of similarities between the Northern and Khartoum provinces of Sudan and Egypt with regard to agriculture: the sources of irrigation water, the size of holdings, the types of crops grown and the types of animals raised.

This study investigates the possibilities of the transfer and adoption of the Egyptian "Sagiya" in the Northern and Khartoum provinces of Sudan.

Economists have long recognized that the transfer of technology is at the heart of the process of economic growth and development. Sahal says that some countries have better chances for producing some technology, so it is desirable that other countries should borrow the same technology rather than wasting their efforts on repeating the whole life history of the new technology (Sahal 1982). Ruttan and Hayami say that the enormous agricultural productivity differences among countries, combined with the success of earlier diffusion efforts, have often been interpreted to imply that a more effective diffusion of known agricultural technology among countries could present an efficient source of economic growth in agricultural productivity and production in the less developed countries. (Ruttan and Hayami 1973).

However, the traditional development strategies of importing the most sophisticated technologies in an attempt to increase GNP have failed to provide the progress once thought possible. After nearly three decades and millions of dollars spent in applying this strategy, two thirds of the world's nations still have a GNP/capita of less than $500. This enormous export of technology has been accompanied by a remarkable lack of development, by growing unemployment in the cities, disruption of the rural areas and widening gulf between the wealth of few and the poverty of the rest (Bulfin and Greenwell 1977).

Some technologies are too complex to be operated and maintained by the local people.

The developing countries do not have the hard currency to import fuel, spare parts and the know-how which is needed continuously.

The fuel pumps in the Northern and Khartoum provinces of Sudan are examples of this policy: they need fuel, spare parts and continuous maintenance by skilled mechanics. But the government lacks the facilities to import such inputs, which has resulted in acute irrigation problems.

The current approach to technology transfer is to transfer the appropriate technology, which is defined as the one best suited to the social, cultural, economical and political climates of the various countries. Bulfin and Greenwell have defined the appropriate technology as:

- adaptable to the environmental condition.
- utilizing the local materials, man power and man-made resources.
- encouraging indigenous imitation and innovation.
- having or developing a logistical support system such as

maintenance services and spare parts availability.

- cost effective and labor intensive. (Bulfin and Greenwell 1977).

A lot of emphasis should be placed on innovations that do not require large purchases of inputs (Solo and Rogers 1972). Ruttan and Hayami argue that the successful transfer of technology involves the domestication and modification of the transferred technology to be consistent with the factor endowments and relative factor prices in recipient countries. A major challenge for the developing countries is to develop the scientific and institutional capacity to design and adapt location-specific agricultural technology to the resource endowments and economic environments in which the new agricultural technology is to be employed (Rutttan and Hayami, 1973). As indicated earlier, the present study investigates the transfer of the Egyptian Improved "Sagiya" (EIS) to Sudan. It examines whether the EIS would be the most appropriate technology to transfer to the Northern and Khartoum provinces of Sudan to help in solving the irrigation problems created by the dependency on imported fuel, spare parts and maintenance services for the irrigation pumps.

The paper demonstrates that the EIS will be very compatible with the system: it could be locally made and it could be locally maintained and it will be very efficient in irrigating the cultivated area in the Northern and Khartoum provinces.

Part I gives a background about the area of the study, the Northern and Khartoum provinces, their location, characteristics and problems.

Part II gives an idea about the EIS, how it works, its capacity, its cost of construction and to what extent they depend on it in Egypt.

Part III reviews the literature on the transfer and adoption of technology.

Part IV is an application to the transfer and adoption of EIS Case.

Part V is a summary and conclusion of the paper.

PART I

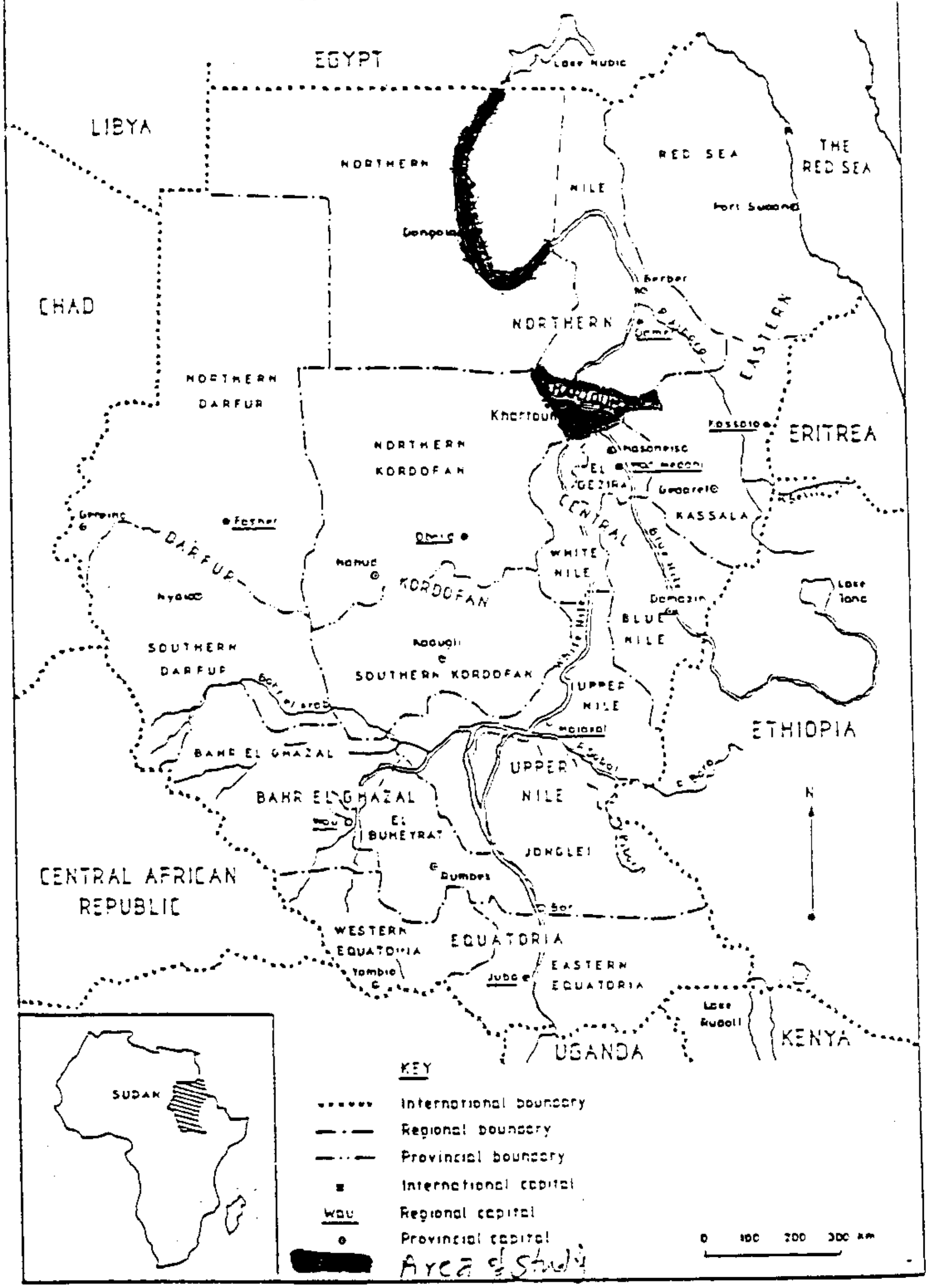
A background about the area of the Study: The Northern and Khartoum provinces: location, characteristics and problems:

