

## Gash Delta Project

### Sudan

Presentation on the 25th of March 1994 to the Department of Irrigation and Soil and Water Conservation, Wageningen Agricultural University in the Netherlands,

by

Mr. Ahmed Tirik<sup>1</sup> and  
Mr. Kees Hopmans<sup>2</sup>

1. Vice Chairman of the Gash Delta Rehabilitation Corporation and Local Leader.
2. HVA Gash Delta Project, Team Leader.

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Gash Delta Project

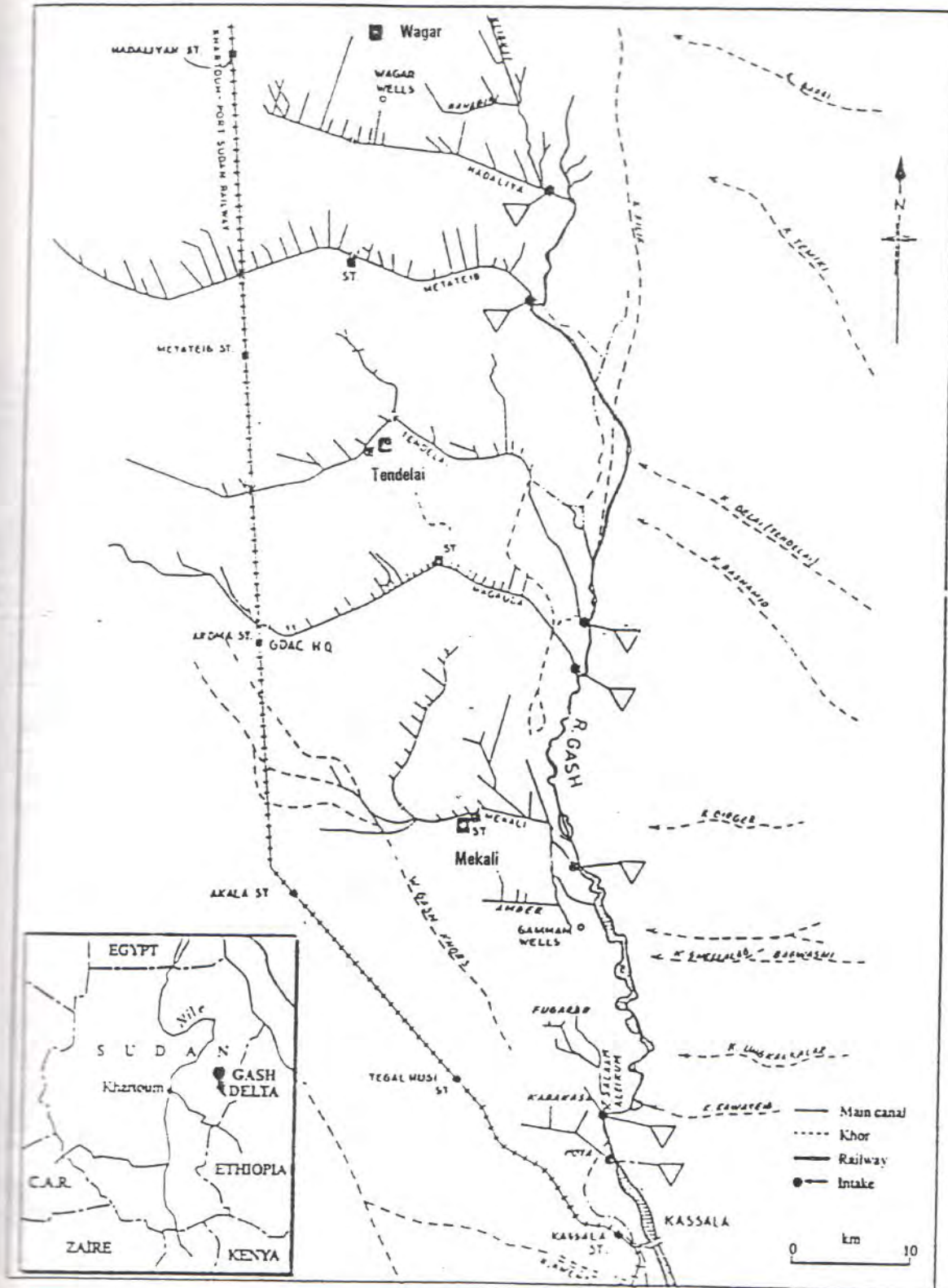
This presentation contains pages taken from reports which were made over the last two years;

- \* Eco-Socio-Economic report
- \* Forestry report
- \* Livestock report
- \* River Training Survey
- \* Horticultural report
- \* Paper on Soil-Water-Plant relationships

At present the farmers in the Delta are mainly growing sorghum. In years with large areas under flooding other crops are grown like sunflower. More crops are identified and tried out. One of the promising crops is groundnuts. This year's programme will focus on on-farm flood management, crop choice and further testing of other crops including foddercrops.



