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Final Report

Annex 6: Agriculture and Livestock

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ANNEX 6

AGRICULTURE AND LIVESTOCK

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1. AGRICULTURE

1.1 INTRODUCTION

Wad Misken agricultural project area is located at the right bank of Rahad River, which starts from Ethiopia and joins the Blue Nile at the North of Wad Medani. Rahad River flows during the rainy season with about one-milliard cubic meters yearly. The proposed project is about 7,500 ha net and lies in the Southern end of Rahad I project and it is a part of proposed Rahad II project. It lies between Hawata Town in the North and Wad Meskin Village at the South. The project area lies on the eastern side of the seasonal Rahad River. The Wad Meskin Project site is close to the Rahad Project Phase II which lays within latitudes 13º - 40´ and 15º - 10´ and longitude 33º - 40´ to 34º - 20´ E.

1.2 CROPPING PATTERN

Due to the seasonal nature of the Rahad river flow which normally starts early in July and continues to late October yearly, early and medium maturity crop cultivars have been recommended for cultivation in the project. Field crops that normally grow in the rain belt, which includes the project area; have been selected for the project with the objective of increasing productivity and improving the quality as a direct result of supplementary irrigation and use of modern technologies. This will result in food security for farmers and area inhabitants in addition to an increase in farmer's returns which will improve their living standards, i.e. poverty alleviation is another goal for people in the area whether farmers or workers in farms. Summer season vegetables with short or medium life span were selected for cultivation in the project. These crops will contribute positively in improving diet of inhabitants of the area as they can supply all necessary vitamins and materials needed for human nutrition. This will help in combating some human diseases present nowadays in the project area, e.g. night blindness.

The remains of crops after harvest can help animal wealth in the area as a good source of animal feed. At least farmers who own animals may not have to follow a nomadic life any more as they can feed their animals from their crops by products. The crops selected for farming in the project area are selected to meet the above objectives and make use of the rains and the irrigation system designed for the project. Economical considerations also were observed beside the farmers experience in cultivating these crops and vegetables. The cropping pattern selected is represented in table 1.1 below. The table shows crop area proposed, sowing date and crop duration.

Table 1.1: Cropping Pattern

Ref	Crop	Area in ha	Percentage of total area	Sowing date	Crop duration
1	Sorghum	2,498	33.3	Second half of June and 1st half of July	110
2	Groundnut	2,498	33.3	Second half of June and 1st half of July	120
3	Sesame/ Sunflower	1,065	14.2	1st half of July and middle of July	100/110
4	Vegetables	1,065	14.2	July and August	80/120
5	Forest trees	0,374	5.0	July/August	Continuous
	Total	7,500	100		

1.3 CROP ROTATION

Taking into account the amount and distribution of rainfall in the project's site together with the short duration of the Rahad river discharge, which is planned to be utilized for supplementary irrigation, crop options have to be within these crops, which have a short or a medium duration period for maturation. These characteristics are available in the following crops; some of which are crops are already grown by traditional farmers under rain fed conditions in the central clays of the Sudan.

1.3.1 Sorghum

Early and medium maturing varieties are recommended. The most popular are Hageen Dura1, Wad Ahmed, Gadam Al Hamam and White Dwarf Milo. The expected yield is 2 to 4 ton/ha.

1.3.2 Groundnut

Early maturing and draught tolerant cultivars Sodari and Ghebaish are grown in Kurdofan states under rain fed conditions normally with low yields but with supplementary irrigation conditions the yield is expected to range between 1.0 to 2.4 ton/ha. Medium maturing varieties are MH383, Kiriz, Ahmadi, Tozi, and Medani. These have been released by ARC and characterized by high yields and good quality. Their yields range from 2.4 to 3.4 ton/ha.

1.3.3 Sunflower

The crop is successfully grown under rain fed conditions in Damazin area especially under zero tillage system. The expected average yield in traditional rain fed sector is about 0.96 ton/ha while under Zero tillage system it may reach 1.2 ton/ha. Under supplementary irrigation conditions the expected yield is 1 to 2 ton/ha.

1.3.4 Sesame

Several cultivars, especially white seeded are recommended e.g. Kennana2. These cultivars under supplementary irrigation are expected to give an average yield of 1.2 to 2.0 ton/ha.

1.4 VEGETABLES

These include different kinds of vegetable like Okra, Cucurbits (Melon, Watermelon, and Cucumber), leafy vegetables (Rocket, Jews mallow, Purslane) and sweet Potato. The lifespan duration of the recommended cultivars of these vegetables can easily fit in the project considering the availability of supplementary irrigation.

1.5 CROP CHOICE

The choice of crops to be cultivated and adoption of an appropriate rotation shall be made according to sustainable economic returns and other related factors particularly soil moisture availability. However, a three-course rotation is suggested as per Table 1.2 below.

Table 1.2: Crop Rotation Schedule

Area	First Year	Second Year	Third Year
7,500 ha	Sorghum	Vegetables/Sesame or Sunflower	Groundnut
7,500 ha	Vegetables/Sesame or Sunflower	Groundnut	Sorghum
7,500 ha	Groundnut	Sorghum	Vegetables/Sesame or Sunflower

1.6 CROP WATER REQUIREMENT

Crop water requirement was calculated from the metrological data collected at the Abu Naama Station using crop factors produced by Farbrother at Wad Medani Agricultural Research Station (ARC). The supplementary irrigation needed for a particular crop is obtained by subtracting total rainfall from the total water requirement of the crop. The planting irrigation water in early July was calculated as 800 m^3 to close cracks and bring the soil profile to field capacity. Subsequent irrigation was calculated according to Farbrother factors for each crop. The calculations are made on the bases of one hectare of land.

1.6.1 Sorghum

Sowing date: Late July

Table 1.3: Sorghum Water Requirements

Month	Crop Water Requirement (m^3/ha/month)	Rain Fall (m^3/ha/month)	Supplementary Irrigation (m^3/ha/month)
July	2,818*	1,550	1,268
August	1,609	1,850	0
September	1,885	1,119	766
October	1,785	381	1,404
Total			3,438

- including the planting irrigation water

1.6.2 Groundnut

Sowing date: Early July

Table 1.4: Groundnut Water Requirements

Month	Crop Water Requirement (m^3/ha/month)	Rain Fall (m^3/ha/month)	Supplementary Irrigation (m^3/ha/month)
July	2,818*	1,550	1,268
August	1,135	1,850	0
September	1,742	1,119	623
October	1,683	381	1,302
Total			3,193

* including the planting irrigation water

1.6.3 Sesame

Sowing date: Early July

Table 1.5: Sesame Water Requirements

Month	Crop Water Requirement (m^3/ha/month)	Rain Fall (m^3/ha/month)	Supplementary Irrigation (m^3/ha/month)
July	3,196*	1,550	1,646
August	1,880	1,850	30
September	1,637	1,119	518
October	1,226	381	845
Total			3,039

* including the planting irrigation water

1.6.4 Sunflower

Sowing date: Early July

Table 1.6: Sunflower Water Requirements

Month	Crop Water Requirement (m^3/ha/month)	Rain Fall (m^3/ha/month)	Supplementary Irrigation (m^3/ha/month)
July	2,818*	1,550	1,268
August	1,333	1,850	0
September	1,904	1,119	785
October	1,833	381	1,452
Total			3,505

* including the planting irrigation water

1.6.5 Vegetables

Vegetable sowing date is July /August and the water requirement can be stated as per table 1.6

Table 1.7: Vegetable Water Requirements

Month	Crop Water Requirement (m^3/ha/month)	Rain Fall (m^3/ha/month)	Supplementary Irrigation (m^3/ha/month)
July	2,818	1,550	1,268
August	1,904	1,850	54
September	1,904	1,119	785
October	1,904	381	1,523
Total			3,630

1.7 Cultural Practices

The selected crops for Wad Misken project are sorghum, groundnuts, sesame, sunflower and vegetables. These crops insure food security for inhabitants of the project area as well as neighbouring areas besides reasonable returns for formers from cash crops. The study suggests the mechanization of agricultural operations wherever feasible aiming at the precision of these operations in addition to the reduction of the cost of production. However, in order to achieve the optimum crop productivity a number of cultural practices are recommended. These are described in Appendix A.

1.8 Productivity and cost of Field crops and Vegetables

The tables below are a summary of productivity and cost of vegetable production.

Table 1.8: Productivity of Field Crops and Vegetables

Ref	Vegetable	Yearly production in ton/ha			
		First Year	Second Year	Third Year	Forth Year
1	Sorghum	1.9	2.4	2.9	3.4
2	Groundnut	2.4	2.7	3.1	3.4
3	Sesame	1.2	1.5	1.8	2.0
4	Sunflower	1.0	1.3	1.5	1.8
5	Okra	7.2	9.6	12.0	14.0
6	Rocket	12.0	13.2	14.6	16.8
7	Jews mallow	14.4	16.2	18.0	19.2

8	Purslane	12.0	16.0	20.0	24.0
9	Melon	12.0	14.5	17.0	19.2
10	Cucumber	19.0	26.0	33.0	40.0
11	Water Melon	19.0	22.0	25.0	29.0
12	Sweet Potato	14.0	20.0	28.0	38.0

Table 1.9: Cost of production per hectare of Vegetables in SDG

Ref	Operation	Cost in SDG
1	Land preparation	71
2	Sowing/planting	62
3	Weeding	95
4	Fertilizer application	24
5	Irrigation (field operations)	71
6	Seeds	190
7	Urea	143
8	Water & administration fees	286
9	Harvesting	381
10	Packing material	48
11	Handling and transport	14
	Total production cost	1,385

Table 1.10: Farm gate prices per ton in SDG for Local market and in USD for export

Ref	Vegetable	Local in SDG	Export in USD	Remarks
1	Sorghum	650-900	250-350	
2	Groundnut	1,360	550	
3	Sunflower	1,040	400	
4	Sesame	2,350	950	
5	Okra	2,000	800	70% of production is exportable
6	Melon	780	300	40% of production is exportable
7	Cucumber	325		
8	Sweet potato	700		
9	Water melon	179		
10	Rocket	800		
11	Jews melon	250		
12	Purslane	3,645		

1.9 Mechanized Operations for Wad Meskin Project

Mechanization of some agricultural practices in this project becomes a necessity in order to reduce cost, save time and perform the required specifications of the practice. The availability of tractors and farm implements, the skilled labour, the technical backup and the technical recommendations make performing the mechanizable operations a good option in the project since farmers are inherent component in the production system. It was agreed that labour intensive, difficult operations and time-consuming practices should be mechanized. The mechanized operations shall include seedbed preparation, seeding, fertilizer applications, herbicide application, harvesting and transport of inputs as well as produce. These operations are:

1.9.1 Seed bed preparation

In order to achieve a good seedbed, a number of operations need to be performed to the predominantly Vertisolic soils of the project.

1.9.2 Disc harrowing

This operation is necessary to break the soil strength, cut, mix and pulverize the soil and control weeds. It is usually performed after 100- 120 mm of rainfall. At this stage, the soil cracks are closed. The early weeds start emerging and the soil is reasonably workable by disc implements. Due to the short period of available working days for machinery in the project area, large size tractors of 160 – 180 hp with matching disc harrows are recommended to be used.

1.9.3 Land Planning

Since supplementary irrigations is used in the project, an operation of land plaining to reduce the clod size of the previous operation of disc harrowing and help level the soil surface is needed.