1. The Location:

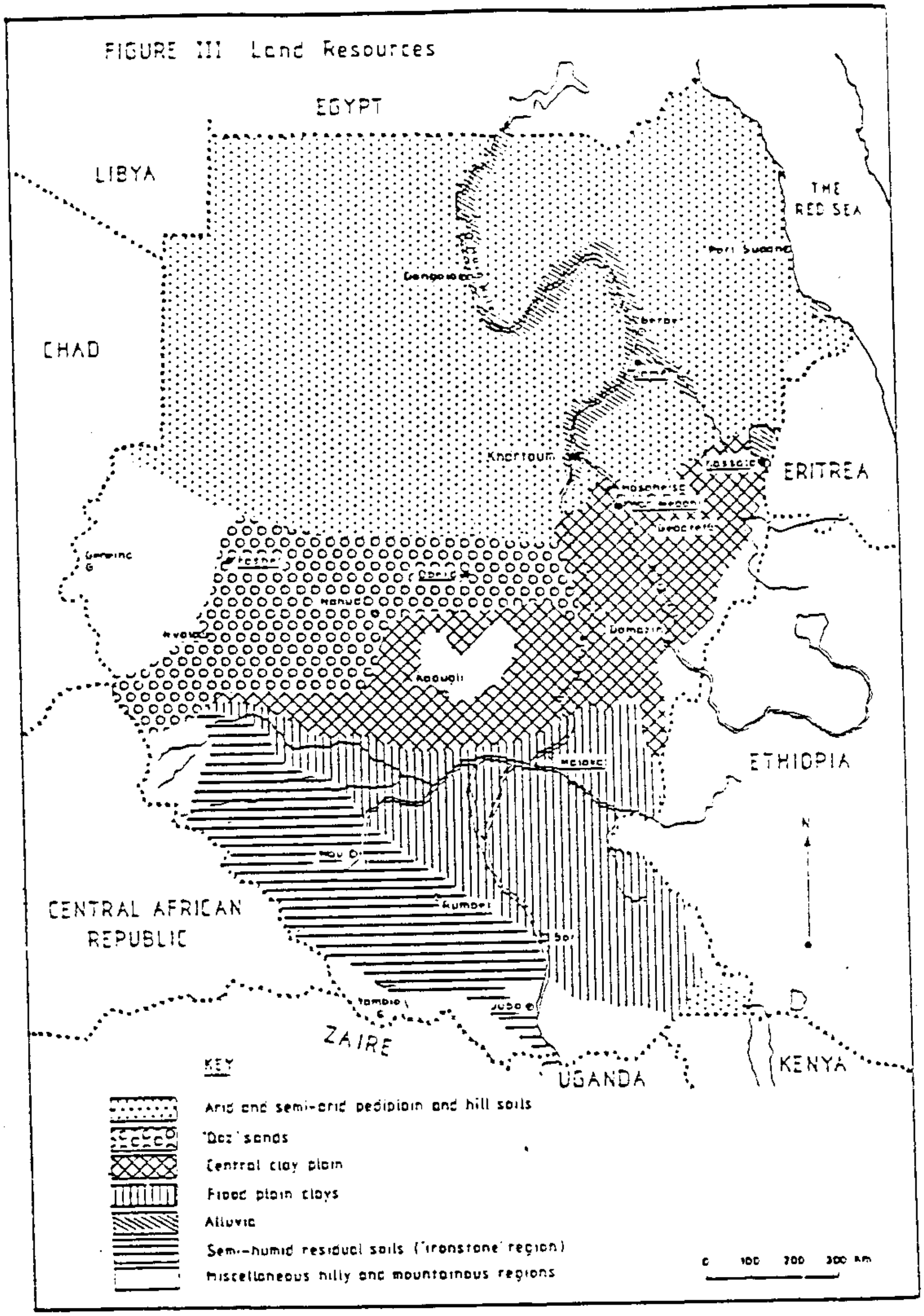
The Northern and Khartoum provinces are the smallest among the Sudanese provinces with regard to the size of the cultivated land. The irrigated part of the Northern province extends from Nuri to old Halfa at the Egyptian border. Cultivated areas may be either small narrow strips along the banks of the river Nile or stretches up to three kilometers wide. Soils are alluvial soils which are generally fertile and are made up of loams and silt deposits. Soils decrease in fertility away from the river (Zahlan 1986). (See the map)

Khartoum province is the capital of Sudan and it includes the three towns of Khartoum, Khartoum North and Omdurman. Being within easy reach of the large market for fresh produce, the Khartoum province cultivation has developed along rather different lines. The schemes of interest here are the pump irrigation schemes which are scattered along the Nile, specifically those North of Khartoum up to El-Gaili and south of Khartoum to Gabel awlia on the White Nile and Ailafoon on the Blue Nile.

FIGURE 1 Political Divisions



(SOURCE: Zahlan 1986)



(SOURCE: Zahlan 1986)

2. The Characteristics:

The characteristics (discussed below) of the Northern and Khartoum province include: size of the holding (a holding is defined as all land used partially or wholly for agricultural production under a single technical unit managed by a person alone or with the assistance of others), fragmentation, land tenure, types of crops grown, types of irrigation, types of animals raised and some characteristics of the holders.

2.1 Size of Holdings:

The size of the holding is very small in both provinces (see Table 1). In the Northern province it ranges from no land (0 6% of total) to about 100 feddans[1] (0 2% of total) with the majority ranging from one feddan to five feddans and with an average size of the holding of 4 feddan.

In Khartoum province, holdings range from no land (22 3% of total) to about 50 feddan (0 4% of total). The majority of the holdings are one to five feddan, with an average of 3 2 feddans.

For the two provinces together the average size of the holding is 3 9 feddans (Dept. of Statistics, Ministry of Planning, SUDAN Sept. 1969).

People without land are farmers who work in others' fields.

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1. one feddan = 4200 sq. meters

Partnership is a common practice (it means the holding is owned and operated by two or more farmers) and about 11% of the holdings were carried out jointly under partnerships (see Table 2).

Table I: <u>Size of the holdings</u>:

Size of holdings	Northern # of holdings	Northern %total	Khartoum # of holdings	Khartoum %total	Both # of holdings	Both % total
1. without land	10	0.57	60	22.30	70	3.47
2. 0.01-0.99	400	22.86	66	24.54	466	23.08
3. 1.00-2.49	587	33.54	69	25.65	656	32.49
4. 2.50-4.99	354	20.23	28	10.41	382	18.92
5. 5.00-9.99	222	12.68	34	12.64	256	12.68
6. 10.00-24.99	152	8.69	11	4.09	193	8.07
7. 25.00-49.99	21	1.20	1	0.37	22	1.09
8. 50.00-99.99	4	0.23	-	-	4	0.20
9. TOTAL	1750	100.00	269	100.00	2019	100.00

(Source: A report on the Sample Census of Agric., Dept. of Statistics, Ministry of Planning, SUDAN 1969.)

Table 2: <u>Extent of joint operations of holdings</u>:

Type of Holding	Northern	Khartoum	Both
Individual	87.45%	95.69%	88.78%
Partnership	12.35%	4.31%	11.22%
TOTAL	100	100	100

(Source: A Report on the Sample Census of Agric., Dept. of Statistics, Ministry of Planning SUDAN 1969.)

2.2 <u>Fragmentation</u>:

Due to the inheritance laws, the holdings are highly fragmented, especially in the Northern province. A holding may be a single continuous piece of land or it may be split up into two or more disconnected parcels. (See Table 3).

Table 3: Average Number of Parcels per Holding:

	Northern	Khartoum	Both
Average number of parcel per holding	2.03	1.23	1.90

(Source: A Report on the Sample Census of Agric., Dept. of Statistics, Ministry of Planning, SUDAN 1969.)

The average area per parcel is about 2.6 feddan in Khartoum and about 2.00 feddan in the northern province. In the Northern province, holdings even under one feddan are split up into as many as four parcels! (Dept. of Statistics, Ministry of Planning, Sudan 1969.)

2.3 Land Tenure:

There are four forms of land tenure: owned, owner-like possession, tribal and hired. Table 4 shows the proportion of each form in the two provinces:

Table 4: Classification of land by form of tenure:

Form of Tenure	Northern	Khartoum	Both
1. a. owned	36.52	23.28	34.76
b. ownerlike possession	10.64	13.10	10.97
c. Total Owned	47.16	36.38	45.73
2. Tribal	8.30	53.55	14.30
3. Hired	44.54	10.07	39.97
4. TOTAL	100	100	100

(Source: Adapted from a report on the sample Census of Agric, Ministry of Planning, Sudan 1969.)

Owned land is the land that is owned by individuals, and is registered under their names. They cultivate it the way they want and they can sell it (but I have never seen that happen because the land is considered as the most valuable property).

Owner-like possession is a public land with cultivation rights inherited by communities or individuals.

Hired lands are public lands with rights to use for a specific period. Public lands can be leased from the government for periods up to 99 years at a nominal rent of 0.20 per feddan per year, and the lease is renewed every year (Zahlan 1986).

Tribal lands are lands which belong to certain tribes; they are commonly used by these tribes for cultivation or for grazing.

2.4 Land Utilization and Types of Crops Grown:

Ahmed Humeida's recent study (in Zahlan 1986) has shown that the crops grown in the Northern province are fruits and vegetables and limited number of field crops. Fruits produced include citrus, mangoes, dates and guavas, while vegetables produced include tomatoes, potatoes, onions, sweet potatoes, okra and some leafy crops like lettuce and jeowsmellow.

A limited number of field crops like wheat, sorghum, fulmasri (tick beans), groundnuts and minor crops of spices are produced (Zahlan 1986). Also some fodder crops like lucerne and lubia are produced.

In the Khartoum province, vegetables are the main crops produced because of the availability of the market in the capital. Due to their short growing season, vegetables can be continuously cropped and generate income throughout the year. Almost all types of vegetables are produced: tomatoes, potatoes, onions, sweet potatoes, cucurbits, eggplant, watermelons, pepper, lettuce, carrot, jeowsmellow, beans and peas and so on. However, some areas are famous for their specializations: Ailafoon is famous for tomatoes, Gili is famous for onions, and Sarorab is famous for potatoes. Some fruits are also produced on a small scale like citruses, bananas and guavas. Abu 70 and lucerne are also produced as fodder crops.[2]

<u>Cost of Production and the Level of Farm Profitability of Some Crops</u>:

Ahmed Humeida showed that vegetables are highly profitable relative to field crops (see Table 5).