Exhibit 1.1: Map of Gash Delta





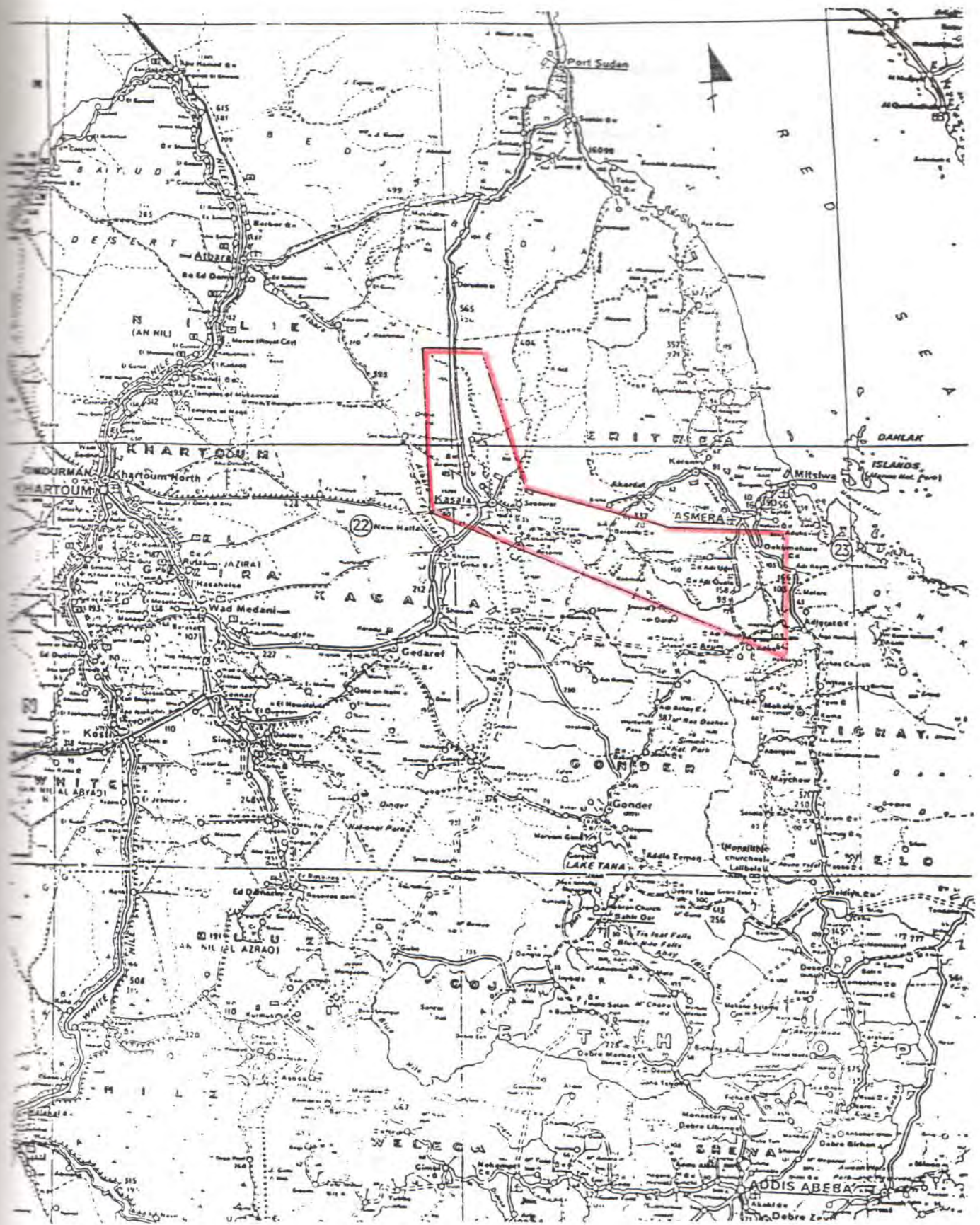


Fig. 1 Map, showing the location of Gash/Mereb River in Eritrea(Ethiopia) and Sudan.



Exhibit 1.2 : Characteristics of the Gash Delta research villages

	<i>Wagar</i>	<i>Tendelai</i>	<i>Mekali</i>
<i>Geographical location</i>	1608' 3613' (N. Delta)	1555' 3615' (centr. Delta)	1540' 3618' (S. Delta)
<i>Population (1)</i>	8,700	5,500	3,000
<i>Earlier research</i>	<i>Ausenda</i> (1987)	<i>Kuhlman et al.</i> (1987)	<i>n.a.</i>

Source: (1) 1993 estimate based on Euroconsult/Newtech (1987) totals and a medium 2.8% annual population increase (rounded figures).

Exhibit 1.3: Universe (N) and sample (n) for research villages

	<i>Wagar</i>	<i>Tendelai</i>	<i>Mekali</i>
<i>Population (persons)</i>	8,700	5,500	3,000
<i>Universe N (households)</i>	1,740	1,100	600
<i>Sample n (households)</i>	81	50	30
<i>n/N (in %)</i>	5	5	5

The data collection method used in the two survey rounds is the questionnaire survey with closed answer categories. The research year covers the July 1992-June 1993 agricultural season. Kassala rainfall of 330 mm was in this year well above average (Kassala long-term mean 1901-1990 is 303 mm but 1960-1990 mean is 246 mm).

The following are main entries in the questionnaire list:

1. household composition and characteristics;
2. household wealth (in land and livestock);
3. livelihood activities (specified by region, agricultural areas and household members);
4. household income components (ibid.);
5. household costs components (ibid.);
6. household resource use;
7. land titles;

Two strategies are followed in the ESE research design to enhance response:

- (i) livelihood activities are as much as possible referred to by their component parts
- (ii) engagement in livelihood activities is gauged household member and area specific. Main categories in the latter include farming areas inside and outside the Gash Delta scheme.

## 2. THE GASH DELTA SETTING

### 2.1 Potentials and constraints

The Gash Delta domain, as administered by the GDAC, covers an area of 700,000 fd. Some 350,000 fd. grouped in six blocks is under command of an equal number of main irrigation canals. Canals vary in length from 27 to 50 km. Irrigation water is from seasonal spates of the Gash River which river system is highly dynamic. Irrigation control by consequence requires skilled engineering input. Responsibilities for land preparation, irrigation and overall scheme maintenance lie with the GDAC.

**Exhibit 2.1: Gash Delta scheme characteristics, situation 1993**

<i>Block</i>	<i>Canal length (km)</i>	<i>Area under command (fd)</i>	<i>Registered tenants (nr.)</i>
<i>Hadalya</i>	27	47,147	6,646
<i>Dugein</i>	33	50,450	6,748
<i>Metateib</i>	33	61,239	6,211
<i>Tendelai</i>	50	73,780	8,830
<i>Mekali</i>	31	49,739	7,218
<i>Kassala</i>	46	62,000	4,884
<i>Total</i>	220	344,355	40,537

*Source: GDAC office Aroma, Cole (1989:290).*

The 1983 census figures for the Gash Delta area (Aroma, Delta North and Delta South Rural Councils and Aroma and Wagar Town Councils) mention a population of 123,360 of which 55,434 are considered nomads. Trends using 1955/56 and 1973 census data indicate a 2.8% annual growth. The extrapolated 1993 total population in the Gash Delta accordingly is some 162,600. Population density in the 5,000 km<sup>2</sup> area is 33 inhabitants per km<sup>2</sup>. This figure is relatively high compared to surrounding dryland zones where figures range 10-20 inhabitants per km<sup>2</sup>.

The natural resources potential in the Gash Delta scheme is high. According to environmental profiles (DHV/IES 1989, IES 1991) agricultural resources are underused. Crop production is seasonal following Gash spates. High sedimentation rates keep the usually limiting factor of soil fertility at acceptable levels. Other natural resources including pasture and woodland are being overused (Exhibit 2.2). Livestock populations are estimated between 370,000 and 672,000 TLU (HVA 1990b:5). Alarming conditions occur at the scheme's margins under both agricultural and livestock land use. Similar boundary effects of land degradation hazard are reported from other irrigation schemes in the country, including New Halfa (Sörbo 1985).



Exhibit 2.2: Natural resources use in the Gash Delta scheme in selected land units

<i>Land unit</i>	<i>Potential</i>	<i>Intensity</i>	<i>Trend</i>
<i>agriculture</i>	<i>high</i>	<i>underuse</i>	<i>constant</i>
<i>pastoralism</i>	<i>high</i>	<i>overuse</i>	<i>increasing</i>
<i>forestry</i>	<i>high</i>	<i>overuse</i>	<i>increasing</i>
<i>settlements</i>	<i>high</i>	<i>overuse</i>	<i>increasing</i>

Source: DHV/IES (1989:62)

Details on the Gash Delta scheme have been documented over the years in Richards (1951), Swan (1959), Euroconsult/Newtech (1987), HVA (1992b, 1992c). A comparison of these studies clearly indicates that its technical and institutional capacities are declining. The present challenge to the Rehabilitation Plan is to redirect developments so that the scheme's capacities can get ahead of potentially constraining conditions of population growth and natural resources degradation.