This will make irrigation be performed in an efficient and easy way. Land planning could be performed using a locally made steel frame pulled by a 75 hp tractor.

1.9.4 Ridging

It is needed for all suggested crops. Ridging should act as a water harvesting technique and at the same time help the crop to avoid water logging.

1.9.5 Seeding

Two types of seeding machines are recommended these are:

a Seed Drill: to seed sorghum, sesame and sunflower

b row planter: to plant groundnut

These are important to achieve the optimum plant population per unit area, which is a pre requisite for optimum production.

1.9.6 Herbicide application

Weeds constitute a serious problem in the project area. In order to help farmers reduce the cost of weed control and to get high yields, herbicides must be used. These are applied using field 2,000-liter boom sprayer trailed by a 75 hp tractor.

1.9.7 Harvesting

A number of harvesting machines are to be used:

a Combine harvesting for sorghum and sunflower. This is done by using a self-propelled combine harvester. It cuts, threshes, cleans and bags the product in one run.

b Stationary thresher for partial mechanization of harvesting. This machine is operated by a 75 hp tractor.

c Sesame cutter/binder is used to cut and bind sesame plants before shattering when the crop had reached physiological maturity. The sesame cutter/binder is a self-propelled machine.

d Groundnut thresher is a stationary thresher operated by a 75 hp tractor. It separates the nuts from the vines. It is manually fed from the heaps of dried groundnut plants collected after being dug out manually.

1.10 MACHINERY MANAGEMENT

Machines and mechanized operations will be arranged by an Agricultural Engineering Unit (AEU). This unit shall be headed by an Agricultural Engineer supported by four technicians, ten tractor operators and four skilled labours. A mechanical workshop equipped with necessary equipment and tools shall be established. It will take care of repair and maintenance of the tractors, machinery and vehicles.

Table 1.11: Tractors and Self-propelled Equipment needed for the Project

Ref	Description	Quantity
1	160 – 180 hp tractor	4
2	75 – 80 hp tractor	8
3	Combine harvester	2
4	Sesame cutter/binder	1

Table 1.12: List of Farm Implements needed for the Project

Ref	Description	Quantity
1	Heavy duty disc harrow	4
2	Land plaining frame	8
3	Seed drill	8
4	Row planter	8
5	Field sprayer	4
6	Stationary thresher	4
7	3 ton trailer	8

1.11 AGRICULTURAL EXTENSION

Farmers are the core group responsible for crop production in this project. Hence, an agricultural extension and technology transfer unit (AETTU) is needed to help farmers organize themselves, extend technology to them, train them, improve their skills in order to increase their productivity and reduce the cost of production. The AETTU will be operated by a five staff team, one manager and four field extension agents. This unit will act as a link between farmers and the research stations.

1.12 RESEARCH AND TECHNOLOGY DEVELOPMENT

Modern agricultural technologies must be adopted in this project in order to achieve high crop yields, reduce cost of production and attain high efficiency of resources utilization. The project needs to rely on a reliable source to provide recommendations of proven technology to technically back the management of the project and the farmers in planning and to provide advice for appropriate decisions. The most relevant and qualified institution to technically back the project is Rahad Research Station. It is located near Faw town about 50 km from the project area. Rahad Research Station is staffed with a competent team of scientists in agronomy, agricultural engineering, soils, crop protection, horticultural and agricultural economics. Rahad Research Station can be contracted as a station team or as individuals to perform the technical back stopping for the project.

The Extension and Technology Transfer Unit of the project will be linking the research with the project management and the farmers. On farm, trials can be conducted to verify technologies at the project. The researchers can also help in the training and capacity building of the farmers and the project staff.

2. LIVESTOCK

2.1 PREAMBLE

This report presents the findings of the Livestock Production/Animal Health team that worked in Sudan during the period 20 November to 26 November 2009. During this period time was spent in Khartoum in discussions and in reading project and related documentation. A field visit was made to the Wad Meskin Project Area during which discussions were held in Hawata with the District Administrator and staff of the Ministry of Animal Resources. Discussions were held in the Wad Meskin entity with administrative and technical staff and the team met with and discussed the problems and aspirations of sedentary farmers and transhumant livestock owners. The team then had discussions with staff members of the Gadarif State Ministry of Animal and Fish Resources and had the honour to be received by His Excellency the Minister.

2.2 LIVESTOCK SECTOR BACKGROUND

Sudan's agricultural GDP includes a contribution of about 20 per cent from livestock. In the north-central part of Sudan which includes the project area, extensive range-based and nomadic or transhumant livestock production has been the main contributor to the provision of animal protein for the Sudanese people and also contributed greatly to export and thus to foreign exchange earnings. Over the final 20 years of the 20th century, however, development of the "central rain lands" with large scale mechanized and semi-mechanized farming schemes that cut across many traditional livestock movement routes had negative effects on animal production. It can be expected that the extension of cropped areas at the expense of grazing land coupled with the development of irrigation and rapid human demographic growth will continue this trend. Sedentary or almost sedentary livestock production systems that associate crops with livestock can, on the other hand, be expected to become more important.

The livestock subsector employs directly or indirectly about 40 per cent of the population and contributes valuable animal protein to the diets of all of Sudan's people. Some 80 per cent of the animal wealth is owned by nomads and transhumant pastoralists. Before the advent of increasingly large oil incomes export revenue from live animals, meat and hides and skins was in the range US$ 66-117 million in the 1990s. This not inconsiderable amount (for those days) represented 20-25 per cent of all foreign exchange earnings. The subsector overtook cotton as the most important export commodity in monetary terms in 1993. The discovery and exploitation of oil has changed the situation somewhat but these facts still remain not unimportant considerations for a country that will continue to have a need for a diversified production base. To add spice to its already substantial comparative advantage the subsector's own foreign exchange requirements are small when compared to those needed for crop production.

Livestock are a strategic element in livelihoods, income generation, and food security and in agricultural development. They contribute to the national economy and to human welfare and livelihoods via four principal pillars:

In **poverty alleviation**

- they are the only assets of many of the landless poor
- their products (milk, meat, eggs, wool) provide a direct or indirect source of income throughout the year
- they are a means of capital accumulation (livestock always appreciate but rarely depreciate) and provide a cash buffer in times of need

In **food security**

- they are a buffer against low crop yields and crop failure and are thus an important element in risk management
- milk and eggs are the only agricultural products that can be harvested every day throughout the year
- they can be productive throughout the year where crop production is difficult or impossible
- they provide draught power without which crop production in many areas would be severely compromised
- they make use of crop and agro-industrial by-products and waste and convert them to high quality human food

In **environmental conservation**

- they produce manure that contributes to sustainable nutrient cycling and maintenance of soil fertility and structure
- they contribute to bush and weed control in many areas

In matters of **gender equality**

- livestock, especially small animals are often owned by women who are denied access to land
- women (and children) often have priority access to livestock products for consumption or sale
- they reduce much of the drudgery of women's and children's work when used for transport

2.3 PRODUCTION SYSTEMS

People in the project area are either farmers or transhumant pastoralists who move seasonally with their livestock in search of feed and water, primarily for their livestock and secondarily for themselves. Income for both farmers and nomads is low because of the limited output of agricultural crops and livestock products. The situation is aggravated by the large number of Internally Displaced Persons (IDPs) who have been forced into the area as a result of drought, famine and civil conflict in their home areas and real poverty is widespread. Local services such as health are no longer able to cope and lack of real employment especially among the young is the norm and creates real economic, social and political problems. In one attempt to alleviate the situation destruction of trees by both residents and incomers has become a major activity with the making of charcoal and firewood contributing to an accelerating environmental deterioration.

2.3.1 Crop production

There is a divide in crop production between the large to very large semi mechanized commercial operations and the smaller essentially subsistence farmers. Both large and small farms are involved in rain fed agriculture but many small farmers practise irrigation on the banks of Rahad and Dinder rivers. The main rain fed crops are sorghum ('durra) and sesame ('simsim') with some millet ('dukhn'). Irrigation is mainly in small plots along the river banks where there are small areas of orchard (mango, guava and citrus) and some vegetables (tomatoes, cucumber, spinach) which are locally marketed. The seasonality of the rivers makes it difficult to cultivate big areas in the absence of water storage facilities. Crop farmers keep very few livestock which comprise some cattle, more sheep and most goats together with some domestic poultry.

Land tenure is transparent *de jure* but tends to be opaque *de facto*. Many if not all small holders have legal documents attesting to "ownership". Large farmers have often taken advantage of the prevailing situation to encroach on grazing lands and particularly on to the all-important stock routes which the livestock owners need for their livelihoods and indeed their very survival.

Continuous rainy season cropping (but note that this does not mean that all land is cropped every year or throughout the year) has resulted in impoverishment and degradation of the soil leaving large areas bare to wind erosion and leading to further reduction in the already low yields due to drought, viral and bacterial diseases and insect pests.

2.3.2 Livestock production

Settled villagers in the Wad Meskin area keep few livestock. In total there are about 650 cattle, 2,100 sheep and 1,450 goats (Table 2.1). These animals provide some milk, a little meat and possibly a small surplus sold for cash.

Table 2.1: Livestock numbers in settled villagers in the Wad Misken area

Village	Livestock		
	Cattle	Sheep	Goats
Bazura Khalifa	100	300	80
Hilat Khalifa	300	500	200
Ingamaina	0	0	20
Kumor Basheer	15	150	70
Wad Batool Mokharim	0	80	20
Wad Batool Hilat Bakheet	0	0	10
Shamam	0	200	200
Wad Abakar	150	400	600
Abdel Lateef	10	200	150
Maykankana	75	300	100