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2. Source: this information is obtained through personal communication with Mr. Abdalla Ahmed Eldaw, Agric. Extension Administration, Khartoum North Box 75 Sudan, who is now studying for M.S. degree in the Dept. of Agric. Extension, MSU.

Table 5: Cost of Production and Level of Profitability of Some Major Crops (1981-1982):

	Wheat	Ful masri	Sorghum	Lubia	Onion	Vegetables
Land Preparation	44	41.5	50	50	70	50
Agric. Operations	27	6.5	50	21	90	60
Harvesting Operations	57	70.5	40	40	43	60
Transportation	12	16.5	7	-	31	10
Material used	52	118	35	23	137	69
Water rates (1)	18	18	10	15	19	25
Land Rent	1	1	1	1	1	1
TOTAL	211	330.5	193	180	391	275
Yield in Ardab(2)/feddan	4.5	4	3.5	18 tons	31	2 tons
Price/Ardab (3)	72	120	60	20	16	300
Gross Revenue	324	480	210	360	496	600
Farmer's Returns	113	149.5	17	210	105	325

(1) Water rates are subsidized and are far below cost.
(2) One Ardab = about 200 kg.
(3) Farmgate prices.
(4) prices are in Sudanese pounds.
(Source: Zahlan 1986)

The table shows that vegetables are the most profitable crops followed by Lubia, Fulmasri, wheat, onion and lastly sorghum. The difference is coming from the difference in yield per feddan, price per unit in addition to the difference in cost of production per feddan. Unfortunately there are no data on citrus and dates, but they do generate returns per feddan more than do vegetables, and this explains why most of the new extensions are in citrus, dates and vegetables. Sorghum and wheat are the least profitable crops.

The Importance of the Date Palms:

The date palms are of special importance to the Northern province. First they generate income as much as other horticultural crops (citrus) do. Second, they are highly drought resistent. Third, they have different uses to the farmer:

- The fruits are a nutritive food as they contain high percentages of carbohydrates, vitamins and minerals and they constitute an important part of the producer diet.
- Roofs and doors of local houses are made from the stem and the branches are also used in roof construction.
- Leaves are used to make baskets, hats, ropes and so on.

Dates are a high value crop and make up a large portion of farmer income. They occupy about 50% of the total area under horticultural crops in the Northern province (Zahlan 1986).

2.5 Types of Irrigation:

Ahmed Humeida (in Zahlan 1986) reported that the irrigation in the Northern province depends on the river Nile, surface wells and deep bore wells. Lift pumps are used to raise water from the river or from bore wells. Two types of schemes are present: public agricultural corporations and private agricultural schemes.

In public irrigation schemes farmers are charged nominal water rates in addition to taxes on land and some crops. In private schemes farmers are charged taxes on land and on some crops also. Due to irrigation problems (fuel, spare parts and maintenance services) the private schemes are operating at about 70% efficiency (Zahlan 1986). The public schemes are even worse and they may be working at less than 50% efficiency.

In Khartoum province the schemes are mainly private, irrigated by lift pumps. Two types of lift pumps are present: fuel pumps and electrical pumps (2-24 inches diameter). The irrigation faces the same problem of the Northern province: shortage of fuel, spare parts and maintenance services in addition to electricity shortage. (Source: personal communication with Mr. Abdalla Ahmed Eldaw).

The 1964/65 agricultural census reported the usage of the traditional "Sagiya" in the Northern province. It is an animal drawn wooden machine for raising water. Typically it is two wheels: a horizontal and a vertical one which are attached together through wooden gears. Pots (jars) made of burnt mud are attached to the vertical wheel with ropes. The animal (mainly cattle) pulls the horizontal wheel which through the gears turns the vertical wheel and the pots. Turning through the water, the pots get filled and when they turn on the other side they pour water which collects in canals to go to the field. Today the traditional "Sagiya" is completely absent in the Sudan.

2.6 Animals Raised:

Animal taxes are one of the principal sources of revenue in the country. In the Northern province 46% of the holders reported raising cattle, 70% reported goats, 59% reported sheep while 80% reported ownership of donkeys. In Khartoum 60% of holder possessed goats and 46% possessed donkeys. (Agric. Census, Ministry of Planning Sudan 1969).

Today the situation is very different, as the number of the animals has greatly decreased.

The main reasons for the shrinking animal numbers is the lack of forage, which comes back to the shortage of irrigation water.

2.7 Some Characteristics of the Land Holders:

In the Northern province agriculture is the main occupation of about 96% of the holders while it constituted the main occupation of about 99% of the holders in Khartoum. Four percent of the holders were females in both provinces. The holder is the one who manages the different agricultural operations and usually is the household head. (Agric. Census, Ministry of Planning Sudan 1969).

Age:

Most of the holders are of ages between 18 to 60 years. Percentages of holders under 18 is almost negligible. Table 6 shows the percent of holders in different age groups.

Table 6: Holders by Age Groups

Age	Northern	Khartoum	Both
1. under 18	0.23	0.37	0.26
2. 18 - 34	20.81	20.08	20.66
3. 35 - 44	24.43	27.13	24.96
4. 45 - 54	21.56	25.66	22.36
5. 55 - 64	19.91	18.21	19.58
6. 65 and over	13.06	8.55	12.18

(Source: Adapted from 1964-65 Agric. Census, Ministry of Planning, Sudan 1969).

Education

Most of the farmers in the Northern province and Khartoum province are literate and they can read the newspaper.

Farmers below 40 years of age may have had formal education: mainly elementary or intermediate and some may even have attended high school.

Farmers about 40 years of age and over have had "Khalwa" education which is the learning of the "Qura'n," our holy book. Literacy was a prerequisite.

So generally, most of the farm population in Northern and Khartoum provinces are literate.

Off-Farm Income:

In the recent years, due to fuel crises, farm income no longer provides an acceptable standard of living. The effects of fuel crises on the agricultural income appear in the lower levels of yields obtained due to water shortage as well as in the increased costs of production. Also the fuel crises are reflected in the high cost of tranportation. All of these have lowered the value of the real agricultural income. Most of the young people have migrated to big cities, Saudi Arabia and Gulf countries to earn money. A lot of this money is coming back to families in both regions. Off-farm income constitutes the main source of farm families income in both Northern and Khartoum provinces.

3. <u>The Problem</u>:

Before I describe the problem I would like to give a short story that seems to be relevant here: a friend of mine told me that one day they were celebrating the first day of the introduction of the fuel pump in their village in the Northern province. Everyone was celebrating except an old man. When they asked him why he was not happy, he said: "Why should I be happy? You are replacing something that we can fix by something that we cannot fix. If the machine breaks down who will fix it? Where do you find the spare parts? Where do you find fuel?" There was no answer. What this wise man was saying became true today! Ahmed Humeida has summarized the production constraints in the Northern province, which is also applicable to Khartoum province, in the following:

- The shortage of fuel for pumping water and mechanized land preparation. Fuel prices on the black market have forced tenant to grow crops that are highly drought resistent like the date palms.
- The shortage and unavailability of spare parts for water pumps and their high cost when they are available.
- The scarcity of agricultural machinery for land preparation and harvesting.
- The shortage and irregular supply of inputs like fertilizers and improved seeds at the time required.
- The lack of clear price policy and difficulty in transporting the produce to the consumption centers.

- The shortage of institutional agricultural credit.
- The continuous migration of local population to other parts of the country looking for better jobs and better living conditions (Zahlan 1986).

This paper is concerned mainly with the irrigation problems in the Northern and Khartoum provinces. A lot of literature is saying that one of the main problems of Africa is the dependency on imported inputs rather than the local endowments. Uma Lele (in Eicher and Staatz 1984) is saying that with the rising fuel cost, mechanization - now often operated through public sector - is frequently highly uneconomical. The more intermediate forms of technology that are used extensively in Asia such as an ox plow would be far more efficient.

The problems of interest here are the ones which are related to the irrigation, mainly:

- shortage of fuel for pumping water.
- shortage and unavailability of spare parts and maintenance services for the irrigation pumps.
- continuous migration of the local people from the agricultural sector: the shortage of fuel resulted in less cropping and hence less jobs.

PART II

The Egyptian Improved "Sagiya"[3]

Description: More than 70% of the irrigated area in Egypt is irrigated by the "Sagiya" It is used all over Egypt, in Upper Egypt as well as in Lower Egypt.

The design of the Egyptian "Sagiya" is basically the same as the Sudanese "Sagiya": two wheels, a horizontal one and a vertical one attached by gears that translate the horizontal movement to vertical movement. The Egyptian machine has three improvements over the Sudanese "Sagiya":

1) There are two standard sizes in Egypt: small and large. The size used depends on the need for water (which depends on the crops planted and the crop area) and the availability of water. Although there are only these two standard sizes, this suggests that the size is controllable and that the size of the machine could be tailored to the needs of a particular region or farmer.