## 2.2 Recent developments

The following developments are to be considered against this background of the scheme's potentials and constraints, (see also Annexes 6 to 8):

1. Irrigation efficiencies are low. Generally less than 45% of the seasonal Gash discharge is diverted for irrigation. Sedimentation rates are high. The irrigation infrastructure is deteriorating. The area under effective command is gradually declining. The commanded area covers some 344,000 fd. but since the 1980s irrigated areas cover only 50,000 fd annually. Canal breaches put land seasonally out of cultivation as occurred in the Tendelay block in 1992/1993. Irrigation is largely uncontrolled in the Hadalya block.
2. The number of registered tenants is steadily growing. Until the mid-1980s, this figure was oscillating around 12,000. In 1988/89, it reached some 22,000, in 1991/92 some 32,000. The present 1993 number of tenants in the GDAC files is about 40,000.
3. Since the early 1990's, private, parastatal and government investors started production of cash crops including water melon, sweet melon, karkadeh, beans, okra and staple sorghum Aklamoy. In 1992/93, the area under cash crops covered some 26,000 fd. (22%) of the total cultivated 118,000 fd.





As a result of these three parallel developments increasingly smaller areas become available for crop production by private tenants.

ESE survey outcomes indicate that the average title to registered land among village-based households is some 25 fd. but actual 1992/93 allocations are an average 6.5 fd. (and less for households' second or third locations of cultivation). Awareness is growing that resources in the Gash Delta area are being tapped in a way that is inefficient and wasteful (Baasher 1992:26).



### 3. RESEARCH VILLAGES

Main results of the ESE survey are discussed in Chapter 4 as aggregate village outcomes. A number of household key-characteristics broken down by research village is presented below.

#### 3.1 Household characteristics

Main tribes in the research villages are Hadendowa, Hausa and other Sudanese, see Exhibit 3.1. Hadendowa of which some 15 main lineages have been counted is the most important. Second come Hausa in Wagar and Tendelai and other Sudanese in Mekali mainly consisting of Northern riverine groups.

Exhibit 3.1: Ethnicity of household head 1992/1993

Ethnic	Wagar		Tendelai		Mekali	
	f	%	f	%	f	%
<i>Hadendowa</i>	35	44	33	67	14	50
<i>other Beja</i>	3	4	3	6	1	4
<i>Hausa</i>	27	34	7	15	6	21
<i>other W-African</i>	4	5	0	0	0	0
<i>other Sudanese</i>	11	13	6	12	7	25
<b>Total</b>	<b>80</b>	<b>100</b>	<b>49</b>	<b>100</b>	<b>28</b>	<b>100</b>

Source: 1993 ESE survey.

The following data are shown in valid percents over 81 cases in Wagar, 50 cases in Tendelai and 30 cases in Mekali. All refer to the 1992/1993 situation.

Most heads of household are born in the Gash Delta area (Wagar: 75%, Tendelai 70%, Mekali 63%) and usually in the village of current residence. Some households have permanent residency in another village and migrate to the Delta at the start of the agricultural season (Wagar 7.5%, Tendelai 8%, Mekali 27%). Total village populations as presented in Exhibit 1.2 accordingly vary with the season. The dominant type of dwelling in all villages is the mud house (Wagar 48%, Tendelai 30%, Mekali 43%) but in mainly Hadendowa inhabited Tendelai an almost equal share of traditional birsh tents occur (28%).

Household size is an average 7.8 in Wagar, 6.8 in Tendelai and 6.2 in Mekali. The highest completed level of education of the household head in most cases is koran school (Wagar 55%, Tendelai 55%, Mekali 48%) and second is primary education (Wagar 30%, Tendelai 28%, Mekali 33%). The same figures for wives are in Wagar respectively 76% and 11%, Tendelai 71% and 29%, Mekali 48% and 33%.





The share of children over 6 years of age without education is in all villages just over half the total number in this category (Wagar 53%, Tendelai 59%, Mekali 54%).

The number of women activities per household in Mekali and Tendelai is an average 2.4 and 2.1 respectively. There is no significant relationship between number of women activities and village of residence, women's age, tribe or level of education.

The only found statistically significant relation ( $\alpha = .05$ ) is with settlement date. The number of women activities per household increases with duration of settlement in the village.

### 3.2 Household wealth

Details on household wealth are presented in terms of land titles, 1992/93 cultivated area, livestock ownership and household income (Exhibits 3.2 to 3.6). Some three-quarter of the households are entitled to scheme land (Wagar 79%, Tendelai 92%, Mekali 73%). Sizes range from 5 to 160 fd. with averages in Wagar of 26.8 fd, in Tendelai of 22.2 fd. and Mekali of 25.7 fd.

Exhibit 3.2: Land titles per household 1992/1993 (in fd.)

Area	Wagar		Tendelai		Mekali	
	f	%	f	%	f	%
< 6 fd.	14	22	12	26	8	36
6-10 fd.	16	25	14	30	4	18
11-25 fd.	15	23	6	14	5	23
> 25 fd.	19	30	14	30	5	23
total	64	100	46	100	22	100

Source: 1993 ESE survey



#### 4. LIVELIHOODS AND NATURAL RESOURCES

The following livelihood activities have been distinguished for the Gash Delta:

- (i) crop production (inside and outside the scheme)
- (ii) livestock husbandry
- (iii) off-farm employment
- (iv) migration (daily, seasonal and long-term)
- (v) "networking", or income from informal transfers and gifts.

In addition, the following women-specific activities are distinguished:

- (i) crop production (grain and vegetables)
- (ii) livestock husbandry (including chicken, rabbits, pigeon)
- (iii) collection of water, wood and forage
- (iv) processing agricultural produce
- (v) handicrafts
- (vi) off-farm activities
- (vii) networking.

Most activities of the first group are intimately related to the market economy. This is not the case for women activities of which only some are income-generating.

Household natural resources use includes:

- (i) water for domestic use, including home-garden irrigation and for livestock watering
- (ii) woody biomass includes domestic use for cooking, heating, food processing, and household industrial use for construction, tools and utensils, fencing.
- (iii) grassy biomass includes livestock grazing and minor applications e.g. in roofing.

##### 4.1 Categories and definitions

###### **Crop production**

Inside the Gash Delta scheme, crop production is under gravity spate irrigation. Around Wagar, Gamman and Salem Aleikum groundwater is pumped up for horticulture. Crop production outside the scheme is under different types of run-off farming, including wild-flooding techniques in beds of seasonal water courses and water harvesting in teras earth bunds. In residential areas, home-gardens are used inside the compound of houses equipped with a tap.

Crop choice on registered scheme land is free since the early 1980's. At this time also water rates were introduced to compensate the GDAC for income forgone from earlier cash crops cotton and castor. The present main crop is sorghum variety Aklamoy.