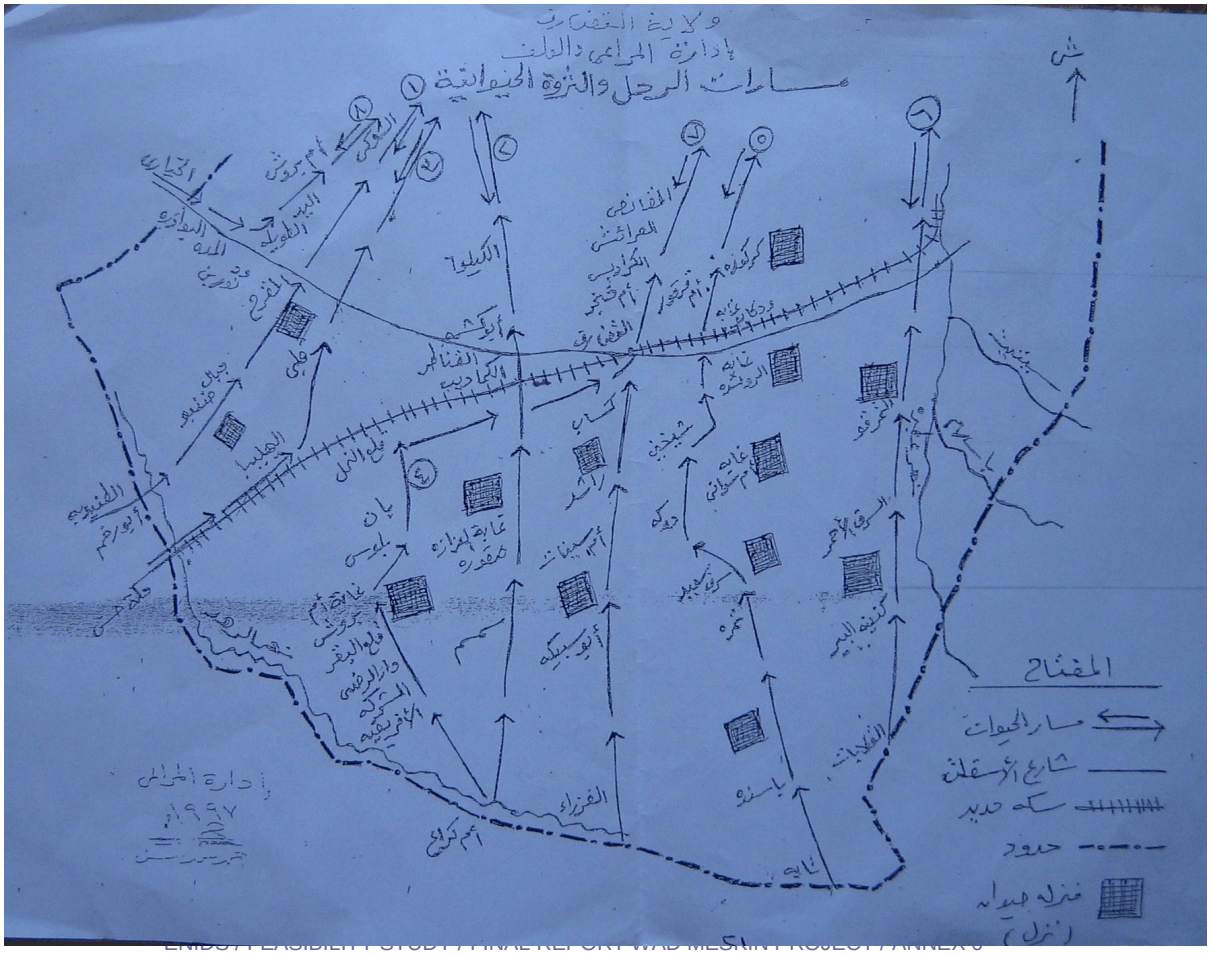
Source: Socioeconomic Field Survey July 2009

Pastoral transhumance is the main livestock production system in the project area. It has been said that this system (together with fully nomadic pastoralism as practised in the far north of Sudan) "are ecological adaptations to the rigours of a stern environment". The project area provides one of the most stern environments imaginable. Transhumance is a logical response by livestock owners to the all pervading problem of finding sufficient nourishment for their animals and themselves. A pastoral transhumance system can be defined as one that obtains more than 50 per cent of the total of its household revenue (including the value of home consumption plus income) or more than 20 per cent of human food energy from livestock or livestock products. Earnings from transport by camels and donkeys and from sale of labour in the urban areas also contribute to total income.

The major pastoral tribes in the area are Rufa'a, Gawasma, Halloween and Lahoween. There are also small numbers of migrant pastoralists from western Sudan as well as "Sudanized" migrants from West Africa. These last were mostly Fulani in origin but are known as Fellata in Sudan: some have been in Sudan for many generations and their origin, among other things, is attested in some of the cattle of the area. In the main part of the Project Area water is plentiful during the rainy season ('kharif') but becomes increasingly scarce as the dry season ('seif') progresses.

Pastoralists, however, must leave the main part of the project area in the 'kharif' as their presence is a constraint to crop production. In the project area, however, movement is also impelled by the increasing presence of noisome physical presence of sucking and biting flies including members of the family Tabanidae which are vectors of many human and livestock diseases including trypanosomosis. Thus, they move from the south in the early 'kharif' travelling northwards, mainly to the Butana grasslands in July and return southwards in late October when rain fed crops should have been harvested. To facilitate these movements a number of "stock routes" traverse the area (Figure 2.1). These are mainly inclined in a southwest/northeast direction and some take in the district centre of Hawata which is an important location for exchange of goods and marketing of livestock (although every village, almost irrespective of its size, also has facilities for such functions

Figure 2.1: Traditional stock routes through the Project Area



Competition for land between cultivators and livestock keepers has intensified in recent years. Although nominally accepted by crop farmers the spread of both subsistence and larger scale semi-mechanized farming has led to encroachment onto and partial or total blocking of the traditional stock routes. The administrative authorities try to minimize the resultant inevitable conflicts between farmer and pastoral groups but these are still very real. Many of the problems also relate to access to water. Livestock owners must have access to water on a regular basis both at their camps in the dry season and on the stock routes during both their northerly and southerly movements. Animal husbandry ("management") practices, within the limitations imposed by the environment, are generally good by the large scale livestock owners. The annual transhumance is a striking example of an adapted management practice. Owners are also aware of disease problems and take traditional and modern steps to mitigate these often by avoiding places that are known risk areas for disease or by using medicines and vaccination.

Many owners are also aware of the value of supplementary feeding: although this is not practised as a general rule because of the expense and difficulty of obtaining concentrates some owners who have created for themselves a niche market in milk production does provide their lactating cows with supplementary feed (Figure 2.2).

Figure 2.2: Feeding a sesame-based supplement to range cattle to increase milk production

2.4 LIVESTOCK RESOURCES

Sudan has one of the largest and most species-diverse arrays of domestic livestock in Africa. A common belief -- the accepted wisdom -- is that Sudanese livestock are of inherently low productivity. What is meant, however, is not "productivity" (which implies an input-output function) but "production" (which implies only an output function). It is further generally assumed that a root cause of low production is the poor genetic quality of Sudanese livestock and, therefore, the need for their improvement.

Belief in the inadequacy of the farm animal genetic resources fails to take account of the systems in which they are bred and expected to produce.

Sudan's livestock "breeds"[1] have adapted over thousands of years to these systems and to the harsh physical environment in which they operate. Their products, and especially meat, are also and certainly not surprisingly in view of their long and close association with man, well suited to the taste preferences of regional customers. It would be difficult -- even impossible and perhaps most important of all totally undesirable -- to find "designer" breeds to replace or improve them in the short or medium term.

There are estimated to be over 3 million cattle in Gadarif State of which as many as 2 million are at sometime or other in the Hawata area. Sheep are the most numerous animals, followed by camels, goats and cattle.

2.4.1 Cattle

The Kenana (Figure 2.3) and Butana (and Baqqara farther to the west) are clearly differentiated types in the Northern Sudan Short horned Zebu group. Others such as the Rufa'a type are also sometimes recognized. All three of these types are common in the project area in both pure and mixed herds. In good quality stock (there appear to be few in the project area!) the withers (shoulder) height in Kenana mature bulls is 140 cm and they weigh up to 550 kg. Females are 130 cm at the withers and weigh 450 kg. The main colour is light blue-grey shading to nearly black on the head, neck rump, hindquarters and legs in the male. Females have black rings round the eyes. Kenana are considered mainly as milk animals but have good potential for beef. The Butana type is similar to the Kenana in conformation and size but is a rich ruby red colour. As for the Kenana, the Butana has mainly been developed as a dairy animal but has good conformation for beef production. The Rufa'a is again similar in conformation but shows a wide variety of colours.

[1] The term "breed" is used here in the conventional sense but it should be understood that most populations are broad types with very considerable variation within them

Figure 2.3: Kenana stud bull at Um Banein Research Station

2.4.2 Sheep

The Sudan Desert sheep is a large long-thin-tailed type (although the tail has varying amounts of fat at the base or farther down) that is justifiably renowned for its generally large size and its outstanding ability to survive and produce under harsh environmental conditions. Mature males usually stand 80 cm or more at the withers and weigh at least 60 kg: females weigh up to 50 kg. Although often treated as a single type there are many subtypes within the population which not only vary in conformation and colour but also in performance. At least two of the major subtypes -- Shugor (Figure 2.4) and Watish – are found in the project area.

Figure 2.4: The Shugor subtype of Sudan Desert sheep

Haemoglobin Type B in Sudan Desert sheep could lead to high productivity, particularly in reproductive performance. Selection for this characteristic would help to increase the number of young born without having to increase the size of the breeding female flock.

2.4.3 Goats

The Sudan Desert goat is the main type in the project area although there are also numbers of the Nubian type. Sudan Desert goats are large and stand 65-85 cm at the withers: males weigh 40-60 kg at maturity and females about 35 kg. They are good producers of meat and milk. Nubian goats are of large size, being 70-75 cm at the withers (with the Shukria variety up to 85 cm): males weigh 50-70 kg and females 40-60 kg.

2.4.4 Camels

Camels are classed as riding or pack (or "baggager") types but many intermediate or multipurpose varieties exist. Transport of people and goods is a major function of Sudan's camels but they have a deserved reputation as milk animals. A specialist trade in racing types, mainly for export, developed in the 1980s and 1990s. Meat has been considered as a by-product but there has always been a thriving informal export trade to Egypt for this purpose with more formal exports to other countries.

2.5 FEED RESOURCES

About 90 per cent of Sudanese livestock are raised in traditional pastoralist systems. In the past in an "average" year it was estimated that 85 per cent of feed for livestock was derived from natural rangelands, 10 per cent from crop residues and by-products and the remainder from sources including cultivated fodder (most of which is irrigated) and purchased concentrates. Variations in the timing and in the amount of rainfall result in very large fluctuations in the quantity (and indeed the quality) of natural range feed that is available from year to year. Similarly, crop areas and yields vary tremendously from year to year in response to a range of factors including rainfall. Much of the feed derived from crops is straw, stover ('qassab') and stubble of very low nutritional value. Supplementation with high protein forages or other protein feeds is central to maintaining livestock productivity. This is a strategy that is well understood but not always put into practice by producers.

2.5.1 Rangelands and natural pastures

Range resources have deteriorated markedly over the years with a corresponding loss of livestock production potential. A number of interacting factors have been involved:

- rain fed cropping (mechanized and traditional) has increased markedly which has reduced the rangeland area. The contribution of crop residues – sorghum and sesame are the principal crops on the clay soils of the project area – partly compensates for this and fallowed crop lands offer better prospects for low cost improvement with exotic legumes, compared with seeding into undisturbed rangeland;
- pastoralists have been pushed into marginal areas subject to more frequent drought;
- rainfall has declined and become less reliable with fragile areas in the north experiencing much greater changes than the higher rainfall areas to the south; and
- stocking pressure on the remaining rangelands, particularly, in the north has increased.

The net result of these effects is a state transition[2] in these crucial rangeland areas. This is manifested in a reduction or loss of the more valuable rangeland components including palatable and productive perennial grasses and tree fodder and a general shift towards more annual species providing a shorter period of quality feed, lower overall productivity and increased erosion hazard.

The rangelands of the clay soils of the project area in the past had as the main grasses *Aristida* spp., *Schoenefeldia gracilis*, *Eragrostis* spp., *Cenchrus setigerus*, *Cymbopogon proximus*, *Lasiurus hirsutus* and *Panicum turgidum*. Important herbs included species of *Blepharis*, *Crotalaria* and *Zornia*. Trees and shrubs were of more significance in the long dry season when forage from grasses was scarce and of low quality. Trees included *Acacia ehrenbergiana, A.tortilis*, *Capparis decidua*, *Maerua crassifolia*, *Salvadora persica* and *Ziziphus spina-christi* ('sidr'; the edible fruit is known as 'nabak'). Fodder yields were highly variable but mainly in the range of 400-500 kg dry matter per hectare (150-250 kg/feddan) with higher yields in some depressions.