2) The vertical wheel is made of metal (usually copper), which makes its weight lighter and its turning easier relative to the Sudanese "Sagiya" which was wholly made of wood. In some places even the horizontal wheel is made of metal. This suggests further that the whole "Sagiya" could be made of metal even the gears, bearing, and the attachments.

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3. The information in this part is obtained through personal communication with: Dr. Salah Eddin Abdel A'ati Saleem, Research Associate, Pesticide Chemistry, Pesticide Research Center MSU.

3) Instead of the burnt pots (jars) which were made of mud and attached to the vertical wheel to haul water in the Sudanese "Sagiya", there are pockets (or grooves) inside the vertical wheel in the Egyptian "Sagiya". These grooves are sloping in a special way so as to carry water when they are coming up and to pour it when they go down. Again the size and number of these pockets is controllable and depends on the size of the "Sagiya" itself. For these improvements, I like to call it the Egyptian Improved Sagiya (EIS). The EIS is made locally by well-trained blacksmiths.

The EIS is communally owned. Dr. Saleem says that no one owns the "Sagiya", it belongs to the community and everyone in the area could use it. He further says that it doesn't belong to the government at all, and the government has no relation to the building of the "Sagiya"; and it doesn't charge any water rates! Dr. Saleem says when there is a need in some place for a "Sagiya", the farmers in the area tell each other and arrange for the materials and the blacksmiths do the job. Then it becomes the community property. But the question remains: who pays for that? Of course this should go into the ben-cos analysis to see whether it affects the profitability.

The Efficiency of the "Sagiya":

The efficiency of the "Sagiya" is defined in terms of the amount of water delivered per unit time. It depends on:

- The size of the "Sagiya" itself, whether it is a large or small design.

- The size of the ox which is pulling the "Sagiya".
- The height (the head) to which the water is to be raised.

Dr. Saleem says the "Sagiya" raises the water up from 3 to 4 meters high, and it can even raise water more than that depending on the size of the "Sagiya" and the size of the ox. There are usually two to three "Sagiyas" in one "hod". The area of the "hod" varies, between 50 - 100 feddans. These three "Sagiyas" can irrigate this area in two to three days. This means that the "Sagiya" can irrigate one feddan in less than two hours! About the size of holdings Dr. Saleem says that the holdings range from no land to 100 feddan with the average size of holding of two feddans approximately.

The Cost of the Construction of the "Sagiya":

We have indicated earlier that the Egyptian "Sagiya" is produced locally, using local materials. The main cost is the cost of the vertical wheel, which is made of copper. Other costs involve the cost of the draft animal in addition to the cost of the horizontal wheel and gears which are made of wood that is locally produced. Excluding the cost of the animal, Dr. Saleem roughly estimated the cost of the whole "Sagiya" to range between 400 and 600 Egyptian pounds (1 U.S. $ = 2.3 Egyptian). In Sudanese pounds this cost will be between 800-1200 Sudanese pounds (1 U.S. $ = 4.5 s). (All these exchange rates are official exchange rates). This cost includes as well the cost of the local blacksmith labor to make the "Sagiya", but it doesn't include the cost of its repair and maintenance.

The cost of the animal is around 1000 Egyptian pounds, as Dr. Saleem indicated, but every farmer owns and uses his own animal and not all of its cost should be charged to the "Sagiya" because it is used for other purposes as well.

Cost Per Farmer:

As we have indicated, about three "Sagiyas" are needed to irrigate a "Hod" of 50-100 feddan. This means the one "Sagiya", roughly, irrigates about 20 feddans. Since the average holding is 2 feddans, this means that one "Sagiya" is shared by about ten farmers and hence the cost per farmer will range between 40-60 Egyptian pounds excluding the cost of the animal (will be about 80-120 Sudanese pounds) which is very low relative to farmer income (which ranges between 3,000 and 10,000 Sudanese pounds per year.) in the Sudan. If we further assume that the "Sagiya" is shared by only five farmers, the cost will double but it will still be very low.

Crops and Animal Produced:

As the average size of holding in Egypt is very similar to the average size of the holding in Northern and Khartoum provinces, the types of crops grown and animal raised are also similar.

In Egypt they grow a variety of horticulture permanent crops like citrus, mangoes, bananas, guava, grapes, etc.

Also they grow almost all types of vegetable like tomatoes, onions, lettuce, carrots, etc. They grow a variety of field crops like cotton, sugar cane, wheat, rice, jute, peas and beans, sorghum, etc.

The animals raised are also similar to those of Sudan: camel, cattle, sheep, goats, and donkeys. Cattle are used in pulling the "Sagiya" and in pulling the plow. Camels are used for "Sagiya" also in some places.

The size of holdings, source of irrigation water and types of crops grown are quite similar to those of the Northern and Khartoum provinces.

Further Improvement in the Design of the "Sagiya":

As we said the design of the Egyptian improved "Sagiya" is basically the same as the Sudanese traditional "Sagiya". The improvement of the Egyptian design was discussed at the beginning of the paper. Dr. Saleem is saying that further improvements are possible, these may include:

1) The horizontal wheel, the gears, the attachments and the bearings could all be made of metal instead of wood.

2) Both the horizontal and vertical wheels could be made of a lighter metal like aluminum rather than copper to make the weight lighter for the animal.

3) The size of the vertical wheel, the size and the number of the pockets could be increased depending on the need and the size

of the animal; this would increase the capacity of the "Sagiya" and would improve its efficiency.

4) The size of the gears could be designed in a way so that the speed of the horizontal wheel is converted to a higher speed on the vertical wheel.

5) Finally the size of the draft animal could be improved through animal husbandry.

All of these measures are possible improvements and it would add to the efficiency of the "Sagiya".

<u>Type of Data Needed</u>:

This paper argues that the profitability from the EIS could occur in two ways:

(1) An increase in the area planted and increases in yield per unit area. To support this argument data is needed on:

(a) The amount of land irrigated by the EIS in Egypt and the amount of land irrigated by pumps plus the unirrigated land that could be reached by "Sagiya" in Sudan.

(b) The yield per unit area in both places. A comparison would show the possiblities of the yield increase.

(2) The reduction of the irrigation costs per unit area: data on costs of irrigation in the Northern and Khartoum provinces (fuel, spare parts and maitenance services) per unit area could be compared to the fixed and operating costs of the EIS per unit

area to estimate the possible reduction. All of this data could be obtained from representative samples of farms in both Egypt and the Northern and Khartoum provinces of the Sudan.

PART III

The Literature Review

The volume of the literature on the transfer and adoption of improved technology is huge, and it will be impractical to cover it all in this review. Instead I will review a representative sample.

This part is divided into two main sections: (A) the literature on the transfer of technology and (B) the literature on the factors that affect the adoption of technology. In part IV both sections will be applied to the transfer of the Egyptian Improved "Sagiya" (EIS) to Sudan.

(A) The Transfer of Technology to the Developing Countries:

(1) The definition of the technology transfer:

Solo and Rogers define the transfer of technology as the process in which an innovation originating in one institution or system is adapted for use in another institution or system (Solo and Rogers 1972).

Driscoll and Wallender define it as the process by which technologies available in one country are transmitted to another country in some form (Driscoll and Wallender 1975). Eckert has similar definitions for technology transfer (Eckert 1981). Also Stewart and Nihei have defined it as the utilization of an existing technique in an instance when it has not previously been used (Stewart and Nihei 1987). It is clear that all of these definitions are basically the same.

(2) Why Technology Should be Transferred?

Economists have long recognized that the transfer of technology is at the heart of the process of economic growth (Sahal 1982). There is no doubt that some countries have better chances for producing some technology. Mann says that it is desirable for other countries to borrow the same technology rather than wasting their efforts on repeating the whole life history of the new technology. He further reported that most of the countries that show very rapid rates of growth in industrial production have heavily imported technology, for example Japan and Germany (Mann 1982). The developing countries have less chance and capabilities for creating their own new technology so it is desirable for them to borrow the technology that is already available in some other places. This shows how important the transfer of technology is for economic growth and development in the developing countries.

(3) Which Technology Should be Transferred to the Developing Countries

There is a lot of discussion in the literature about what is called the appropriate technology and which technology is appropriate for the developing countries. Bulfin and Greenwell have characterized the appropriate technology to be:

1. Adaptable to the environmental conditions.

2. Compatible with the various cultural, political and economical conditions.

3. Utilizing local material, manpower and man-made resources.

4. Encouraging indigenous imitation and innovation.

5. Having or developing a logistical support system such as maintenance services and spare parts availability.

6. It should be cost effective.

Bulfin and Greenwell go further and argued that while most technologists have always applied a technology which they believed to be the appropriate one, their ignorance of certain physical/environmental parameter and social culture and ideology have often led to the failure of the development. The enormous export of technology has been accompanied by a remarkable lack of development, by growing unemployment in the cities, disruption of rural areas and widening the gulf between the wealth of a few and the poverty of the rest! Why? Because the technologies transferred were inappropriate: some technologies are too complex to be operated and maintained by local people. For example, a two million dollar date-processing plant was idle for over two years for the lack of the technical expertise to repair the failed de-stoning unit! A lot of tractors are rusting in the fields where they stopped for want of fuel, parts or know-how to fix them (Bulfin and Greenwell 1977).