Second crops include water melon, sweet melon, karkadeh, bamia, lubia and various beans. All crops are also cultivated outside the scheme under run-off farming without any water cost. In 1992/1993, inside and outside sorghum yields did not significantly differ (see Exhibit 4.9). In horticultural areas, a wide range of crops is grown including peppers, tomatoes, cucumber, onion, okra, alfalfa, pumpkin, eggplant, jews mellow, rocket.

Cultivation can be under sharecrop arrangements. Any agreement on the division of costs and income between title holder or land owner and the sharecropper is possible in areas both inside and outside the scheme. Women have no access to registered scheme land but contribute in activities like sowing, harvesting, bundling and threshing. Women of West-African origin are more involved in these than other Sudanese. Women engage in home-gardening where they show a clear preference for high-value crops like water melon, lubia and different forages. They furthermore participate in recent GDAC/HVA programmes of agro-forestry.

### **Livestock husbandry**

Livestock husbandry of camels, cattle, goats and sheep has traditionally been the economic mainstay of the Hadendowa. Settled Hadendowa but also other tribes still keep livestock. In the dry season, forage is found inside scheme and water is drawn from shallow wells and hafirs. Small stock and cows in melk are kept around the house.

Fodders from own production or purchased include sorghum, stalks and seed-cakes. Strict herding regulations apply inside the scheme after the start of the irrigation season. Livestock is not allowed near cultivated lands which regulation is enforced by armed police or army patrols (Baasher 1992:23). In the wet season, camels, cattle and sheep graze outside the scheme. They are also sent with herdsmen on seasonal treks to distant pastures where destinations depend on the rainfall pattern.

Women own stock of cattle, sheep or goats which usually have been transferred to them as dowry. They are involved in the husbandry and curing of animals, mainly those kept around the house. With the exception of West-African women, they are by custom not allowed to milk.

### **Off-farm employment**

Off-farm employment is defined here as an income-generating activity carried out in the village domain which includes block basins, or misqas. Main off-farm activities are in agricultural labour, animal husbandry, collection of wood, grass and forage, charcoal-making, water-drawing and employment in trade, administration and local services. This employment type is an important local subsistence means since crop production both inside and outside the scheme is highly seasonal. Strict cultural restrictions exist for public appearance of women. This holds especially for the Hadendowa, but much less for West-African women who seem increasingly engaged in off-farm activities.





## 5. LAND RIGHTS AND ACCESS TO LAND

### 5.1 Historical backgrounds

Land rights are vested in the Sudan government as laid down in the 1970 Unregistered Lands Act which replaced the 1925 Land Settlement and Registration Act. The parastatal GDAC in the capacity of scheme management in turn regulates access to its irrigable land according to the 1967 Rural Water and Development Corporation Act.

Within this legal framework, customary rights to land have been recognized from the beginning. The tribal domain in which the Gash Delta scheme is now located traditionally belongs to the Hadendowa. The Hadendowa are numerically and politically the most important Beja tribe. Under the 1922 Powers of Nomad Sheikhs Ordinance, a head of tribe or nazir was appointed for the Gash Delta in 1927. The Hadendowa nazir was to administer his tribe and to mediate in all relevant matters with the colonial government.

In the early 1920's with the establishment of the Gash Delta scheme, the Hadendowa received preferential access to land as compensation for lost grounds. They received some 70% of the tenancies, the remainder going to Northern Sudanese and West-Africans. Individual land allocations for all tribes followed tribal sections and lineages and was controlled by traditional leaders or sheikhs. For the Hadendowa, this allocation system did not significantly differ from that practised in indigenous basin-irrigation or shayote in the area before the 1920's.

Between the 1960's and 1970's, many Hadendowa took up tenancies as individuals. With the gradual transition to sedentary life and rising levels of education they ever more came to dispute the authority of tribal leaders. This process of change was further fueled by the 1971 Peoples Local Government Act. This law introduced new administrative divisions, curtailing the administrative powers of sheikhs.

New forms of local leadership have developed more or less simultaneously in the Gash Delta. The present-day leader of farmers or sheikh muzareen has allocation responsibilities that are apparently similar to those of earlier leaders. The main difference is that he is seasonally elected by tenants from among their own group. This group is made up of farmers who have received neighbouring land in the lottery allocation system in the particular year (see for all formal rules on the lottery system e.g. Euroconsult/Newtech 1987). Tribal lines are not adhered to in these groups. Any tenant can become sheikh over any multi-ethnic group. Leaders reportedly are selected mainly on their alleged problem solving capacities.

In the present-day situation, rights and access to irrigable land is a negotiated outcome of formal GDAC rules on the one hand and local interpretations of these rules according to custom on the other. The situations de jure and de facto are discussed below.





## ANNEX 6

-1-

## Land allocation in the Gash Delta scheme 1992/1993 (in fd.)

<i>Block</i>	<i>Irrigated</i>	<i>Bad areas (1)</i>	<i>Cultivated (tenants)</i>
<i>Kassala</i>	14,274	923	11,173
<i>Mekali</i>	18,599	1,353	10,565
<i>Tendelai</i>	18,509		14,459
<i>Metateib</i>	35,583	1,992	5,776
<i>Dugein</i>	19,591	5,068	9,859
<i>Hadalya</i>	39,684	17,864	4,778
<b>total</b>	<b>146,240</b>	<b>27,843 (*)</b>	<b>56,610</b>
	<i>Compensation (2)</i>	<i>GDAC employees &amp; poor people</i>	<i>Investors</i>
<i>Kassala</i>	1,069	715	360
<i>Mekali</i>	3,049	1,075	2,050
<i>Tendelai</i>	815	640	2,135
<i>Metateib</i>	2,282	1,388	16,917
<i>Dugein</i>	1,073	967	75
<i>Hadalya</i>	2,391	634	4,090
<b>total</b>	<b>10,679</b>	<b>5,379 (*)</b>	<b>25,627</b>
	<i>Others (3)</i>	<i>Outside GDAC control (4)</i>	
<i>Kassala</i>	30		
<i>Mekali</i>			
<i>Tendelai</i>			
<i>Metateib</i>	3,430	3,787	
<i>Dugein</i>	1,411		
<i>Hadalya</i>	1,017	8,910	
<b>total</b>	<b>5,888</b>	<b>12,697</b>	

Source: GDAC offica Aroma.

Notes: (1) remains outside lottery allocation, (2) rejected land in lottery (poorly irrigated), (3) including flood-affected people, (4) including spontaneous cultivation. (\*) figures as presented at the GDAC office in Aroma; totals do not match.



## 6. CONCLUSIONS

ESE survey outcomes provide a data base contained in annexes as frequency tables and statistics. Only a selected range of issues has been commented upon in the report. The following are the main findings. It should be kept in mind that the ESE research population consists of village-based households. Any comparison with other studies should be made with caution.

### 6.1 Socio-economic conditions

Research villages significantly differ on certain household characteristics. These include ethnic composition, levels of education and household wealth. The factors are partly interrelated. Villages proved more homogeneous on household land titles and (1992/1993) cultivated areas than indicated in earlier studies and notably Euroconsult/Newtech (1987) which is entirely based on GDAC records.