In the project area of 2009, as noted on the field trip, the dominant tree species south of Hawata are: *Acacia seyal* ('talh'), *Balanites aegyptiaca* ('heglig', desert date, the hard round fruit is called 'lalob') and scattered stand of *Acacia mellifera* ('kitr). Along the banks of Rahad river *Acacia nilotica* ('sunt') and *Acacia seyal* are dominant. Away from the Rahad the landscape includes blocks of rain fed farming between patches of "rainland" which appear to be very long term fallow. These latter have been invaded by weedy shrubs including *Acacia mellifera* and *Acacia nubica*. The field layer has been largely reduced to weedy less palatable species including *Cymbopogan nervatus* ('naal'), *C.proximus* ('mahareb') and *Ocimum basilicum* ('rehan').

2.5.2 Postharvest crop residues and by-products

Fallows and stubbles are used to provide some feed. Crop residues are available mainly from dry land crops but small amounts can also be found on irrigated areas. Crop residues are a strategic source of feed for livestock during the dry season with a part grazed *in situ* and part transported and stored for subsequent use (Figure 2.5). Transport of these bulky materials of low nutritive value is a major constraint to their large scale use. Rain fed crop areas and yields vary greatly from year to year so it is not practicable to estimate the quantities available. The quantities are low, however, in relation to the potential and reflect poor practices, lack of inputs and difficult cropping environments.

Considerable areas of forage sorghum (especially the 70-day 'abu sabeen' variety) are grown either as a late rains catch crop or on residual soil moisture.

[2] **A state transition is a change which is unlikely to be reversed without either a major improvement in climate or other environmental factors (including stocking pressure).**

As most of this is produced by crop farmers most of it is produced for sale. It is mainly channelled to the local market where it is sold as green or partly dried fodder.

2.6 SERVICES

2.6.1 Animal health

Decentralization of the major agricultural support services consequent on the establishment of the federal system has led only partially to a real sharing of tasks especially in animal health delivery and extension provision. Training, policy formulation and financing remain largely the responsibility of the federal government. Service delivery is weak in many areas and much still remains to be done to make this an effective weapon in the development of Sudan's agriculture. Each of the 26 Federal States that constitute the Sudan Republic has an Animal Resources Department which includes animal health services and Gadarif is no exception in this respect.

Figure 2.5: Sorghum stover and sesame haulm stored for use as livestock feed

The "Ministry" of Animal Resources of Gadarif State based in the capital town of the same name appears well staffed, active and knowledgeable. It supports animal health and some production services in the local areas both technically and financially. It has recently received a new consignment of Mobile Veterinary Units (MVUs) for work in the field. In the Hawata area there are two fully qualified veterinary practitioners, six veterinary assistants and several other support staff, some of whom are posted out to the villages. The animal health service in Hawata is reasonably well supplied with buildings, equipment and pharmaceuticals. It also operates a number of MVUs (Figure 2.6(i)). The veterinary assistants in the villages have basic equipment and pharmaceutical supplies and are allowed to supplement their income by setting up their own veterinary pharmacy (Figure 2.6(ii)).

Disease surveillance is a – and indeed probably the – major animal health activity. Serological, histopathological and faecal samples are collected by the MVUs. Some testing is undertaken in the field but most samples are returned to the central and regional laboratories for testing. The main diseases reported in the area which can be controlled by vaccination are Peste des Petits Ruminants (a rinderpest-loke disease of goats and sheep), sheep pox, anthrax and blackquarter. Most animal health services and pharmaceuticals are provided free of charge to livestock owners.

The latter, however, are prepared to pay for the cost of vaccinations because of the protection it provides to their most important asset. Trypanosomosis, transmitted seasonally by tsetse flies to cattle and all year round by other biting flies to camels (in which the disease is called 'nagana') is well recognized by owners who will buy drugs for self treatment. Tick control treatment in order to prevent the spread of Theileria, Babesia and Anaplasma is also available from the MVUs.

The Animal Resources Department is also responsible for "improvement" of the local livestock. Its inputs in this respect in the project area have fortunately been limited. This involved supplying male goats of the Toggenburg (a European breed) and Damascus (a Middle Eastern breed also known as 'shami') breeds to producers on request and provision of a very limited artificial insemination (AI) service which would purportedly improve the genetic value and milk production of local cattle.

Figure 2.6: (i) Mobile Veterinary Clinic in Hawata, (ii) Private Veterinary Pharmacy in Bazura

2.6.2 Marketing

Livestock marketing in Sudan has always been a private sector activity. Government's role has been to ensure that animals for the internal market are healthy (through inspection and movement control if necessary). Similarly for the export market Government's role has been to ensure that importing country regulations for quarantine and disease status are satisfied.

The local "informal" market works well and is reasonably fair to all parties.

Producers nonetheless may occasionally not have access to the most recent prices in larger markets away from the immediate area. Most villages hold weekly or daily markets (Figure 2.7(i)) at which several strata of producers, agents, 'wakil', middlemen and final purchasers are present. Other commodities such as eggs and milk (Figure 2.7(ii)) find readily available outlets through local largely informal channels and networks.

Figure 2.7: (i) Local livestock market and (ii) household marketing of milk in Hawata

2.7 LIVESTOCK PRODUCTIVITY

The productivity of Sudanese livestock is widely reported as low. The parameter most often referred to is usually, however, production and not productivity as there is no reference to input: output ratios. Traditional systems in northern Sudan seem to be rather efficient (Table 2.2) in view of the constraints in which they operate. Improved productivity would be achieved if more favourable total environmental -- including input supply and availability of extension and veterinary services -- and economic conditions were to be made available. There has been considerable research on the genetic potential of Sudanese livestock which has shown the possibilities of improvement. Regrettably very little has been transferred to or taken up by the mass of traditional producers.

2.7.1 Cattle

Cattle are used mainly as dairy animals in most Sudanese traditional production systems. On comparative basis cattle produce less meat than the other species (Table 2.2) but cattle herds that make regular seasonal movements are 50 per cent more productive than sedentary ones.

Table 2.2: Livestock vital statistics and production parameters in traditional systems

Parameter		Species				
		Cattle	Goat	Sheep	Camel	Donkey
Herd/flock structure						
Males	total (per cent)	31.2	23.6	22.2	50.0	51.4
	breeding (per cent)	4.2	5.2	8.4	?	37.0
Females	total (per cent)	68.8	76.4	77.8	50.0	48.6
	breeding (per cent)	42.8	49.8	57.0	30.0	31.8
Vital statistics						
Birth rate (young/female/year)		0.49	2.08	1.45	0.70	0.65
Death rate (per cent/year)		19	19	23	15	?
Off take (sales + consumption, per cent/year)		16	28	26	15	n.a.
Breeding female weight (kg)		300	30	40	414	120
Productivity						
Dressing percentage		45	49	41	49	n.a.
Index (g meat/kg female/year)		44	374	253	67	n.a.

Sources: Wilson, Bailey, Hales, Moles and Watkins, 1980; Wilson and Clarke, 1975

Kenana cattle usually have their first calf at about 4.5 years but this can be reduced to 3.5 or even 3.0 years under better and more intensive management (Table 2.3).

Calving intervals at Um Banein averaged about 18 months in 1964-1980 where lifetime production total averaged 4.02 calves but some cows produced as many as 12 calves. Birth weights averaged 22.7 kg. At six months the average weight was 56.7 kg. Adult cows showed seasonal weight changes being heaviest at 315 kg in October, lightest at 262 kg in February and 253 kg in June and then heavier again at 299 kg in late July in an overall range of 180-440 kg. Milk yields averaged 1415 kg per lactation of 251 days with the highest individual yield being 4530 kg in 1959-1983. Most milk parameters from Gezira and Khartoum University farms in earlier years were better than those at Um Banein. The performance of Butana cattle is probably similar to the Kenana. The estimated calving rate in South Darfur herds in the 1970s was 59 per cent but was higher (60 per cent) in migratory than in sedentary (40 per cent) herds. Most traditional system cows were culled after three calvings and few were kept for more than five calvings: average lifetime production was 2.90. Some 65 per cent of calves are born in April-June, related to conceptions in the previous year's rainy season, and there are very few births in August-December. Weights in all age classes are lowest in the late hot dry and highest at the start of the cool dry season. Seasonal changes in weight reflect not only the capacity for compensatory gain – of which advantage can be taken in fattening operations – but also the genetic potential for resilience to environmental stress.

The output of meat of weaned 6-month calf equivalent per kg live weight of breeding female per year was 57 g and 23 g in migratory and sedentary herds in 1973 in South Darfur. Most traditional owners take off 1.5 kg of milk per day per cow for periods that often exceed one year for drinking fresh and for making 'semn' (= ghee, clarified butter).

Table 2.3: Performance traits of Sudanese indigenous cattle under research station management

Parameter	Breed in Northern Sudan Group		
	Kenana	Butana	Baqqara
Reproductive traits			
Age at first calving (months)	42 → 8	47 → 11	66 → 7
Calving interval (months	13 → 3.0	13 → 2.5	14.9 → 0.3
Gestation (days)	286	290	287
Feedlot performance			
Daily gain (kg)	0.78→0.28	0.89→0.2	1.00→0.23
Age at slaughter (months)	17.8	11.5	21.8
Weight at slaughter (kg)	231.8	159.6	271.1
Feed conversion (kg feed/kg/gain)	8.15	6.20	6.44
First lactation milk yield (length in days/yield in kg)			
Um Banein[a)]	251/1423		
Nisheishiba[a)]	287/120	242/1,095	
Atbara[a)]		220/1,213	
Ghazala Gawazat[b)]			244/671

Notes: a) green pasture b) natural range

2.7.2 Sheep

Sudanese sheep have the capability to be highly productive. Most types are potentially prolific, can (and often do) have more than one parturition per year, have rapid growth rates, good dressing percentages and produce an acceptable and indeed a sought after carcass for local markets.

Age at first lambing was 13-15 months in the Southern Darfur traditional system. At El Huda station it was about 14 months for all of Shugor, Dubasi and Watish types when ewes ran continuously with rams but was delayed to almost two years when a conception weight of 35 kg was imposed before access to rams was allowed. Lambing intervals in Southern Darfur were spaced at about nine month intervals but were longer than 14 months at El Huda.

Litter sizes in the traditional system were 1.14 but improved to 1.22 on average for the three subtypes studied at El Huda where there were differences between the three types.

In spite of more lambs being born per parturition on station the important parameter of number of lambs born per ewe per year or annual reproductive rate was much higher in the traditional system at 1.52 than the 1.05 at El Huda due to the much shorter lambing interval. Weights at birth average about 4.0 kg and animals reach 18-20 kg at five months. By one year female Sudan Desert sheep weigh more than 30 kg but growth then slows so that at two years they are 36 kg and at three years 40 kg: males weigh some 50 per cent more than females of the same age. Dressing percentages approach 50 per cent in well-finished sheep but vary with nutrition and especially the amount of dietary fibre.

Useful comparisons can be made on the basis of analyses in overall productivity between the supposedly "better" station system and the often presumed "poor" traditional system. This is not only in respect of actual performance but also in relation to management. For all three subtypes at El Huda performance is similar but grossly inferior to comparable types of sheep under traditional management in the South Darfur traditional system. Differences between the two systems are mainly related to control of the breeding process (leading to poor reproductive performance because of long parturition intervals -- and also to advanced ages at first lambing) and very high mortality rates. Long term improvements would be achieved by selecting for superior stock within the local populations.