This doesn't mean that the appropriate technology should be always simple or intermediate (as some authors will call it), it could be highly sophisticated but still appropriate if it satisfies the characteristics of the appropriate technology discussed earlier.

Many authors have shared this same idea of the importance of the appropriate technology for the developing countries, among them are: Schultz (1964), Ester (1965), Solo and Rogers (1972), Driscoll and Wallender (1975), UNCTAD Secretariat (1975), Santikarn (1981), Williams (1985), Stewart and Nihei (1987), and Pingali, Bigot and Binswanger (1987).

(4) Types of Technology Transfer:

Ruttan and Hayami identified three types of technology transfer:

(a) Material transfer: this involves transfer of materials from one country to another.

(b) Design Transfer: this involves the transfer of the design of some technology and its production domestically. Ruttan and Hayami reported that the Soviets were able to use design transfer to acquire quickly and with very little effort the technical knowledge of tractor production which had taken years to develop in the United States.

(c) Capacity Transfer: This involves either the hiring of experts from one country to come and train people in another country, or the sending of trainees from one country to be educated in another and bring the knowledge to their country. Basically it is the transfer of the knowledge itself. (Ruttan and Hayami 1973).

Mansfield and others discuss the same types of technology transfer, but add that transfer could be vertical (from basic research to applied research to production), and/or it could be horizontal from one country to another (Mansfield, et al. 1982).

Other authors who have similar classification are Mascarenhas (1982) and Singh (1983). Solo and Rogers have taken this classification further to say that these types could come as a single track, a new track or a cross-track transfer.

The single track means that the new technology can fit into an already established system, for example new fertilizer. The new track means the new technology can not fit into the established system: a new track must be laid down. The cross-track means the new technology is to be transferred to an activity or used for a purpose of different sort (Solo and Rogers 1972). Again Singh (1983) has mentioned the same idea of single new and cross-tracks. Solo and Rogers have indicated that most of the technology to the developing countries is of the new track type.

(5) <u>The Cost of Transferring the Technology</u>:

There is no agreement between economists about the cost of transferring the technology: while some consider the transfer of technology to be costless others consider it very costly! Mansfield and others define the cost of transfer as the cost of transmitting and absorbing all of the relevant unembodied knowledge. They cite the different points of view of economists: Arrow indicates that the transfer cost must be high. E.A.G. Robinson believes that economists tend to exaggerate the size of transfer costs while Mansfield and Freeman take the opposite view, (Mansfield and Others 1982). Chatak identifies the cost of transfer to include:

- replacement of labor if the technology is labor saving.
- creation of monopoly if it is protected technology: If there is restrictive trade policy this may open the door for certain companies to monopolize the trade of the technology being transferred.
- negative balance of payment.
- it may create dependence on imported components (Chatak 1981).

Doctors (1981) says that the cost of transfer mentioned above will be justified by benefits not otherwise realized without the technology transfer.

Rodriguez (1975) assumes that the transfer of technology between countries is costless. He argues that technology is nothing but a set of blue prints that are usable at a nominal cost. He says that it is possible for the country which owns the technology to operate a plant in a foreign country without any transfer of factors (Rodriguez 1975).

Driscoll and Wallender (1975) identify the cost of technology to include:

- Technological dependence.
- Restrictive trade policy.
- Overpricing of technology
- Failure to adapt imported technologies to local conditions.

Teece (1977) reported that the cost of transferring technology in 26 international projects ranged between 4-22 percent of the total projects costs.

Mann (1982) and Sahal (1982) also argue that the transfer of technology is very costly. Sahal reported that in a sample of projects, technology transfer costs about 20% of the total cost of establishing an overseas plant. Generally most of the economists consider the cost of technology transfer to be very high but some say that it is justified by the benefits of transfer. But it is important to know who bears the costs and who reaps the benefits because this will vary on a case by case basis. If the technology is transferred, the costs were presumably lower than the benefits for someone even though in aggregate the costs may have exceeded the benefits. This is important to be addressed.

(6) <u>Absorption of the Transferred Technology</u>:

Absorption is the degree to which a country is able to modify, reshape and adapt the transferred technology in order to be compatible with the socio-economic system of the country. The benefits from the transferred technology depend on the absorptive capacity of the country. Solo and Rogers (1972) say that absorption of technology requires an existence of a form of organization capable of making the required transformation. Driscoll and Wallender (1975) say that the environment for absorption is important: this includes the need for training of technicians and scientists in addition to centers to facilitate the transformation. Eckert (1981) says that absorption depends on the characteristics of the receiving country. Mascarenhas (1982) says that effective absorption depends on developing policies for encouraging indigenous development of the technology. Adei (1987) summarizes the factors for successful absorption in:

- availability of people with basic training.
- legal and administrative framework for ensuring the importation, transfer and assimilation of the technology.

Stewart and Nihei (1987) says that the real trouble is the lack of abilities (educational system and infrastructure) to digest, absorb and diffuse the modern technology.

So the benefits from the transferred technology depends on the degree to which the technology is absorbed in the importing country. As indicated earlier, for better absorption and utilization, the transferred technology should be appropriate and compatible with the system.

(7) Importance of Communication in Technology Transfer:

Communication is the process through which information about new technology in one country reaches another country. Communication is very important for technology transfer. A country will not be able to benefit from a new innovation unless it has its a well developed communication system to provide access to the new information, but doesn't mean that the internal communication system has always to be well developed to benefit from the new technology. Solo and Rogers (1972) say that communication is one of the important aspects of technology transfer: it ensures that the information will reach the people who will make the most use of it. Driscoll and Wallender (1975) say that one of the main problems for technology transfer in the developing countries is the lack of communication. Most of the authors put much emphasis on the role of communication in technology transfer and how this represents a main problem in the developing countries. Among these are Doctors (1981) and Stewart and Nihei (1987).

(8) Importance of Research and Development in Technology Transfer:

A lot of literature has dealt with the role of research and development (R and D) in technology transfer. Solo and Rogers (1972) indicated that R and D is quite important for receptivity, absorption, modification and adaptation of the new technology.

Ruttan and Hayami (1973) say that the most serious constraint on the international transfer of agricultural technology is the limited capacities of the experimental stations in the developing countries. De Castro (1979) indicates that Japan had a well-defined strategy to import western technology and to ensure its assimilation to the extent of adapting and even generating new technology. Driscoll and Wallender (1975) have recommended that developing countries should establish indigenous research and development facilities both to adapt imported technology to domestic contexts and to create indigenous technological capabilities. Santikarm (1981) considered the cost of R and D to be one of the main cost items of technology transfer.

Mascarenhas (1982) has indicated that for every dollar spent on technology transfer four dollars are spent for quick absorption of the technology. Among authors who consider that R and D is essential to exploit technology transfer, absorption and adaptation, are Singh (1983), Adei (1987) and Stewart and Nihei (1987). This shows how important the research is for the absorption and adaption of the transferred technology.

(9) Role of the Governments in the Transfer and Adaptation of Technology:

As indicated earlier, political authorities play a very important role in the selection and transfer of the appropriate technology. They also play a central role in the assimilation, absorption and adaptation of the imported technology. The UNCTAD

Secretariat (1978) delineated the role of governments in technology transfer to be:

- The creation of social, economic and institutional framework to ensure access to technology.
- Creation of indigenous capacity for getting the technology know-how for applying both foreign and domestic technology.
- Control of importation of technology.
- The development of mechanisms for mobilizing mass participation in the choice and application of technology.

Singh (1983) indicated that stable and efficient governments are essential for providing finance, education and training, and investing in research and development. Mascarenhas (1982) says if the developing countries adopt a clear policy on the import of technology, including the establishement of a regulatory mechanism to control its flow, then the problems associated with technology transfer should be manageable. Doctors (1981) put the blame for the ineffectiveness of technology transfer on the governments. Among other authors, who put much emphasis on the role of governments in technology transfer and adaptation, are Solo and Rogers (1972), Driscoll and Wallender (1975), DeCastro (1979) and Adei (1987).

(B) Factors That Affect the Adoption of The New Technology

The Definition of the Adoption:

Schultz defines adoption as the degree of use of a new technology in long-run equilibrium, when the farmer has full information about the new technology and its potential (Schultz, 1975). Solo and Rogers categorized individual farmers with regard to adoption into five categories: the innovators (the first 2.5% who adopt), the adopter (the following 13.5%), the early majority (the following 34%), the late majority (the following 34%) and the laggards (the last to adopt 16%) (Solo and Rogers 1972).