Livelihoods show a great diversity. Economic risk-spreading is at the base of such strategies. Households are mobile and explore opportunities well beyond the Gash Delta boundaries. Labour is not in abundant supply as suggested or stated in earlier studies. Labour-opportunity costs usually rise in function of distance to (urban) labour markets.

According to aggregated incomes and costs (see Exhibit 6.1) crop production ranks relatively low on the list of Gash Delta livelihood categories. Informal transfers through networking frequently go unnoticed in studies but were found to make important contributions, especially among women.

**Exhibit 6.1: Livelihood incomes and costs by sector 1992/1993**  
(averages over different households, rounded in 1992/1993 £Sud.)

<i>Livelihood activities</i>	<i>Income</i>	<i>Costs</i>
<i>Livestock husbandry (1)</i>	114,000 }	51,000
<i>Livestock husbandry (2)</i>	177,000 }	
<i>Crop production</i>	23,000	19,000
<i>Off-farm</i>	85,000	
<i>Migration</i>	56,000	
<i>Networking</i>	15,000	9,000

Source: 1993 ESE survey.

Notes: 1) excluding livestock assets, (2) including livestock assets. Income and cost categories refer to different units and can not be related to each other.





## 6.2 Natural resources use

Scarce natural resources of water, woody and grassy biomass are drawn by households mainly from the Gash Delta itself. Source areas include protected forestry reserves. Local populations are fully aware of the long-term hazard of land degradation that may result from resources overuse. On the short-term, they usually have no viable economic alternative to turn to however.

## 6.3 Land tenure

Situations de jure and de facto concerning access to land in the Gash Delta scheme differ for reasons related to the dynamic natural environment and rigid GDAC organizational structures. Formal rules remain in force but local interpretations tend to follow customary practice. The parties involved seek consensus in solutions that are in the first place practical.

The subject of land tenure reform is caught between two distinct but related developments. Tenant numbers increase while the area of irrigable scheme land decreases. Clear policy decisions on how to address main mechanisms causing the growing pressure on scheme land are required first before new tenure systems can be detailed.

## 6.4 Further research

The situation for non-village based households in the Gash Delta expectedly differs from the one in researched populations. Gaining better insights into these livelihoods especially the seasonal local and non-local labour patterns including those of women is of paramount importance to development planning in the Gash Delta.

Natural resources use has been studied from the household demand side. Where, when, and to what extent use is out of balance with Gash Delta potentials can only be assessed by other means. Remote sensing on a multi-temporal basis using LANDSAT TM imageries is the most appropriate method. This approach also allows quantitative assessments of carrying capacities of different land units in the Delta.

## GENERAL INFORMATION

### Forestry and agriculture, mutually exclusive ?

*"In 1924 the Gash Delta was taken over from the Hadendowa people who considered themselves owners of the area according to the traditional rules for access to and control over natural resources. The area was given to an English firm which got a concession to grow cotton with the help of irrigation from the Gash river.... because of major disputes with the original "owners" over the rights to the natural resources, the right in 1927 went to the state authorities who established the Gash Delta Agricultural Corporation which is in charge of the daily administration and operation of the irrigation scheme. After the take over, the land was allotted as parcels to tenants, mainly to the Hadendowa people" (after Nautrup, 1992).*

GDAC holds authority over land and water from an agricultural production perspective only. The concept of integrated land use, which recognizes, appreciates and includes the role of livestock and forest and trees in the overall land use system, has never been applied so far. Instead of natural resources management as traditionally practised by the Hadendowa, land use merely concentrated on agricultural production. This one-sided view resulted in a diminishing forest and tree cover, triggering the process of desertification in the Delta, recognizable by dust storms and creeping sands. Through these, living conditions for the people and their livestock are deteriorating while the agricultural production potential of the Delta is under threat.

The Gash Delta Project, being a rural development project, needs to advocate a more integrated land use system in line with farmer's perspective, in which along with agriculture, also animal husbandry and forests and trees need to be included.

In this context, besides natural forest management and the establishment of village woodlots, trees outside the forest should be considered.

*"There is enormous potential for introducing trees on land that is conventionally seen as strictly agricultural. The objective is not only to increase wood supply, thus reducing the pressure on forest. It is also to contribute to food production, whether directly by fruit or fodder from the trees, or indirectly by giving shelter from wind and sun, restoring nutrients from deeper layers, and increasing nitrogen fixation. Such planting may take many forms, occupying strips and pockets of land not used for crops, mixing trees with agricultural crops in various proportions, or alternating annual crops with tree fallow.*

*The trees used may have as their primary products timber, poles, fuelwood, fodder or food, and preferably several of these together" (FAO, 1978).*

From a forester's point of view, it is important that the institution linked with the GRDC for the project operation has proven its readiness to understand forestry's relation with agriculture, quoting FAO's Forestry Paper 26 (1981).

*"In the case of forestry, the relations with agriculture are of particular importance. The production of food crops and trees & forests, together with the management of natural ecosystems, are interrelated parts of plant husbandry, which, combined with animal husbandry, is itself part of a larger land & water husbandry. Without this understanding by all concerned there is very little chance of any rural development programme being successfully implemented".*

Meanwhile, the project's forestry programme increasingly sought cooperation with the Forests National Corporation (FNC) in Kassala in fields of mutual interest, notably the village woodlot programme and forestry extension.





### 3. PRESENT LIVESTOCK SITUATION

#### 3.1 Introduction

Long before the Gash Delta Agricultural Corporation and the irrigation scheme was established in 1923, the people in the delta have been pastoralists and had herds of cattle, goats, sheep and camels. They were mainly depending on livestock production for their livelihood and some sorghum was cultivated on the flooded lands. They were nomads and utilized the available resources and grazed the rangelands in a wide area around the delta.

With the introduction of the irrigation scheme, the livestock owners had to send their animals outside the scheme during the crop season. Although initially it was stated that the livestock production would not be negatively effected by the establishment of the irrigation scheme, the tenants were forced to change their way of live.

However, the Hadendowa's in the delta continued keeping livestock and -till present day-, if requested to make a choice, prefer livestock over crops. The families in the delta still heavily depend on livestock products for their daily food, as milk is an essential part of their diet. Furthermore for many persons in the delta, livestock embodies their "bank account" and sales of livestock and the produce, are often their only cash income.

During the last decade with the severe droughts (1984/1985 and 1990/1991), many families in the delta have lost the majority of their herds because of starvation. By 1993, several animals are owned by people from Kassala while being herded by the delta people. If in the position to buy new livestock, they will however, try to built up their own herds again.

The present chapter describes the livestock situation in the delta, the interactions with the surrounding rangelands and the livestock in Kassala township and sagia's (gardens).

#### 3.2 Animal health situation

The animal health situation in the delta is directly linked to the amount of forage and grazing available. In years with bad floodings and low rainfall and consequently little vegetational growth, the nutritional status of the animals deteriorates and their susceptibility to diseases increases.