2.7.3 Goats

Nubian goats have average kidding intervals of about seven months. These are prolific goats with a rather high proportion of 30.4 per cent of parturitions resulting in twins and 3.5 per cent in triplets to give an average litter size of 1.4 overall. Births occur throughout the year. Birth weights are in the range of 2.5-3.0 kg. Males weigh 22.2 kg at 12 months and females 18.0 kg. Nubian goats are reputed as milk producers and yield 150-200 kg per lactation in addition to that taken by the kids. Dressing percentages were 43.2 at 14.1 kg live weight with cotton seed cake as the nitrogen source and 38.4 at 12.1 kg live weight with blood as the nitrogen source.

Many Sudan Desert goats have their first kid at less than 10 months of age and most have already given birth by 15 months. Kidding intervals in South Darfur and South Kordofan traditional systems are usually in the range of 7-9 months. Multiple births are rather common with 30.2 per cent of parturitions resulting in twins in first kidders and 54.5 per cent in twins and 6.5 per cent in triplets in multiparous (= more than one birth event) females in the South Darfur. These figures give an overall litter size of 1.57 with primiparous does (first birth event females) achieving 1.30 young and multiparous does 1.68 young per litter. The annual reproductive rate averages 2.41 kids per breeding doe and a lifetime production of 9-10 kids is achieved. Birth weights average 2.13 kg and is 2.27 kg for single births, 2.05 kg for twin births and 1.82 kg for triplet births. Kids weigh an average of 12.6 kg at five months and 14.7 kg at six months. On a diet comprising high roughage/sorghum bran with an addition of 30 mg Monensin per day average daily gain was 89 g from 26.5 kg to 33.2 kg with a conversion rate of 10.7 feed/gain and on a high concentrate/sorghum grain diet with 30 mg Monensin added was 93 g at a conversion rate of 9.0 from 29.9 to 34.0 kg. Entire males have a dressing percentage of 48.2 at a live weight of 34.7 kg with castrates yielding 51.2 per cent at a live weight of 35.8 kg in South Darfur: dressing percentages are slightly lower at 46.0 per cent in central Sudan.

2.7.4 Camels

In the Butana area only two per cent of females first had a calf at 3-4 years old, 10 per cent calve at 4-5 years, 37 per cent at 5-6 years and 51 per cent at more than six years. Advanced ages at first parturition and subsequent long intervals averaging about two years or more mean that more than half of female camels do not have their second calf until 9-10 years and only about a quarter have had their third calf by this age. Almost 50 per cent of fourth calves are born to dams (= mothers) over 15 years old.

Calving is very seasonal and depends to a great extent on nutritional status which is why calving intervals are so long. Birth weights range from 26-45 kg and are affected by several factors including season of birth and age of dam.

Daily weight gains of young camels range from 300 g to more than 1000 g for animals from birth to one year old. Mature camels weigh from 450 kg for the lighter and leaner riding types to 650 kg for the heavy pack or baggager types.

Many traditional owners keep camels solely or mainly for milk. Their value in this role, at least for traditional owners, is their ability to give milk over long periods. They also provide milk through long dry seasons when perhaps the only other domestic animal providing very small amounts of milk is the goat. Meat, with few exceptions, is usually a by-product of a camel system and comes mainly from old males and females that have served usefully in other functions in earlier life. Camel meat contains 36.8 kJ/g of energy in the fat and 17.9 kJ/g in meat protein, the protein content being 270 g/kg of meat. Camel meat is a good source of protein but a lesser source of energy. Dressing percentages of camels are in the range of 45-55 per cent, exceptionally up to 60 per cent. Total carcass composition is about 66 per cent muscle, 19 per cent bone and 14 per cent fat, the last being mainly in the hump. Lean meat has more moisture and less fat than beef, with the pH being about 5.75. Muscle is formed of 75.5 per cent water, 21.4 per cent protein and 1.4 per cent fat.

2.7.5 Improved livestock

It is often assumed that Sudanese livestock produce very little and are of low genetic potential. It is also considered that improvement is only possible by introduction of exotic stock with increased genetic worth. Neither assumption takes account of the resources available. There are certainly if somewhat limited opportunities for the use of exotic animals but improvement of the locally adapted types by selection within existing populations will provide the most appropriate and sustainable genotypes.

2.8 LIVESTOCK PRODUCTION: OPPORTUNITIES AND CONSTRAINTS

2.8.1 Opportunities

The age old tradition of extensive livestock production and the potential for improved pasture land management and introduction of new techniques and systems such as grazing reserves and cooperatives or producer organizations for pasture management provide considerable opportunity for the livestock subsector. Sudan's livestock breeds have adapted over thousands of years to local production systems and to the harsh physical environment in which they operate. There is thus considerable potential for breed development based on the adaptive genetic characteristics of Sudan's native livestock breeds and certainly in cattle and sheep production.

As a corollary to this it should be understood that genetic quality is not the primary constraint in greater animal productivity in the project area and that replacement of existing breeds by "improved" ones is not some kind of magic formula.

Further attention to mitigation of some production constraints would greatly help the livestock subsector. Aspects such as whole herd health and not just vaccination would reduce the effects of disease. Amelioration of disease impacts would also enable stock to make better use of the limited feed resources which would assist in increasing livestock output.

2.8.2 Constraints

Livestock genetic resources are not considered a primary or short term constraint to livestock output. Producer management skills for improved systems of production and their very limited access to information and new and appropriate technology because of poor extension services are factors that will potentially limit production in the future. There are inadequate technical packages for traditional producers and encouraging research results are seldom transferred to the producers.

Much of the productive rangeland has been converted to marginal crop production especially by the proliferation of mechanized farming schemes. Many of these cut across the traditional migration routes. The consequent decreased or hindered mobility of the pastoral herds and semi-sedentarization of the herders in addition to the increased stocking rate lead to a severe degradation of the pasture land.

The major epidemic diseases have been contained or at least their containment and eradication is possible. The Pan African Rinderpest Campaign is a laudable example of what determination and good organization can achieve. New diseases will undoubtedly appear and existing ones will assume more importance. Provision of more clinical and consulting services to complement the mass campaigns is also needed. Continued vigilance should be the watchword.

The two major constraints to sheep and cattle production might be considered to be:

- seasonal variability in feed and water which may reduce reproduction rates, increase mortality and lower growth rates; and
- inadequate access to full health services in some places and at some times (and especially with regard to the presence of "first aid" activities at village and pastoral camp level) that further aggravates the productivity problems associated with the feed supply.

2.9 LIVESTOCK PRODUCTION: POSSIBLE PROJECTS

2.9.1 Stock routes and water points

Traditional routes for the movement of stock from the wetter and insect infested areas of the south to the more amenable areas of the north have existed for centuries (see Figure 2.1). Similarly pastoralists have had free access to water in the Rahad river, its tributaries and meander channels.

The advent of irrigated cultivation by settlers and the rapid expansion of semi-mechanized cereal cultivation have given rise to conflict although in theory (and to an extent in practice) stock routes and access to the river still exist.

The time is now ripe for binding agreements to be made among all users with respect to rights of passage and access to water. Routes and access ways should be marked in a permanent manner to prevent encroachment on to and out of the legal passageways. Additional water points should be made available on the stock routes in the form of 'hair' or of pumped wells/boreholes. Access to these water points could be closed at certain times to prevent random animal movements.

2.9.2 Improved nutrition

There is a wealth of information available on techniques for improving the nutritive value and rendering fibrous content more digestible and palatable of crop residues including treatment with urea and with sodium hydroxide. These techniques are technically sound and can provide improved nutrition. The alternative of supplementation with readily available high protein feeds is widely understood (but currently less practised) in Sudan and also offers good prospects for intervention. Animal conversion of the fibrous content of both coarse range feed and crop residues can also be improved by providing readily available sources of energy (e.g. molasses) and protein (e.g. nitrogen in the form of urea). Most animals also have a deficit or imbalance of minerals and vitamins.

A project should be set up provide livestock producers with the necessary information, training and equipment to treat fibrous feeds as described and also to manufacture molasses-urea/multi nutrient blocks to feed to their stock.

2.9.3 Paravets

The Gadarif State animal health services work relatively well. Of necessity, however, visits to producers and opportunities to treat stock on a herd basis or as individual cases are limited.

The Gadarif State Ministry of Animal Resources has the ability to and has experience of training Paravets. Paravets are usually persons from within the local community (and therefore often known as Community Animal Health Workers (CAHW)) who have been trained in "first aid" measures for the prevention and control of animal diseases and for dealing with minor accidents and surgical procedures. Support for the setting up of a parapet service would contribute to improved production and better welfare for the livestock of the area. Producers would be expected to pay for any veterinary pharmaceuticals they receive and would also pay a "consultation" fee to the paravet.

2.9.4 Market information

There is very little to no formal market information accessible to livestock producers. Traders are usually better informed about market conditions and prices than producers via their informal or formal networks. Producers therefore largely rely on actual market day information or on information obtained from relatives, neighbours and friends to aid them in making selling and price decisions. Lack of market information therefore is a hindrance to improved livelihoods for livestock producers.

With rapid growth and widespread use of mobile telephones and the increasing availability of satellite television there is an opportunity for the establishment of a more formal market information system (MIS) which producers could download and therefore be better informed as an aid to decision making.

2.10 FEED PRODUCTION: OPPORTUNITIES AND CONSTRAINTS

2.10.1 Opportunities

The opportunities to be exploited for increased feed and fodder production are:

- a large area of rangeland that compensates to some extent for the intrinsic low productivity of the land;
- a broad range of feed resources including rangeland with a very wide array of genera and species, crop residues and by-products and agro industrial by-products;
- good prospects for low input rangeland improvement and scope for developing improved forage production systems in rain fed and irrigated systems in both mechanized farming and smallholder sectors;
- a good possibility of expanding the limited range of forage species for incorporation into farming systems;

- a clear potential for intensification of fattening in the irrigated crop-livestock system as well as elsewhere; and
- possibilities for improved nutritional value of crop residues using any or several of the well known techniques for intervention.

2.10.2 Constraints

The main constraints in feeds and forage production are:

- lack of forage reserves for feed shortage and drought periods;
- inadequate technical support to livestock holders in the project areas;
- inadequate research extension activities related to range improvement;
- low level of involvement of populations in range improvement and seeding activities;
- insufficiency of public funds allocated to range rehabilitation programmes;
- absence of private investment in range infrastructure and management;
- lack of producer knowledge of the nutritional value of feeds and the application of balanced rations; and
- recurrent droughts.

2.11 FEED PRODUCTION: POSSIBLE PROJECTS

The level of livestock husbandry within the pastoral system is high. Pastoralists have exceptional skills in managing stock within a very demanding production environment. Interventions to adjust use of rangelands on a community basis can be successful but require extensive participatory planning. They are also long term and are unlikely to have a marked impact on the system in the immediate future.

2.11.1 Over sowing rangeland areas

The strategy is based on:

- careful site selection but initially over a wide variety of sites to enable both a rapid accumulation of local knowledge and high rates of spontaneous lateral spread;
- use of "shotgun" mixtures to provide a better chance of finding the most useful species; and
- low seeding rates (0.5-1.0 kg/ha) such that on suitable sites optimal densities will generally be reached within 3 years (and low seeding rates avoid excessive wastage of seed on less suited sites).