Rogers and Shoemaker (1971) divided the adoption process into four stages: knowledge, persuasion, decision and confirmation. Feder, Just and Zilberman differentiate between the divisible and non-divisible technologies; for divisible technologies they define the extent of adoption as the share of farm area utilizing the technology in a given time. For non-divisible technologies the extent of adoption is dichotomous: use or no use, but in aggregate measures it becomes continuous and expressed as the percentage of farmers using the new technology (Feder, Just and Zilberman 1984).

(1) The Need and the Profitability of the New Technology:

The need and profitability are highly correlated, as the need is defined in terms of the need to increase profit. The need for the new technology is considered one of the main factors that accelerate the rate of adoption. Wildening (1952) relates the variation in adoption of new farm practices to the seriousness of the need. Gallup (1955) regards the need as the continuing awareness of a problem which has to be solved. Elliots (1968) findings agree with the Wilkening and Gallup results. Among other authors who find a positive relation between the need and the rate of adoption of new technologies, are Solo and Rogers (1972) and Mascarenhas (1982).

The profitability resulting from the new technology is also considered to be one of the main factors determining the rate of the adoption of this new technology. Zvi Griliches (1957) reported that the rate of imitation tended to be faster for innovations that were more profitable. Brander and Strauss (1959) say that the congruity of an innovation with the one it replaces accounts for a large portion of its acceptance. Zvi Griliches (1960) considers the congruity to be one form of profitability. Martinez (1973) found that the acceptance of hybrid corn in Argentina is explainable by differences in the profitability of the shift from open-pollinated to hybrid varieties. Barton and Loomis (1957) found that if the new technology has an immediate benefit, such as higher yield or higher economic returns, the technology is more likely to be adopted. So profitability is rating very high among the factors that affect the adoption rates. Among other authors who have related the rate of adoption of a new technology to its degree of profitability are, Bittner (1959), Rogers (1962), Fliegel and Kivlin (1966), Solo and Rogers (1972), Ruttan (1977) and Mansfield (1982).

(2) Access to Information:

Wilkening (1952), Rogers (1962) and Fliegel and Kivlin (1966) see that the ease with which the results of an innovation could be diffused to others affects the rate of adoption. Houghaboom (1963) also found a positive relation between access to information and degrees of adoption. Mansfield (1982) says that the adoption today is faster than yesterday because of communication accessibility. Feder and Slade (1984) say that certain levels of cumulative information must be attained before new technology is adopted. They have found that farmers with better access to information adopt earlier than others. Among other authors who see positive relations between access to information and the adoption rates are: Thorat (1966), Hiebert (1974), Solo and Rogers (1972), Perrin and Winkelmann (1976) and Feder, Gershon and O'Mara (1981).

(3) Compatibility with the Existing Farming System:

Compatibility is defined as the extent to which an innovation is congruent with the existing values and the past experience. Rogers (1962) found a positive relation between compatibility and the adoption rate. Brandner and Strauss (1959) say that the congruity of an innovation with the one it replaces accounts for a large portion of its acceptance. Schultz (1964) also says that the new technology should be compatible with the farming system. Ester (1965) has shown the importance of the farming system in the choice of mechanical technology. Among other authors, who see a positive relation between the compatibility of a new innovation with the existing farming system and its adoption rate, are: Mansfield (1961), Solo and Rogers (1972), Ruttan and Hayami (1973), Doctors (1981) and Pingali, Bigot and Binswanger (1987).

(4) <u>The Initial Cost</u>:

The initial cost of an investment in a new technology (especially for non-divisible technologies) is considered to be one of the determinant factors of its adoption rate. Gross and Taves (1952), Barton and Loomis (1957), Wasson (1960) and Fliegel and Kivlin (1966) have claimed essentially that the higher the initial cost, the lower the rate of adoption. Barnett (1953) says that innovations may be accepted superficially but cost acts as a determinant of actual acceptance. Bittner (1959) found that the amount of investment required affects the rate of adoption. Mansfield (1961) found that the rate of imitation tended to be faster for innovations that require relatively small investments. Kivlin found that the rate of adoption is higher for investments that have easy recovery costs, while the rate of adoption is lower for investments that have continuing costs like continuing purchase of fuel (Elliot 1968). The negative effect of initial cost on adoption may be related in part to the risk involved in taking such a decision and in part to the lack of the funds needed for such investments. Among other authors who see a negative relation between the adoption rate of an innovation and its fixed initial cost, are: Feder and O'Mara (1981), Mansfield et al. (1982) and Feder, Just and Zilberman (1984).

(5) <u>The Farm Size</u>:

The relationship between the farm size and the adoption rate depends on such factors as fixed adoption costs, risk preference, human capital, credit constraint, labor requirements and so on (Feder, Just and Zilberman 1984). For this reason the findings of the empirical studies varies between positive and negative relations between farm size and the rate of adoption. Randall (1963) and Thorat (1966) have found a positive relation between farm size and adoption rate. Feder, Just and Zilberman (1984) have also cited a number of studies that have found a positive relation between farm size and rate of adoption, including Parthasarthy and Prasad (1978), Vyas (1975), Perrin and Winkelmann (1976). Alviar (1972) also found that farm size affects the type of tractor to be purchased in the Philippines. Other studies that have found positive relation between farm size and adoption rates are: Feder and O'Mara (1981), Doctors (1981), Mansfield (1982) and Feder and Slade (1984). Ruttan (1977) and Perrin and Winkelmann (1976) have found that even the smaller farms that initially lag behind larger ones eventually catch up.

However a number of other studies have found a negative relation between farm size and adoption rate: Hayami (1981) has cited from Barker and Herdt (1978) that the relationship between adoption of modern rice varieties and absolute farm size is negative. Feder, Just and Zilberman (1984) have cited a number of studies that have shown no significant relation between farm size and adoption rate, from these: Lipton (1978), Burke (1979) and Singh (1979). Feder, Just and Zilberman (1984) concluded that the wide variety of empirical results suggests that size of farm is a surrogate for a large number of potentially important factors such as access to credit, capacity to bear risk, access to source inputs (water, seeds, fertilizer), wealth, access to information and so on. Since the influence of those factors varies in different areas and over time, so does the relationship between size of the holding and the adoption behavior.

(6) Risk and Uncertainty:

In most cases adoption of a new technology entails some sort of risk and uncertainty due to the unfamiliar technique or unfamiliar input. However, not many empirical studies have focused on the relation between risk and adoption rate. Solo and Rogers (1972) have cited from Fleigel and Kivlin (1966) that minimization of risk and economic returns were found to be highly related to the adoption rates of innovations among Pennsylvania dairy farmers.

Feder, Just and Zilberman (1984) have cited from Gerhart's (1975) study of maize adoption in Kenya, which used the presence of drought-resistant crops as an indication of especially high risks and found this variable statistically significant in explaining adoption performance. Perrin and Winkelmann (1976) have found that the adoption behavior is explained by the degree of risk aversion. As indicated earlier Feder and O'Mara (1981) claimed that the inconsistent relations between farm size and rate of adoption are explained partially by the degree of risk aversion. However, Feder, Just and Zilberman (1984) have concluded that most of the empirical work on the role of risk is not yet rigorous enough to allow validation or refutation of the available theoretical work which has shown a negative relation between the degree of risk and adoption rate.

(7) Land Tenure:

As with farm size, the empirical results on land tenure relations to adoption are somewhat varying. Feder, Just and Zilberman (1984) have cited from Parthasarathy and Parsad (1978) that tenants had a lower tendency to adopt the HYV's than owners, and they cited from Vyas (1975) that tenants were not only as innovative as landlords but sometimes used more fertilizer per hectare than did landlords. They also cited Schutjer and Van der Veen (1977) who claim that conflicting results are due to the fact that the effect of tenancy may be indirectly explained by the relationship between tenure and access to credit, input markets, product markets and so on. Because of the variation of such factors in different places and over time, the relation between land tenure and the adoption rate tends to vary with the different situation.

(8) Credit Availability:

Feder, Just and Zilberman (1984) have cited from the theoretical literature that the need to undertake a fixed investment may prevent small farmers from adopting the new technology but on the other hand the lack of credit does not inhibit adoption of innovation that are scale neutral. A lot of empirical studies results are consistent with that argument: Barton and Loomis (1957) have found that some innovations cannot be adopted because of unavailability of credit. Feder, Just and Zilberman have cited from Bhalla's study (1979) in India that lack of credit was a major constraint for 48% of small farms and for only 6% of large farms. Alviar (1972) argues that the availability of credit has enhanced the adoption of hand tractors in Philippines. However, Scobie and Franklin (1977) have concluded that access to credit may not encourage adoption if it entails restrictions on other input use. Also Feder, Just and Zilberman have cited from Lipton (1976) that subsidization of credit does not necessarily ease the problem for smaller farms, since subsidized credit may find its way to larger farms. Among other studies that have found a positive relation between availability of credit and adoption behavior, are: Martinez

(1973), Ruttan and Hayami (1973), Perrin and Winkelmann (1976) and Feder and O'Mara (1981). The importance of credit is coming from the fact that with technologies that are not scale neutral, there is a need to undertake initial investment. Farmers may not have enough funds to take such investments.