In normal to good years the animal health situation in the delta is quite favourable for livestock keeping and an annual herd mortality rate of 5 to 7% is normal. A number of diseases however, do occur:

##### Anthrax

Within the delta, Anthrax is endemic and despite the availability of vaccines, annually outbreaks occur (in 1991 there were outbreaks in Aroma and Kassala). It is estimated by the Department of Animal Resources of the Ministry of Agriculture, Natural Resources and Animal Wealth of the Eastern State, that only 5% to 6% of the animals are annually vaccinated against Anthrax in the delta. The livestock owners appear to be reluctant to vaccinate their animals, although it is still free of charge.





As there are now plans to charge a fee for the vaccination of bacterial diseases, the risk is that an even lower coverage percentage will be obtained.

### Rinderpest

As part of a national Rinderpest campaign, all animals in the delta can annually be vaccinated (free of charge) against Rinderpest. No cases have been diagnosed in recent years. The Department of Animal Resources estimates that in 1992, 40% of the eligible animals have been vaccinated against Rinderpest. The lack of proper extension is considered to be the main reason for this low percentage.

### Haemorrhagic septicaemia (HS)

In recent years no case has been diagnosed but vaccination is recommended.

Other diseases which have been reported in the area are: Contagious Bovine Pleuro-pneumonia (CBPP), Tuberculosis and Black Quarter.

Ticks are ample present and Theileriosis, Anaplasmosis and Babesiosis are reported. During the mission several engorged ticks have been found on cattle and camels.

In small ruminants (sheep and goats) Contagious Pleuro-pneumonia is the most important disease.

Several animals, in particular camels, with mange and lice have been observed during the mission. It is not a regular practice in the delta to spray or dip animals against external parasites.

Internal parasites are effecting the production of all livestock in the delta. Farmers are aware of this and some do treat the animals (Ivomec). In general however, this aspect of livestock husbandry is still not well accepted and extension is needed.

On the more intensive dairy farms around Kassala, the feeding of large quantities of alfalfa causes sometimes bloat (tympany of the rumen). On those farms, with several different persons milking the cows, mastitis can also be a problem.

The known major poultry diseases in the area are Fowlpox, Marek disease and New Castle Disease (NCD). Against these diseases the larger farmers vaccinate. Gumborro disease is present in the Khartoum area, but the farmers in Kassala do not vaccinate against Gumborro as no cases have been reported in Kassala.

## 3.3 Livestock in the Delta

There are no regular animal censi in the delta. The last one was in 1976-1977 based on an aerial survey in combination with a ground survey. For the Red Sea hills area an identical survey was implemented again in 1990 whereby the northern part of the delta was included.

Annually the numbers of livestock present in the delta, in Kassala and the surrounding areas, are estimated by the Department of Animal Resources.

Since 1900 the livestock population in the Delta has increased. In the Environmental Profile Kassala Province (1989) it is estimated that the livestock population in 1984 was three to four times the population of 1900.





This is partly explainable by the fact that part of the animals are now, not only seasonally supplemented with feedstuffs (wheatbran and durra), but nearly all year around receive supplementation. In this way artificially more animals can be kept in the delta and around Kassala. The increase can of course, also be explained by the increase of the human population.

It is not appropriate for the Hadendowas' to count the animals in a herd or boast about the numbers. In interviews with herders and livestock owners, this was reflected in inaccurate informations. The information is furthermore cautious because of taxation fears. The estimations made by the Department of Animal Resources are therefore difficult to evaluate. According to the tribal leaders the estimations are too high.

Seasonally camel herds from as far as the Red Sea Hills, come and graze in the Gash Die or the northern part of the Gash Delta. Furthermore, there are seasonal movements of the residential herds to areas outside the delta because of crop cultivation or scarcity of forage and/or watering points. Any census would therefore only be an indication. In general it can be said that during the period February to June the largest number of animals will be present within the delta and during August to November to lowest number of animals will be present in the delta.

For a good picture of the livestock population in the total area, the livestock in Kassala and the livestock in the area between Kassala and the Atbara river should also be considered. Herds from the delta go as far as Halfa to graze on the crop residues and camel herds from the Red Sea hills come to graze in the western Gash Die.

As an average of 1992, the Department of Animal Resources of the Ministry of Agriculture of the Eastern State, estimates that the following numbers of livestock were present in the Gash Delta, including the Gash Die:

**Table 3.1: Livestock population in the Gash Delta, including the Gash Die**

CATEGORY	HEADS OF ANIMALS
Cattle	110,000
Sheep	190,770
Goats	144,000
Camels	90,640
Donkeys, horses	no records available
<b>Total number of ruminants</b>	<b>535,410</b>

Source: Department of Animal Resources, Kassala

Of the Gash Delta farmers 29% own livestock, of which 66% own cattle, 60% own sheep, 80% own goats and 32% own camels.

As quoted in the Euroconsult/Newtech report of 1987, the ruminant population in the Gash Delta was in 1984: 1,295,643. Although a very high mortality has occurred during the droughts of 1984/1985 and 1990/1991, this figure indicates that the pressure on the vegetation in and around the delta has even been more severe in the recent past.





The present number of animals may be better sustainable.

Cattle breeds present in the delta are the Gash breed (also called the Erashai breed), the Butana breed and the Kenana breed. Close to Kassala the bigger dairy farms have crossbred cattle with Holstein Friesians. These animals are kept on zero-grazing rations and are kept for the supply of milk to Kassala town.

An interesting aspect is that the cattle owners in the delta do not like the crossbreeds because they do not run fast enough and do not have the "instinct" to escape if they are caught accidentally "grazing" a crop field. With the policy of guarding crop fields (and fining cattle owners!) this is an important factor. Furthermore, the local breeds are much hardier and are better able to survive the harsh conditions.

Another interesting aspect is that the majority of the cattle, sheep and goats are owned by the women. At marriage they receive 2 or more cows which are the basis for their herd. Furthermore through inheritance animals are obtained by the women. Camels are owned by men. The men herd the cattle and children often herd the goats and sheep. Some lactating animals are often kept close to the village to provide the daily requirement of milk. Camels, cattle, goats and sheep are being milked. Cow's milk is preferred.

The productivity of the local breeds under natural grazing conditions is from 3 to 8 kg milk per cow, per day. The lactating animals in the southern part of the delta are for 9 - 10 months out of the year, daily supplemented with wheatbran (3 to 4 kg) and grinded sorghum grains (2 to 3 kg). The length of the lactation period depends on the survival of the calf and the period of the year in which the calving has taken place and varies from 100 to 240 days. The peak calving season is from September to November.

There are two sheep breeds in the delta, primarily for meat production: the Kenana sheep breed and the western sudan desert sheep breed. Sheep of the last breed are often owned by large sheep exporters to Saoedi Arabia and graze at the delta. During the mission a herd of 10,000 sheep, of which 3,000 breeding ewes, was present in the Hadaliya area. The milk production is about 0.5 kg/day. The twinning rate is about 30%.