The likely results are:

- higher rainfall will produce more successes but seasonally heavy cover of native grasses will limit success in some areas and some success may be achieved even in sites of 250 mm rainfall if grazing pressure is not extreme;
- on suitable sites there will be good persistence and spread and in heavily grazed areas with little grass cover livestock gains will be directly related to legume productivity;

- where legumes are successfully established in areas with better grass cover there can be a synergistic effect through having a high protein legume available to complement the low-nutritive value of dry season grasses;
- livestock productivity gains may be in the region of 30-50 per cent even in the absence of other interventions; and
- in suitable areas lateral spread through grazing livestock can be rapid.

2.11.2 Rainfed mechanized cropping areas

The most promising techniques are:

- establishment of pasture legumes on fallow areas using various species adapted to the local environment; and
- sowing immediately after the cropping phase or under sowing forage legumes in the last season of the cropping phase (dedicated fodder crop types include lablab, cowpeas, Desmanthus, Burgundy bean (*Macroptilium bracteatum*) and Leucaena (on some favourable sites).

2.11.3 Irrigated areas

The approach would be to use species which are already known locally and introduce a limited number of other types. In the latter case lucerne seed which may be contaminated with *Cascuta* should be strictly avoided. Better use should be made of locally available forage sorghums and maize (from 75 day to 120 day).

New forage species to be included in intensive irrigated areas (but not to replace lucerne on areas well adapted lucerne) include:

- Leucaena (*Leucaena leucocephala* cv Tarramba) for grazing or cutting;
- Centurion centro (*Centrosema pascuorum* cv Cavalcade) for cutting and hay on sites not suited to lucerne; and
- Desmanthus (*Desmanthus leptophyllus* cv Bayamo) for heavier soils, for cutting, pelleting or grazing but not for hay.

Stocking rates under irrigation would vary with site and particularly with soil type and pasture species. Likely sustainable stocking rates are 3-5 head per ha on a year-round basis with weight gains of 0.6-0.9 kg per day with minimal supplementation.

2.11.4 Intensive smallholder cut-and-carry systems with irrigation

The range of species that has already been discussed with respect to larger scale operations is also very appropriate to use on smallholdings.

A cut-and-carry Leucaena/grass option is, however, most appropriate for small irrigated areas with good management and with labour available for field operations and stall feeding.

Leucaena leucocephala (several cultivars with various agronomic characteristics are available) would be established in hedgerows at 0.5 m between seedlings and 3 m between rows with a productive grass such as Guinea or Mulato between the rows. Continual cutting would be carried out to about 1.5 m height at 6 week intervals. Up to 8-10 head of cattle/ha could be supported on a year round basis with minimal supplementation with weight gains of 0.7-1.0 kg/head/day.

2.11.5 Forages in seasonally flooded lowland and in drawdown areas

There are good prospects even if flooding occurs only once every few years. 1-10 ha. The approach is based primarily on quick maturing legumes with good tolerance of water logging which would regenerate after subsequent flooding. The seasonally flooded oxbow lakes of the Rahad river are typical and suitable drawdown sites (Figure 2.8).

Figure 2.8: An oxbow lake suitable for rapid production of flood-tolerant fodder legumes

- broaden the fodder species and varieties available and ensure that the best genetic material and propagation systems are used from the outset;

- initiate a broad based programme covering rangelands, larger semi mechanized fattening units and intensive smallholder systems (rangeland interventions will be slow to come to fruition but some tangible results should be obvious within two seasons and especially with the use of very productive and conspicuous material such as Leucaena, the more intensive interventions would stimulate rapid interest;

- establish an immediate capacity for limited multiplication of key exotic material and develop a strategy for larger multiplication (production of significant quantities of seed should be feasible within the second year);

- research groups could be involved in refining some on-farm recommendations but the programme will founder unless conventional research is by-passed and

- organize regular exchange visits between the various stakeholder units involved.

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APPENDIX A: CULTURAL PRACTICES FOR DIFFERENT CROPS

CULTURAL PRACTICES FOR DIFFERENT CROPS AND VEGETABLES

CROPS

a. Sorghum

1. Land preparation:

The land is ploughed using an offset disc harrow to a depth of 15 cm then levelling using a scraper and Ridging at 80 cm width.

2. Cultivars

The recommended cultivars include early maturing, medium maturing and late maturing according to the time of rainwater availability i.e. in case of early rains the farmer can go for medium and late maturing cultivars. Early maturing cultivars: White Dwarf Milo. Medium: Hageen Dura 1, Wad Ahmad, Gadam El Hamam, late Tabat .

3. Sowing date

Between the second half of June and first half of July according to the onset of the rains.

4. Seed treatment and Seed rate

Seeds are treated with a suitable seed dresser against dura smut disease. Recommended seed dressers are Fernasan-D at a rate of 3 gm/kg of seeds, Thiram and captan-2 at the same rate. Seed rate is about 7.2 kg/hectare. Spacing is 80 cm between ridges and 10 cm between holes i.e. plant population of about 126,000 plants per hectare.

5. Weed Control

a. Chemical Control: The recommended herbicides for sorghum in the Sudan are:-
   1- Pre-emergence herbicides: Sorghoprim 500 at 1.44 kg active ingredient per hectare.
   2- Post-emergence herbicides: Bazargan 48% (EC) at 1.8-liter active ingredient per hectare. 2-4-D at a 0.77-liter active ingredient per hectare. Sorghocal 500 at 1.7 kg active ingredient per hectare.
   3- Pre and post emergence herbicides: Gizaprim W.P. at 0.6 – 0.9 kg active ingredient per hectare.

b. Manual Control: Two to three hand weeding during the first 8 weeks of the crops growth.

6. Fertilizer Application

The recommendation is to add nitrogen at a rate of 2N i.e. 192 kg of urea per hectare. This is applied either as a single dose at sowing or as split application of 96 kg at sowing and 96 kg just before the second irrigation.

7. Harvest

Heads of the crop are cut manually and left to dry for few days, then collected in heaps to be threshed using a stationary threshing machine. The crop is collected in Jute sacks of 90 – 100 kg and transported to the market or storage.

8. Productivity

First year	1.9 ton/ha.
Second year	2.4 ton/ha.

Third year	2.9 ton/ha.
Fourth year	3.4 ton/ha

b. Groundnuts

1 Land Preparation

Land is ploughed using an offset disc Harrow at 20 cm depth. This is followed by levelling using a scraper then the land is ridged at a 60 cm width.

2 Cultivars

Early maturing, drought tolerant cultivars of Sodari and Ghibiesh are recommended for seasons characterized by late rains. For seasons of early rains medium maturing cultivars of MH383, Kiriz, Ahmahi, Tozi and Medani are preferred.

3 Sowing date

The early maturing cultivars could be sown during July when irrigation water is available. The medium maturing cultivars, i.e. cultivars recommended for irrigated agriculture should be sown not later than fifteenth of July.

4 Seed treatment and Seed rate

Seeds should be treated with a suitable fungicide e.g. fernasan at 3gm/kg of seeds. The seed rate is about 60 – 72 kg of Kernel per hectare i.e. 120 kg of shelled seed. This gives the optimum plant population of about 222,000 plants per hectare. The spacing between holes is 8 cm and between ridges 60 cm with one seed per hole

5 Weed Control

a. Chemical weed control:

Herbicides recommended for use in the crop are Ronstar – 25 at a rate of 4.7 L/ha, Goal at 3.8 L/ha and stomp at 3.8 L/ha. Application of herbicides is recommended to take place after sowing and before the first irrigation.

b. Manual Weed Control:

Two to three weeding during the first six weeks of the crop growth and weeding is prohibited after the 6^{th} week as it interferes with the flowering and pegging process i.e. the insertion of flowers into the soil to produce the pods.

6 Harvest

The crop becomes ready for harvest after about 120 days from sowing when the leaves start to show the yellow colour. The crop is pulled from the soil by hand or mechanically. The moisture content of the soil should be at a level that helps pulling the plants with all the pods or with the minimum loss. This is especially essential in heavy clay soils like Wad Meskin Project Soils.

After pulling the plants, they are put so that the pods are at the upper side and they are left for a period of 8 – 12 days to dry. This drying is important to avoid the secretion of the harmful fungal aflotoxiur material. After drying, the crop is put in heaps then threshing is done using a mechanical thresher to separate pods form vines. The crop is packed in jute sacks and transported to the market or storage.

7 Productivity:

First year	2.4 ton/ha.
Second year	2.47ton/ha.
Third year	3.1 ton/ha.
Fourth year	ton/ha

c. Sunflower

1 Land Preparation:

Same as in sorghum.

2 Cultivars

Seeds are usually imported and expensive but some efforts are underway to produce seeds locally in collaboration with the international companies. The most commonly used cultivar in the country is the hybrid Hysen 33. Generally open pollinated cultivars are recommended for irrigated and high rainfall areas while hybrids are advised in both irrigated and rain fed production. Recently few cultivars from South Africa have been released by Agricultural Research Corporation.

3 Sowing Date

The recommended sowing date for the irrigated crop is in the middle of July.

4 Seed Rate

The seed rate is about 2.9 kg/ha, which gives an optimum plant population of about 95 thousands plants per hectare from a plant spacing of 70 × 15 cm with one seed per hole.

5 Weed Control

Weeding is important especially at the early stages of the crop. It could be done chemically using pre emergence herbicides like Goal, Ronstar – 25 or stomp (like in the case of groundnuts) or manually using hand labour.

6 Fertilizer application

Normally irrigated sunflower is given 2N/ha i.e. 192 kg urea per hectare.

7 Harvest

Harvest Signs: The crop reaches maturity when the colour of the rear part of the head changes to yellow and the brown colour dominate the centre of the disc. The crop becomes ready for harvest when the rear part of the head changes to the brown colour.

The discs are cut before the seeds completely dry to minimize losses of jumping seeds. Combine harvesting should commence when the moisture content of the seeds does not exceed 8 – 9%.

Delaying mechanical harvesting leads to losses due to dryness of the plant and its breakage and hence dropping of fruits.

8 Productivity

First year	1.9 ton/ha.
Second year	1.3 ton/ha.
Third year	1.5 ton/ha.
Fourth year	ton/h

d. Sesame

1 Land Preparation

Same as in the case of groundnuts.

2 Cultivars

Some white, high yielding, uniform and late shattering cultivars have been released by ARC. Those fall into two groups with respect to the timing of flowering and maturity.

a- Cultivars that flower after about 55 days and mature after about 100 – 110 days from sowing. These are recommended for areas with longer rainy season with precipitation that exceeds 600 mm per annum e.g. Ziraa 9.

b- Early maturing cultivars that flower after about 27 – 35 days and mature after 80 – 90 days after sowing are suitable for shorter rainy seasons of precipitation levels of 400 – 600 mm per annum e.g. Khidir, Bromo and Kenana.

c- Another collection of cultivars has been in use before the Variety Committee of the ARC regulations were in effect. These are two white cultivars Ziraa 7 and Ziraa 5 besides two brown ones Huriya 31 and Huriya 18. Gadarif 1 cultivar exceeds other cultivars in responding positively to fertilizer application, irrigation, mechanical harvesting and accordingly in productivity. Other cultivars used in rain fed agriculture can also be options to use in supplementary irrigated areas.

3 Sowing Date

First half of July with preference to the early days of July.

4 Seed Treatment and Seed Rate

The Seed rate is 3.6 kg/ha. Spacing of planting 60 cm between ridges and 7 cm between plants within the row. Plant population is 210 – 240 thousand plants per hectare.