(9) Human Capital and Experience:

Schultz (1964) is the first to emphasize human resources as a factor of production. He argues that frequent introduction of new technologies results in disequilibrium suboptimal use of inputs and technologies, even though resource allocation is optimal.

Thorat (1966) has found a strong positive relation between level of education of farmers and the adoption rate. Solo and Rogers (1972) also argue that the rate of adoption is affected by the level of education of the farmer. Huffman's study (1977) shows that farmers with better educations adjusted their nitrogen use to a decline in price better than less educated farmers. Feder, Just and Zilberman (1984) have cited from Petzel (1976) that farmers with better education are earlier adopters than less educated farmers. Among other studies that support these results are: Randall (1963) and Feder and Slade (1984).

Experience is another aspect of human capital. Lowell and Kearl (1964) have shown that hybrid sorghum varieties were adopted faster in areas where hybrid corn had been grown. Randall (1963) has found that the early adopters are more knowledgeable of recommended practices. Elliot (1968) has cited from Tucker's study (1961) that past experience is positively related to adoption rate. Kisler and Bachrach (1973) have found that an innovation is first adopted by skilled and experimenting entrepreneurs and then diffuses down the skills scale.

(10) Complexity and Divisibility:

Rogers (1962) and Fliegel and Kivlin (1966) have defined complexity as the extent to which an innovation may be difficult to understand, use or require learning of new skills. Erasmus (1952) has argued that the more complex the practice is, the more likely it will not be accepted. Similarly Barnett (1953) has argued that the less complex an innovation the more likely it will be accepted. Among other studies which found negative relations between the complexity of an innovation and its adoption rate are Wason (1960), Fliegel and Kivlin (1966), Kivlin (1960) and Tucker (1961) (cited in Elliot 1986), Solo and Rogers (1972) and Doctors (1981).

With regard to divisibility, Barton and Loomis (1957) have defined divisibility as the degree to which a large initial capital outlay is required as opposed to a gradual one. Ryan (1948), Rogers (1962) and Fliegel and Kivlin (1966) have used the same definition as the degree to which an innovation may be tried on a limited basis without replacing the old one. Feder, Just and Zilberman (1984) have given the HYV's and fertilizer as examples of divisible innovations and the harvester as an example of a non-divisible innovation. Fliegel and Kivlin (1966) have found a significant relation between divisibility for trial and the rate of adoption for middle-scale farmers. Elliot (1968) has cited from Tucker (1961) that the combined ratings of six attributes profit advantages, time saved, complexity, comfort, experience and divisibility of trial, were significantly related to the adoption rate. Also Solo and Rogers (1972) have claimed this positive relationship between divisibility of innovation and its adoption rate. The effect of divisibility could be related to the effects of initial cost and the effects of risk and uncertainty. Divisible technologies can be tried on small scales without replacing the old ones. This in one part is a measure against risk and in another part is avoidance of large initial investment that farmers may lack.

Part IV

Application To The Transfer and Adoption of the Egyptian Improved "Sagiya" In Sudan

(A) The Transfer:

(1) The Definition, why should it be transferred, and is it the appropriate technology?

According to the definition, the transfer of the Egyptian Improved "Sagiya" (EIS) to Sudan is a kind of technology transfer. The transfer of EIS to Sudan could be material, design or capacity transfer:

- Sudan could import already built "Sagiya"; this would be material transfer.
- It could import just the design of "Sagiya" and build it locally; this is design transfer.
- Sudan could send people to be trained in Egypt and acquire the skills of building the "Sagiya"; this would be capacity transfer.

The design and capacity transfers seem to be the appropriate forms of the EIS transfer since transferring already built "Sagiya" is another form of dependency unless it is accompanied by the capacity transfer.

The answer for why should it be transferred, it is cheaper for Sudan to borrow the same technology rather than wasting effort repeating the whole life history of the technology.

Referring back to the characteristics of the appropriate technology given by Bulfin and Greenwell (1977) we will see that the EIS is very appropriate for the Northern and Khartoum provinces in Sudan:

1. It is adaptable to the environment.
2. The traditional "Sagiya" has been used in Sudan before, so it should be compatible with the cultural system. When they introduced the irrigation pumps, people have never thought of the problem of the continuous need of inputs which are difficult to obtain because of lack of working capital and foreign exchange. Of course,if you can keep it running, the irrigation pump is far more efficient in financial terms compared to the "Sagiya" and that is why it has replaced it completely.
3. It is made of wood and metal and it is drawn by animals so it utilizes local materials. Wood and metal (could be iron, copper or aluminium) should be available in Sudan and if they are to be imported they shouldn't be expensive relative to the continuous cost of importing fuel and spare parts. Animals could be raised on the farm and could be improved through animal husbandry. This was discussed earlier.

4. It is locally made in Egypt, so the Sudanese should be able to obtain the skills of building and maintaining it.

5. According to the size of land it irrigates in Egypt it will be more than enough for irrigation in Northern and Khartoum provinces. Of course water is available permanently from the river and the surface wells.

6. Finally it seems to be cost effective (See (2) below).

(2) The Cost of Transfer:

As indicated earlier, some economists consider the transfer of technology as costless while other consider it to be very costly. If we take the extreme of the argument that cost of technology transfer ranges between 4% and 22% of total cost of projects, then the cost of the transfer of the EIS to Sudan will not be high. (Cost is estimated in Part II.) But we cannot ignore the fact that the cost given in Part II is just an estimation, so more accurate data on the cost of the EIS is needed. This will include:

- The cost of the metal and the wood which is needed to build the "Sagiya".
- The cost of the blacksmith who builds the "Sagiya".
- The cost of the transportation of the EIS if it is to be transferred in a material form.

- The cost of teaching vocational training students how to build the "Sagiya": This cost will include the cost of sending them to be trained in Egypt or the cost of hiring Egyptian experts to come and train the students in Sudan (this is if the EIS is to be transferred in a design or capacity form).
- Then finally comes the cost of training the farmers how to fix and maintain the "Sagiya" so as to adapt the EIS to the local conditions, otherwise we fall in the same problems of dependency on imported expertise.
- It is also important to notice that although the cost of purchasing and maintaining the animal is very high, it shouldn't be charged to the "Sagiya" alone because the animal could be used for other purposes like the different agricultural operations or milk production.

(3) <u>Absorption of the Transferred Technology</u>:

The traditional "Sagiya" was used in the Sudan until the sixties and was adapted to the socio-economic system. Also Sudan has a well integrated vocational training system. Part of it could be directed towards the development and improvement of the EIS. So I would say it will be easy to modify, reshape and adapt the EIS to be compatible with the socio-economic system. But this adaptation and compatibility depend on the efficiency of the vocational training system in acquiring the skills as well as the effectiveness of the research in improving the Egyptian "Sagiya".

All of these, of course, depend on the ability of the government in developing the policies for encouraging the indigenous development of the technology.

(4) Government, Research and Development

As indicated in Part II, there are a lot of possibilities for further improvements in the EIS to increase its capacity and its efficiency. A well equipped research program is needed for this improvement. We already have an agricultural research corporation in Sudan, but like other developing countries the research - which is a key element in development - is handicapped by lack of facilities.

So for improvement and adaptation of the EIS, the role of the government is very important: (This could be done by the private sector as well but I am putting more emphasis on the government because these activities are now run by the government.)

- It has to put much emphasis on research and has to provide the facilities needed to do enough research on "Sagiya" improvement.
- Part of the vocational training has to specialize in the construction and maintenance of the "Sagiya".
- It has to provide capital for both programs in addition to credit for farmers to acquire this technology. The Government can borrow money from outside and there is a tendency in the international lending institutions to encourage the development of technologies that depend on local materials and local skills,

so I think the Government will be able to find a source of finance for such programs.

- The government also has to regulate the importation of the EIS and to find in which form it should be transferred.

- Hence, the role of the government is very important to ensure the integration of these programs and to ensure the improvement and adaptation of the EIS to the farming system.

(B) Factors that May Affect the Adoption of The EIS

(1) The Failure of the Fuel Pumps:

I have indicated in Part I that the fuel pumps have failed in solving the irrigation problems in these regions due to the reliance on imported fuel and spare parts that need hard currency which is lacking. There is a need to grow crops. Gallup (1955) defines the need as the continuous awareness of a problem that has to be solved. So, one of the solutions would be a technology that utilizes the local resources, and at the same time, is able to irrigate the area; The EIS does! It is made of local materials and the area it irrigates in Egypt is many, many times greater than the area needed to be irrigated in Northern and Khartoum province. The bad need for irrigation may facilitate the adoption of EIS in North Sudan and the need will be one of the main factors that encourages the adoption of the EIS in the Northern and Khartoum provinces.

(2) <u>The Profitability and Compatibility With the Farming System</u>:

As defined earlier, compatibility is the extent to which an innovation is congruent with the existing values and the past experience. The EIS is. The traditional "Sagiya" was used in Northern Sudan until the sixties and it was part of the life of the people. You find it even in our national songs today! So I would say that the EIS will be highly compatible with the farming system in Northern and Khartoum province and that will encourage its adoption as the literature says.