Two types of goats have been noticed. The most appreciated one is the Nubian type which is mostly kept for milk production. The majority of the goats in Kassala and Aroma towns are of this type. The milk production varies from 0.5 to 2 kg/day. The percentage twins is about 50%. The second type of goat, the Tagar breed, is a smaller type of goat, kept for meat production, but with a very good fertility: about 70% twins and 30% triples.

For the small farmers, donkeys are very valuable and are their mains of transportation (water is often collected with them). Horses are mostly kept by commercial transporters in and around Kassala. There are however, no statistical data on the number of donkeys and horses in the Kassala area or the Gash Delta. Donkeys are daily sold at the Kassala livestock market.

#### 3.4 Livestock in Kassala township

The livestock in and around, Kassala consists of livestock at: settled farmers, intensive poultry units, semi-intensive dairy farms and the goats and chicken kept within the compounds of the community.





The margin over feedcosts is about 75%. The farm would cultivate Sudangrass and Alfalfa under irrigation as soon as the rains started. Two boreholes were present.

For farmers like this one, the investments are very high but the profitability is good.

### 3.5 Movement of livestock in and around, the Delta

The livestock population in the region from south of Kassala to the western Gash Die, can be divided in the following sub-populations:

- a. The livestock in Kassala and the sagia'.
- b. The livestock in the southern part of the Delta, south of Aroma.
- c. The livestock in the Tendelai, Metateib and Hadaliya area.
- d. The livestock in the Gash Die.
- e. The livestock in the area between the Atbara river and the Gash Delta.

#### Ad a.

The majority of the livestock in Kassala remains all year around in Kassala. Some of the larger dairy farms have their dry cows and youngstock herds grazing in the Delta or south of Kassala. The dairy farmers in Mukram graze their cattle during the rainy season further to the east or north/east but still within reach of the Kassala market.

Several inhabitants of Kassala are owners of cattle grazing in the delta who pay herders to take care of their animals. These herds are kept as investments and a "tool" to fight inflation.

#### Ad b.

It is estimated that about 15,000 heads of cattle, 30,000 head of sheep, 25,000 head of goats and a few thousand camels are in average, present during the period February to July.

The southern part of the Delta is heavily overgrazed and large herds of cattle are herded there during the period February to July. There are only limited water wells and water is becoming a very limiting factor. During the dry season the herds move to the western side of the delta as there is more water available although the grazing is inferior and the accessibility of Kassala town is more difficult.

During the rainy season and cropping season, part of the animals remain in the area. No good numeric picture could be obtained.

#### Ad c.

In this central part of the delta, also large herds of cattle graze and herds of sheep and goats are kept. During the mission about 6,000 head of cattle and 4,000 head of goat and sheep were watering at the wellsite of Tendelai.

During the dry season most herds walk long distances from the grazing grounds (Hadaliya, west of the road Kassala - Port Sudan) to the few wellsites available and around those sites heavy overgrazing takes place.



Ad d.

The limited availability of water makes that only around permanent waterwells herds of cattle can remain all year around. West of the road to Port Sudan, around the oasis of Sararnowar there are large herds of cattle, goats, sheep, camels and donkeys. The number of animals in the rainy season is much larger.

It was impossible for the Consultant to obtain a good indication of the number of animals grazing in the western Gash Delta during the year, as the numbers vary significantly from year to year, and throughout the year, depending on the rains and/or the floods.

Ad e.

The area between the Atbara river and the Gash Delta has been the traditional area for grazing during the crop growing season. Unfortunately the canals from the Gash Delta irrigation scheme which yearly refilled the hafirs west of the road, are no longer functioning. Consequently the herds have to retreat to the well sites within the Gash Delta for watering.

Large herds going from North to South pass this area but never stay long. The number of animals present varies consequently throughout the year. As the vegetation is very heavily overgrazed, the carrying capacity is very low.

The Rasheida herds of camels and goats and sheep, traditionally graze this part of the region. With the reduced availability of good rangelands the Rasheida herds also penetrate the Gash Delta.



## 2. GENERAL INFORMATION ON THE HORTICULTURE SECTOR AROUND KASSALA AND IN THE GASH DELTA

### 2.1 Background

Although there is quite some background available on the Gash Delta it is felt necessary to summarize some important issues as it has a direct bearing on the growing of vegetables.

Each year, for 10 to 20 days, the Gash river floods the Gash Delta fields in a rather uncontrolled way, through irrigation canals, during July, August and September. Annually some 80,000 feddan is prepared for irrigation, but only 40,000 to 50,000 feddan are actually being irrigated. In principle only one third of the land is being irrigated annually; the rest being left fallow (in practice the fields are often left fallow for 5 years). The reason for leaving two third of the land fallow is due to the fact that annual irrigation of the same fields would result in uncontrolled weed growth. The rotation system practised results in less weed growth. On basis of a lottery system the land is being allocated to farmers. As a result a farmer is moving each year from one place to another place. As will be discussed later in this report this is not conducive to the development of horticulture.

In the mid-eighties a study was carried out by Euroconsult resulting in recommendations to improve the irrigation infrastructure and to stimulate the permanent settlement of farmers. The latter would be certainly to the benefit of especially vegetable farmers. During the execution of the programme by HVA it has become apparent that still some form of land-rotation will be necessary. Presently a pilot project is being worked out by the Gash Delta Rehabilitation Corporation which should result in farmers being rotated on land which belongs to them and which will receive better distributed water. Eventually this should lead to higher yields and better income for the farmers.

Cotton was the cash crop for many years. Because cotton production failed, castor was tried as an alternative cash crop in 1959 and gradually replaced cotton as from 1970. However, castor yields rapidly declined till a low average yield of 68 kg per feddan in 1977/1978 (Euroconsult). Sorghum has been, and still is, the only food crop grown in the Delta area. Other crops grown are, on a limited scale, melons, karkadeh and okra.

As the returns from sorghum are extremely low Euroconsult recommended research into alternative crops, amongst others vegetables, which could improve:

- the present diet and health of the population;
- cash earnings and
- involvement of women in farmers' activities.

During the presence of HVA, research in alternative crops, amongst which vegetables, have been intensified. It was considered worthwhile to evaluate the present state of affairs and, if possible, to give directions and recommendations to future developments.

### 2.2 Areas, crops grown and cropping patterns of vegetables grown around Kassala and in the Gash Delta

In the context of this study two distinct (horticultural) areas can be distinguished viz. the area around Kassala town (irrigated by water from wells) and the Gash Delta north of Kassala (one-time flood irrigation).

### **Kassala**

Most of the horticultural crops are found some 20 kilometers north and south of Kassala. Details for the Kassala area are shown below (1992/1993; Source: Horticultural Department).

Vegetables (feddan)	1,997
Citrus (trees) <sup>1)</sup>	63,088
Guave (trees) <sup>1)</sup>	9,098
Mango (trees)	4,043
Banana (feddan)	1,825
Berseem (feddan)	264
Number of holdings	863
Area under cultivation (feddan)	12,811
Number of wells	874
Number of electric pumps	101
Number of diesel pumps	776

1) According to the underlying breakdown 78,593 citrus and 1,298 guave trees. However arithmetic mistakes have been made by the Horticultural Department.