5 Weeding

Weeds should be removed manually especially during the first six weeks after sowing and germination.

6 Fertilizer Application

Irrigated sesame responds to nitrogen fertilization, which raises yield by about 40% compared to non-fertilized sesame. 40 kg of urea/hectare is an excellent suggestion in the absence of an official recommendation.

7 Harvest

Harvest time is about 80 – 90 days for early maturing cultivars and 100 – 110 days after sowing for medium maturing cultivars. A cutter binder machine is used to harvest the crop. The bundles

are stoked in small heaps. After drying, the bundles are shaked in sieves then sesame is collected in bags to be transported to the market or storage.

8 Productivity

First year	1.2 ton/ha.
Second year	1.5 ton/ha.
Third year	1.8 ton/ha.
Fourth year	2.0 ton/ha

VEGETABLES

Vegetables are very important crops for human diet because of their rich contents of vitamins and minerals that protect people from disease and help them lead healthy lives. Water availability in the proposed Wad Misken project is expected to be from July to October, which put limitations to the kinds of vegetables to be grown. Therefore, concentration on summer time short span vegetables is advised. Accordingly, the study recommends the following vegetables:-

i. Okra.
ii. Leafy vegetables (Rocket, Jews mallow and Purslane)
iii. Watermelon.
iv. Melon.
v. Cucumber
vi. Sweet Potato.

e. Okra

1 Land Preparation

The land is ploughed using the offset disc harrow then smoothened and levelled using a scraper followed by ridging at 70 cm width. Direction of ridges is advised to be north south to plant on the eastern side of the ridge so as to avoid the higher temperatures on the western side of the ridge, which may reach over 35^0c during the afternoon. This ridge direction also breaks the strength of the hot dry winds and minimizes their effect on the crop.

2 Cultivars

- Khartomia: spiny, most common in the country, suitable for local markets.
- Karari, Raiba, Higierat: spineless local cultivars good for local and international markets.
- Imported cultivars: Climson spineless, Boza swani, Dwarf long Green Pod. These are spineless and favoured over the local cultivars because of their early maturity. They are suitable for local as well as foreign markets.

3 Sowing Date

It is a summer crop, which is recommended to be sown in July.

4- Seed rate

The rate is 9.6 – 14.4 kg/ha.

5- Sowing

Seeds are sown directly at one side of the ridge in holes at a 2 – 3 cm depth with 3 – 4 seeds/hole. The distance between holes is 25 – 30 cm. In two weeks time, when the plants reach the three leaves stage, the plants in the hole are thinned to two plants.

6- Irrigation

Watering should be done every 5 – 7 days or according to the weather during the rainy season.

7- Fertilizer Application

a. Organic fertilizer at about 35 – 45 m^3/ ha rate is recommended to be added before ploughing.
b. 190 kg/ha of urea (Nitrogen e,g.) as split application the first half after 21 days from sowing and the second application after one month from the first or at the beginning of fruiting.

The crop should be irrigated immediately after fertilizer application.

8- Weeding

Weeding is an important operation especially at the early stages of the life of the crop.

9- Insects and disease control

a. Insects

- Aphids
- Jassid
- White fly
- Boll worm

Most of these insects could be controlled using agronomic practices like good land preparation, weed control, cleaning the land from remains of last season's crops and good irrigation. Chemicals could act like a last resort for the control of economic insects.

b. Diseases

i. Powdery mildew – attacks the crop in winter
ii. Leaf curl virus – transmitted by aphids and white flies.

10- Harvest

The crop becomes ready for harvest after about 45 days from sowing. Harvest continues for about 2–3 months. It is recommended to harvest the fruits 4 – 5 days from flower opening and to make the period between pickings short (2 – 3 days).

11- Post Harvest Handling

The crop is taken to the shade and packed in boxes or sacks with openings to permit aeration. The crop is transported to the market. The surplus or non-marketed crop is normally dried to be consumed as dried powdered okra (Waika). This powder is used to prepare the most popular dishes in the Sudanese diet.

Okra can be kept fresh and in good shape for 7 – 10 days under refrigeration (7 – 10^0c) and 85 – 90% relative humidity.

12- Productivity

First year	7.2 ton/ha.
Second year	9.6 ton/ha.
Third year	12.0 ton/ha.
Fourth year	14.0 ton/ha

f. Rocket

Rocket is the main leafy vegetable used for green salad in the Sudan.

1 Land Preparation

Land preparation should lead to a fine seedbed because rocket seeds are small in size and can easily fail to germinate because of water logging, water stress or the unsuitable depth of sowing.

The land is ploughed once or twice according to the soil condition using an offset disc harrow followed by levelling. In lighter soils sowing takes place in flat basins while in heavier soils it is advised to plant on ridges with 80 cm width.

2 Cultivars

The cultivars grown in the country are a mixture of local lines, which differ in their plant size, leaf taste and aroma. All of them are known as Baladi.

3 Sowing Date

The rainy season crop is grown during July – August.

4 Seed Rate

Seed rate differs according to the soil nature. It decreases for lighter soils and increases for heavier soils because of the expected losses in the latter.

Light soils	16 kg/ha
Heavy soil	26 kg/ha

5 Sowing

Seeds are sown directly in basins or ridges that have been sufficiently pre-watered. Due to the small size of seeds, it is advised to mix the seeds with a neutral substance like sand, which must be clean and free of pests and diseases. The mixture is broadcasted uniformly on basins or top of levelled ridges. Soil is moved using rakes so as to cover the seeds. This is followed by a light irrigation so that water reaches the seeds by seepage to avoid movement of the seeds.

6 Irrigation

Irrigation before sowing (pre-watering) is an important practice in crops with small seeds. Second irrigation should be light and the third may be delayed to encourage deep growth of roots. Watering is normally done every week because of the expected hot weather.

7 Weeding

In case of leafy vegetables, the heavy pre-watering before sowing will trigger the growth of most weeds so that the weeding is done before sowing. It is difficult to remove weeds that appear after sowing, germination and emergence of the crop without hurting the crop itself.

8 Fertilizer Application

It is advised to add organic fertilizer to the soil at a rate of 36 – 48 kg per hectare before ploughing and 96 kg of urea per hectare after 21 days from sowing. It is preferred that crop's leaves are dry and do not carry any moisture at the time of application. This is because of the fact that when particles of the fertilizer fall on wet leaves they cause a corrosive effect on the leaves tissues. After application of the fertilizer, a special irrigation becomes a necessity.

9 Insects and Diseases

Some jumper insects attack rocket leaves causing some pitting and also stem borers were reported but both do not cause economic losses. The same apply for diseases. The recommendation is not to use chemicals but resort to other protection measures.

10 Harvest

The crop is cut after about three to four weeks from sowing. The crop is cut three times. The hot weather may cause flowering of the crop, which stops the vegetative growth. After cutting the crop, it is gathered in a shaded aerated place. Normally it is tied in big bundles to transport it to the market.

11 Productivity

First year	12.0 ton/ha.
Second year	13.2 ton/ha.
Third year	14.6 ton/ha.
Fourth year	16.8 ton/ha

g. Jews mallow

1 Land Preparation

The same as in the case of Rocket.

2 Cultivars

The cultivated varieties are a mix of several local cultivars that differ in the height of the plant, area of leaves and degree of green colour. They are known by the names of districts where they are normally cultivated.

3 Sowing Date

The best time for production of stems and leaves is the rainy season 'Kherif' i.e. July – August.

4 Seed Rate, Irrigation, Weeding and fertilizer application

Same as in the case of Rocket.

5 Harvest

The crop becomes ready for harvest after about one month from sowing. The stem is cut under the area of thick leaves leaving about 5 – 6 cm for the new growth for the second harvest. The crop could be harvested several times in summer and 'Kherif'. After harvest, the crop is collected in a shaded aerated area where it is tied in bundles and sent to the market.

6 Productivity

First year	14.4 ton/ha.
Second year	16.2 ton/ha.
Third year	18.0 ton/ha.
Fourth year	19.2 ton/ha

h. Purslane

1 Land Preparation

Same as in the case of Rocket except for the fact that purnslane's seeds are even smaller than Rocket's which necessitates more attention to prepare a fine seedbed.

2 Cultivars

Cultivars cultivated nowadays in the country are a mixture of local lines. These could be divided into two groups, the first group is the cultivar 'Baladi', which is characterized by small, leaves and the second is the cultivar 'Romy" which has stout fleshy leaves.

3 Sowing Date

During the rainy season i.e. July – August.

4 Seed Rate, Sowing, Irrigation, Weeding and fertilizer application

Same as in the case of rocket with more emphasis on weed control before sowing because of the small size of purslane's seedlings.

5 Harvest

The plant normally becomes ready for harvest after 30 days from sowing in summer and autumn crops. The plants are cut 3 – 5 cm from soil surface to allow for re-growth of stems for subsequent cuts. The crop is prepared for the market in a shaded aerated area.

6 Productivity

First year	12.0 ton/ha.
Second year	16.0 ton/ha.
Third year	20.0 ton/ha.
Fourth year	24.0 ton/ha

i. Water Melon

1 Land Preparation

Land preparation includes ploughing the land once or twice using an offset disc harrow according to the nature of the soil. Breaking of big soil clots and levelling follow then the land is made into beds "Masatib" 2 meters wide.

2 Cultivars

Several cultivars are grown in the country e.g. Congo, Charleston Grey, Early Mexican, Sugar baby besides some local cultivars.

3 Sowing Date

Watermelon performs very well during the rainy season. Early July is the recommended sowing date with an advice to plant the early maturing cultivars like sugar baby, which reaches maturity after 2.5 months from sowing.

4 Seed Rate

Seed rate is 3.2 – 5.3 kg/ha.

5 Sowing

Watermelon is sown directly in the field on the side of the bed (Mastaba) with a spacing of 1 meter between holes. The holes should preferably be 20 cm from the lower surface of the furrow and with a 5 cm depth. Three to four seeds are sown in each hole. Re-sowing is advised during the first two weeks. Thinning of plants to two plants per hole is important after 21 days from sowing or after the appearance of 4 – 6 true leaves.

6 Irrigation

Pre-watering is advised, the second irrigation, which is the first after sowing, should be light and the third is delayed to encourage roots to grow strongly both horizontally and vertically. The crop should not be subjected to water stress as cucurbits are characterized by large surface area of their vegetative part, which helps water loss through evapo-transpiration especially under warm climates. Irrigation is recommended to be every 7 – 10 days according to the condition of the crop, soil and weather. During the maturity of fruits, irrigation should be moderate every 12 days to avoid excessive water in the fruits, which lowers quality of the produce.

7 Weeding

Weeds must be removed especially in the early stage of plants growth. When plants grow bigger, they cover soil surface with their big vegetative parts and by so doing smoother weeds and perform self-control. Despite the smothering action of watermelon, some weeds find a chance to grow; these must be removed without hurting the roots of the plants.

8 Fertilizer Application

Watermelon and the rest of cucurbits respond to the organic fertilizers because of their favourable effect of loosening the heavy clay soil and hence improving its drainage. The organic fertilizer is added before ploughing to be incorporated in the soil at a rate of 36–48 cubic meters/hectare. It is followed by a heavy irrigation. Nitrogen is added at a rate of 2N. Split application is recommended, the first dose is immediately after thinning and the second one is a month from the first application. If urea is the source of nitrogen, then each dose is 96 kg/ha. Watermelon also responds to phosphate. It is recommended that 96 kg/ha of triple super phosphate is added once with the organic fertilizer to be incorporated into the soil.