Several factors will influence the potential profitability of the EIS. I have indicated earlier that the Northern and Khartoum provinces have very fertile idle lands because of the prohibition of growing seasonal crops (cereals, peas, beans and vegetables) so as to save water for the permanent crops (mainly citruses). And I have indicated also that sorghum and wheat (the staple food) and meat are imported from other parts of Sudan and milk is imported from outside Sudan. The EIS will enable people to grow their stable food and will enable them to grow fodder to raise animals for meat and milk. In addition to that it will enable them to grow beans and vegetables which have a very high market demand in Khartoum, the capital. All of these are profitability factors that I think will encourage the adoption of the EIS in Northern and Khartoum provinces. Of course the profitability should be calculated on benefit - cost bases. Costs should include all of the types indicated earlier. Items of benefits and costs will be summarized in the following table:

Table 7

Summary of The Benefit-Cost Items:

The following table sumarizes the items of benefits and costs on which analysis should be based. All calculations should be done on a per ha basis when comparing the costs and benefits of the Sagiya with those of the pump:

*Benefit items:	*Cost items:
(1) Increased area of perennial (citrus, date palm, mangoes) and annual (wheat, sorghum, broad beans, vegetables, fodder) crops. (More area could be irrigated than currently.)	(1) Cost of construction and maintenance of the "Sagiya" (indicated in the previous section.)
(2) Increased output per unit area of all crops. (Due to better irrigation.)	(2) Cost of the purchase and maintenance of the draft animals.
(3) Meat and milk production (Animals could be raised due to the availability of forage crops.)	(3) Cost of training farmers.
(4) Reduction of irrigation cost per unit area (Reduction of fuel and spare parts use.)	(4) Cost of investment in research and extension.
(5) Increased number of jobs (due to intensive cropping	

A comparison between benefits and costs in Sudan and Egypt will show how effective the transfer of the Egyptian "Sagiya" to Sudan will be.

(3) Access to Information:

The lack of information I think was the main factor that prevented the transfer of EIS to Sudan. I, myself am from the

Northern province, and I am an agriculturalist graduated from the faculty of agriculture, so I know the agricultural problems in North Sudan very well. If I had any information about the EIS, I should have thought of its transfer to the Sudan a long time ago! But there was no information, and I think that was the main reason. Surprisingly enough, at the same time where a locally made technology is irrigating more than 70% of the Egyptian irrigated land, a very acute irrigation problem is occuring in North Sudan, and only non-existing geographical boundaries separate both countries! But the more surprising question is why don't farmers in Sudan know that? This is what the analysis should answer. With regard to its effects on adoption, there should be a well integrated extension services in both provinces. We already have many extension units in each province and they should be very effective in encouraging the adoption of the EIS, but these extension units need to be equipped with enough facilities.

(4) The Initial Cost and the Credit Availability:

As indicated in Part II, the EIS may cost between 80 to 120 Sudanese pounds per farmer, if we assume the "Sagiya" is shared by ten farmers, and between 160 to 240 Sudanese pounds per farmer if the "Sagiya" is shared by five farmers. In addition to this there is the cost of the ox, which no one owns today (and each farmer will have to purchase the draft animal because animals have to work in shifts and one animal cannot do more than one shift per day) is very high it ranges between 2000 to 3000 Sudanese pounds, which only a few farmers in either province can afford. So most, if not all, of the farmers are going to need credit for purchase of the animal, in addition to credit for purchase of the "Sagiya" itself and the purchase of other inputs needed.

So the government has to arrange a program for credit. The agricultural bank is already involved in such services but it does need the support of the government, and as I have indicated earlier there are a lot of international monetary agencies that are willing to give money for technologies that utilize the local resources, as the approach today, so I think the government will be able to find a source of finance.

The repayment could be in a form of crop tax, land rent, animal tax or it could be installments collected after each harvest. Any way credit availability will be one of the most critical factors that will affect the adoption of the EIS and the government has to manage that.

(5) Farm Size and Tenure Arrangement:

As indicated earlier, the effects of farm size and tenure arrangements on adoption are not straightforward because they depend on other factors like the initial cost, credit availability, human capital, labor requirements and so on. Because of the variation of those the results of studies tended to be contradicting, so it is difficult to tell what effects land tenure and farm size are going to have on the adoption of the EIS. The only thing I could say is that according to the data in Part I and II the farm size and tenure arrangement in Northern and Khartoum provinces are very similar to those of Egypt so I would say if they do not encourage the adoption of EIS they will not discourage it. Even the institutional arrangements and the village structure are more or less similar between Sudan and Egypt to the extent that together they are called the Nile Valley nation.

(6) Human Capital and Experience:

I think human capital and experience are going to be the main factors that will encourage the adoption of EIS in Northern and Khartoum provinces. Indicated in Part I that farmers below forty years of age in both provinces may have had formal education, and farmers above forty have had "Khalwa" education. Since the level of education proved to be positively related to adoption rate, the human capital in both provinces will encourage the adoption of the EIS. With regard to experience: the traditional "Sagiya" had been used in Sudan for a long time, so "old people" should have a very good experience on how it is made and how it works and that will help much in encouraging the adoption of the EIS in Northern and Khartoum province.

I have talked to Dr. Schwab about which factors he thinks will affect the adoption of the EIS most. He said the introduction of the EIS is a durable major change in the irrigation system. So he thinks that the culture and the attitudes of farmers towards acceptance of an intermediate technology will be one of the major factors that will affect the adoption of the EIS. He also considers the need and the profitability to be very important in determining the adoption rate. Dr. Schwab also considers the initial cost, the operating cost and the cost of the loan (the interest rate) in addition to the credit availability itself to be major factors in determining the adoption. He also considers the social and cultural relations between Sudan and Egypt to play a role in encouraging the adoption. Lastly, Dr. Schwab says the stability of the government is also important for such major change in the irrigation system. (Schwab 1988 - personal communication)

SUMMARY AND CONCLUSIONS

The River Nile, the surface wells and deep water wells are the main sources of irrigation water in the Northern and Khartoum provinces. Lift pumps are used to raise water whether from the river, the surface wells or the bore wells. There are two types of irrigation schemes: governmental (public) and private. The shortage of fuel, spare parts and maintenance services for the lift pumps has created acute irrigation problems:

- The perennial crops (citrus, mangoes) and the annual crops (wheat, sorghum, vegetables, beans and fodder crops) suffer so much from delayed irrigation that they lose a lot of their crop during the summer season.

- Animals are decreasing in number due to lack of fodder; animals for meat are imported from other parts of Sudan and milk is imported from outside Sudan.

- People are continuously migrating from the agricultural sector looking for jobs in the cities.

* Surprisingly, more than 70% of irrigation in Egypt is done by the Egyptian improved "Sagiya" (EIS) which is locally made (from local materials) and locally maintained. It is drawn by animal power.

* This study has investigated the transfer of the EIS to the Northern and Khartoum provinces of the Sudan. The study has concluded that: <u>the transfer of the EIS may help in solving the problem</u>:

- The production of the perennial crops (in the governmental and private schemes) and the annual crops (in the private schemes) will be increased by maintaining the recommended irrigation interval.

- The production of the stable food (wheat and sorghum), beans and fodder will be allowed in the governmental schemes.

- The production of vegetables will be allowed in the governmental schemes. There is a high market demand for vegetables, especially in the Khartoum province, and more than one crop is possible in the private schemes.

- Animals will be raised for meat and milk and for pulling the "Sagiya".

- More jobs will be created due to the intensive cropping.

The study has shown that the EIS will be highly compatible with the farming system:

- It could be locally constructed from local materials and it could be locally maintained.

- People have a good experience with the old traditional Sudanese "Sagiya," which will help much in accepting the EIS.

- As indicated, it will create more jobs through intensive cropping.

* Human capital, experience, need, profitability, initial cost and credit availability are found to be the most important factors determining the adoption rate.

* The role of the research is very important for adapting the EIS. Possible improvements are:

- The size of the EIS and the size of the pockets could be varied according to the need.

- The horizontal wheel, the attachments and the bearings could be made of metal like the vertical wheel to make the weight lighter for easier draft.

- The gears could be made in a way that the speed of horizontal wheel would be converted to a higher speed on the vertical wheel.

- The size of the draft animal could be improved through animal husbandry.

* The role of the government is very important in:

- Adopting a clear policy for importing the EIS (whether it is material, design or capacity transfer form).

- Investing in research by assigning the right staff and providing the required facilities.

- Supporting the Extension Services to ensure adequate information and training programs.

- Directing the vocational training and creating a section of specialization in construction and maintenance of the "Sagiya".

- Adopting a very clear credit policy through the Agricultural Bank to provide credit for farmers so as to be able to acquire the new technology and to purchase the draft animal.

- Finally, an effective transfer and adoption of technology depends on developing the policies for encouraging the indigenous development of the technology.

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