9 Insects and Diseases

a) Insects:

Watermelon like the rest of cucurbits is infested with white fly and aphids, leaf bug, ladybird beetle, Red cucurbits beetle, cucurbits bug and fruit fly.

i. Whitefly is treated with Malathion 57% at a rate of 4.8 litter per hectare.

ii. Aphids may be treated with folimat 80% at a rate of 480 cubic cm per hectare or primer 50% at a rate of 540 cubic cm per hectare.

iii. Ladybird beetle: in small areas may be collected by hand at all stages of its growth. In larger areas, it is recommended to use sumicidin E.C. 20% at 720 cubic cm per hectare or Kafel E. C. 10% at 1440 cubic cm per hectare.

iv. Cucurbit's fruitfully: Removal of infested fruits and burying them away from the field in deep holes. Use poisonous baits as traps because it is not possible to use chemicals on the fruits.

v. Cucurbit's bug: The infested leaves are collected and buried away from the field.

b) Diseases include:

- Powdery mildew.
- Fusarium wilt.
- Viral diseases.
- Physiological diseases.

i. Powdery mildew: Control is by following the right agronomic practices like eradication of weeds that act as hosts for the disease and growing cucurbits away from the disease hosting crops like beans and Roselle. Chemical control include the use of a suitable fungicide i.e. Benlate 50% (powder) at a rate of 240 gm/ha or Tilt 25% E.C. at a rate 48 L/ha.

ii. Fusarium Wilt: Control is advised to be by perfecting agronomic practices, fertilizer e.g. application to strengthen the plant and increase its resistance to disease. Follow a good scientific crop rotation because the use of resistant varieties.

iii. Viral diseases:-

Can be controlled by the use of certified seeds free of viruses and also control of insects that transmit the viruses.

iv. Physiological Diseases:-

The most important of these is "Blossom End Rot' which is caused by poor irrigation management, improper fertilizer application and lack of calcium. The disease is controlled by cultivating resistant varieties, good management of irrigation and proper balanced fertilizer regime.

10 Harvest

The watermelon fruits become ready for harvest after less than 2.5 months for early maturing varieties like "Sugar Baby". Other medium and long-term cultivars take 3–4 months to reach maturity.

11 Post Harvest Handing

Immediately after harvest, fruits are kept in a shaded cool place to avoid direct sunrays, which hurt them. In Sudan, normally they do not use modern cold storage for watermelon but studies

have shown that it can be stored for a period of 8 to 15 days under a temperature of 10 – 13^0 c and relative humidity of 85 – 90%.

12 Productivity

First year	19.0 ton/ha.
Second year	22.0 ton/ha.
Third year	25.0 ton/ha.
Fourth year	29.02 ton/ha

j. Melon

1 Land Preparation

Land is prepared like in the case of watermelon. Melon is grown in beds (Masatib). The beds are prepared with 2.0 m width.

2 Cultivars

Cultivars normally grown in Sudan are "Ananas", "Galia", "Sudan Galia 14" and local cultivars. In the project, early maturing cultivars are recommended.

3 Sowing Date

First half of September is the recommended date. So as to avoid disease as well as the decrease in sweetness of the fruits as a result of rains, and high humidity during July and August.

4 Seed Rate

The seed rate is 2.1 – 2.7 kg/ha according to the spacing used.

5 Sowing

Melon is sown directly on both sides of the bed (Mastaba) in holes at a reasonable distance from the bottom of the furrow and with spacing of 50 cm between holes. Three seeds are put in each hole. Re-sowing and thinning to one plant per hole are to be done during the first two weeks from sowing.

6 Irrigation

It is recommended to follow the same irrigation schedule for watermelon. Moderate irrigation should be adopted especially during fruit maturity and ripening as an increase in the moisture content of the fruits lowers their quality.

7 Weeding

Like Watermelon and other cucurbits.

8 Fertilizer Application

Like Watermelon and other cucurbits.

9 Insects and Diseases

Melon is attacked by the same insects as watermelon but the mid September planting helps in avoidance of aphids and powdery mildew. The most important diseases on Melon in Sudan are the Fusarium Wilt and Powdery Mildew. The control of these diseases is as described in the case of Water Melon.

10 Harvest

The crop becomes ready for harvest after about 60 – 65 days from sowing depending on the cultivar, sowing date and weather.

11 Post Harvest Handling

The fruits are cut with part of the stem so as to protect them from entrance of pests and diseases. Fruits are kept in a cool-shaded area until they are transported to the market. Cold storage for melon is not common in the Sudan except for the exported melon in Khartoum state. Nevertheless, melon could be kept for 8 – 15 days under a temperature of 7–10^{0}c and 85–90% relative humidity.

12 Productivity

First year	12.0 ton/ha.
Second year	14.5 ton/ha.
Third year	17.0 ton/ha.
Fourth year	19.2 ton/ha

k. Cucumber

1 Land Preparation

Like watermelon and other cucurbits. The bed width is 2.0 m.

2 Cultivars

All cultivars used in the country are local known by the place where they are cultivated like Kosti, Shendi, Ghadambelya, Karari, and Medani etc.

3 Sowing Date

During July and September.

4 Seed Rate

2.7 – 3.2 kg/ hectare.

5 Sowing

Cucumber is sown at a rate of 3 – 4 seeds per hole. The holes are 50 cm a part on both sides of the bed alternatively. The place of the hole should be at a reasonable distance from the bottom of the furrow of the bed away from direct contact with water in the furrow. Re-sowing is done during the first two weeks besides thinning plants to 1 or 2 plants per hole.

6 Irrigation

Like water melon.

7 Weeding

Like all cucurbits weeds must be controlled during the early stages of the crop as cucumber resist weeds with the smothering effect of its vegetative parts as it grows bigger.

8 Fertilizer Application

Organic fertilizer is advised to be added at a rate of 36 – 48 cubic meter per hectare before ploughing to be incorporated into the soil. This is followed by a deep irrigation. After thinning

nitrogen fertilizer 1N (96 kg of urea per hectare) is applied to the field, another dose (IN) could be added according to the condition of the crop.

9 Insects and Diseases

Control of insects is like in the case of other cucurbits with a special consideration for the control of Whitefly and aphids. Disease control is as in the case of watermelon with emphasis on powdery mildew, Fusarium wilt and viral diseases.

10 Harvest

Cucumber is harvested 30 – 45 days from sowing before complete ripening of fruits and formation of seeds, so as to get high quality produce. Harvesting continues at short intervals to guarantee high yield and quality.

11 Post Harvest Handling

The fruits are cut with part of the stem at about 1 cm or less to prevent pests and diseases from entering the fruit. Fruits should be handled carefully to avoid wounding or scratching and put in a cool shaded aerated area until transported to the market. Cold storage needs of cucumber are like other cucurbits.

12 Productivity

First year	19.0 ton/ha.
Second year	26.0 ton/ha.
Third year	33.0 ton/ha.
Fourth year	40.0 ton/ha.

I. Sweet Potato

1 Land Preparation:

The land is ploughed with a heavy offset disc harrow followed by smoothing and levelling. The last operation is essential because the crop is sensitive to water logging. The last operation is ridging at 80 cm width, which give large ridges that help the root crop to give a big yield.

2 Cultivars

The known cultivars of the crop in the Sudan are divided into two groups with respect to flesh colour.

a. White flesh group: Widely spread in the Sudan
   The disadvantage in this group is its low carotene (precursor of Vitamin A) content. They are known by their areas of cultivation like Damazin, Dalanj and Halfa.
b. Orange flesh group: These are rich in carotene and hence the orange colour. This is important because the traditional Sudanese diet suffers from poverty in vitamin A. This group contributes in supplying vitamin A in people's diet and stops the spread of night blindness disease. The main cultivars in this group are 'Portreko', 'Gold Rush' 'Red Gold' and 'Julian'. These cultivars were introduced by ARC from the International Centre for Tropical Agriculture. ARC released them in the main irrigated schemes like Gezira and

Rahad. Despite the fact that growth and yield of the crop were excellent, consumers were reluctant in accepting these cultivars. This problem is expected to be overcome by time

3 Sowing Date

Early July is a suitable sowing date for the project area.

4 Seed rate

Sweet potato is propagated vegetativly, mostly by stem cuttings. About 26–34 thousands cuttings are required per hectare, if the planting occurs in ridges of 80 cm width and 50 cm spacing between plants along the ridge.

5 Planting

The land is pre-watered with a deep irrigation and planting starts when the soil moisture reaches a level that allows walking on the soil easily without contaminating feet with mud. The moist soil is important to fix the cuttings to the planting site on the soil and also to start the physiological activities for growth especially in stem cuttings free of roots. Half of the stem cutting length is buried in the soil and the other half is left at the surface of the soil. Buds should be present in both halves. The spacing between cuttings along the ridge is 50 cm, the size of the produced fruits is decided by the spacing between plants i.e. larger spacing gives larger tubers while shorter spacing produce smaller tubers.

New vegetative growth appears within ten days from planting with some absent holes. It is important to replant these holes within one to two weeks after planting.

6 Irrigation

Light consecutive irrigations every 3–5 days in the early stages of the crop are advised to increase chances of successfully establishing new seedlings from the cuttings. Subsequent irrigations could be weekly or fortnightly according to the condition of the soil, weather and the crop besides considering sensitivity of the crop to water logging.

7 Weeding

Careful light hand weeding is required during the first month when plants are still small. Later in the season, the plant resists weeds by itself, as it owns an extensive vegetative growth. The tall weeds that penetrate the vegetative cover of the plant can be uprooted by hands.

8 Fertilizer Application

Organic fertilizer is added before ploughing at a rate of 36 – 48 cubic meters per hectare to be incorporated into the soil. Nitrogen is added at 2N rate (192 kg Urea/ha) in two doses, the first one after one month from planting and the second after one month from the first dose.

9 Insects and Diseases

The main insect pest is sweet potato weevil, which may cause extensive economic damage that necessitates its control. There are secondary pests like piercing sucking insects, red spider mite and leaf eaters but their damage is not comparable to that of sweet potato weevil. The sweet potato weevil adult feeds on the vegetative parts of the crop with little damage but the real damage happens by the larva which penetrates the root tubers and start to feed on them leading to spoilage of the tubers. They also attack the water absorbing roots rendering them unable to

perform their function which lead to water stress or even death of the plant when the roots lose their function.

It is recommended to avoid using chemicals in controlling the sweet potato weevil because the insect is found inside the tuber which is the main edible part of the crop. Agronomic practices are advised, these include:

i. Use of good, healthy free of disease cuttings
ii. Soaking of cuttings, before planting, in a systemic chemical for 5 minutes to kill the different stages of the weevil on the cuttings.
iii. Follow a scientific crop rotation.
iv. Cleaning of the field and neighbouring fields from weeds.
v. Planting should be to a reasonable depth so that tubers are out of reach of the weevil.
vi. Sweet potato nurseries should be in remote and isolated areas away from sweet potato fields.
vii. Collection and burning of the remains of the crop completely after harvest.

Diseases that infect sweet potato include black rot, bacterial rot and Alternaria. These diseases can be controlled by:

viii. Use of clean healthy cuttings.
ix. Follow a scientific crop rotation
x. Taking care of the tubers not to be cut or scratched
xi. Planting resistant varieties.

Chemicals should not be used.