For vegetables no breakdown is available, but the main vegetable crop is onion. In the past a factory processed the onions but the factory was closed in 1985 due to mechanical problems.

Part of the fruits are processed in the Kassala Fruit Juice Factory.

### **Gash Delta**

The Gash Delta is located between 15°30' and 16°30' N and 35° 50' and 35° 30 E'.

Only in 1981, at the request of the Regional Minister of Agriculture, a first attempt was made by the Agricultural Research Corporation (ARC) to grow vegetables in the Gash Delta. Since that time commercial expansion of vegetables has been, apart from water melons, negligible due to a number of constraints discussed at a later stage.

As mentioned above, the major vegetable crop in the Gash Delta is water melon grown near Wagar in the Northern part of the Delta. The 1993/1994 area for this crop is estimated at 2,000 to 3,000 feddan (it once reached 10,000 feddan). Quantitative data for other crops are lacking but are believed to be negligible. Horticultural crops grown on a (very) limited scale are sweet melon, okra, tomato, eggplant, karkadeh, hot pepper, squash, etc.

Table 1 shows the sowing dates for a number of vegetables and karkadeh grown in the area around Kassala (pump-irrigation) and in the Gash Delta (one-time flood irrigation).



Table 1: Sowing dates for a number of vegetables and karkadeh grown in the area around Kassala and the Gash Delta

	J	F	M	A	M	J	J	A	S	O	N	D
Cucumber (snake)	k	k	k			K	K	K g	K g	k g	k g	k g
Eggplant	k	k						k g	K g	K g	k	k
Hot pepper							k	K g	K g	K g	k	k
Karkadeh					k	k	K	K g	K g	k g	k	
Okra		k	k	k		K	K	K g	K g	g		
Pumpkin	k	k					k	K g	K g	K g	k g	k g
Squash								g	K g	K g	k g	k g
Sweet melon	k g	k						g	K g	K g	K g	k g
Tomato	k	k					K	K g	K g	K g	k g	k g
Water melon	k g						k	K g	K g	K g	K g	k g

Legend: k = sowing dates for crops under permanent irrigation (K = optimal sowing date).  
g = sowing dates in the Gash Delta (Nov./Dec./Jan. in the Wagar area).

### 2.3 Institutions related to horticultural activities

#### *Technical Committee*

Some three years ago the Central Ministry established a Technical Committee consisting of:

- Director General Regional Ministry of Agriculture
- Director of the Kassala Agricultural Research Station
- Director of the Horticultural Department
- Director of Extension

The objective of this Technical Committee is to formulate a plan for introducing vegetable crops in the Gash Delta. The Technical Committee has submitted and discussed the plans with the Director of the GDAC.

Three years ago it was proposed by the Committee to develop some 500 to 1,000 feddan of vegetables in each of the six irrigation blocks and one hopes that a start can be made in the 1994/1995 season with the realization of this plan.

## 1. INTRODUCTION

The river Gash has its origin in Eritrea (Ethiopia), some 25 km south of Asmara, where it is known as the river Mereb. It first runs in a south-western direction, during which it is joined by numerous tributaries. When the river enters Sudan, it changes its course in a northerly direction (Figure 1). After passing the western face of Jebel Kassala, it reaches the apex of the Gash Delta (Figure 2). The total catchment area of the Gash is estimated at approximately 21,000 km<sup>2</sup> (Figure 3). The upper reaches of the river in the catchment area has a drop in elevation over the first 175 km of approx. 900 m, starting at an elevation of 2000 m above sea level. In the lower reaches, starting before the Sudan border, the drop in elevation reduces to approx. 1 to 2 m per 1000 m. The riverbed has become even and sandy.

When entering the Gash Delta, part of the river's flood water is diverted for the controlled irrigation. The remaining flow will spread in an area, located north of the irrigated area, where the water infiltrates and evaporates. The Gash river only flows during the rainy season, the period July to September, although it may occasionally start to flow in late June and continue into the first week of October.

The average daily discharge, during an average yearly flood, will be in the order of 150 m<sup>3</sup>/s.

Due to the very strong fluctuations of the river discharge, the heavy suspended-load of silt (5500 ppm at times) and the sandy bed-load, the course of the Gash river in the Gash Delta is very variable.

The sandy bed-load will remain in the bed of the river course, while the finer suspended-load of silt will enter the irrigated lands via the irrigation canals and the area north of it.

In the Gash Delta, there are two main soil types to be found, through which the Gash river follows its course.

The two main types of soil are :

- a rich silt, with high permeable qualities and locally called "lebad"
- a heavy cracking clay, with less permeable qualities and locally called "badobe"

Apart from these two main soil types, there exists all kind of gradation of these two soil types. The particle size of the soils to be found in the Gash Delta will be less than 100  $\mu$ m.

The Gash Delta Agricultural Corporation (GDAC), the organisation responsible for the management of the Gash Delta irrigation scheme, is facing serious problem to provide an adequate and controlled water supply to the irrigation system. A main problem is that the water supply cannot be properly regulated at the head intakes. The result is an erratic water supply to the Misga canals and frequent breaches. The situation at Metateib intake is particularly critical.

In order to obtain a clear understanding of the problem and to recommend on short term and long term solutions HVA-International, the implementing agency for the Gash Delta Project, proposed to conduct a specialized river trainings study.

HVA requested DEMAS (dredging, engineering and management studies), who has experience in the Gash Delta, to execute the study.



## 2. OBSERVATIONS

During the first stage of the mission, prior to the seasonal flow of the Gash river, visits were made to the various head intakes. Annex 1 provides a detailed report of these visits. Unfortunately, there were no drawings or plans available of the existing structures and river embankments near the structures.

This report covers the items 1 and 2 of the 'Terms of Reference', being the assessment of present status of the head intakes. Various photographs (Annex 1.1-1 to 1.1-10) were taken to provide supporting evidence for the observations and to allow for a comparison of the situation prior, during and after the seasonal flow of the Gash River.

During the second stage of the mission, while the seasonal flow of the Gash River was in progress, visits were made again to the various head intakes. The main objective of these visits was, to observe the flow pattern around the head intakes and the situation of the water drawn through the head intakes. Annex 2 provides a detailed report of the visits. Again, various photographs (Annex 2.1-1 to 2.1-11) were taken to support the report.

During the third stage of the mission, after the seasonal flow of the Gash River, visits were made again to the various head intakes.

The main objectives of these visits were :

- to observe the pattern of the river bed, from which the river flow can be visualized for comparison with the observed flow during the second stage of mission;
- to advise on the preparatory works (such as surveys, master charts, drawings etc.) to facilitate the proper monitoring of the Gash river flow and the future design and lay-out of the river training works.

Annex 3 provides a detailed report of the visits. Again, various photographs (Annex 3.1-1 to 3.1-10) were taken to support the report.

From the reports it becomes clear that the head intakes are in general not functioning properly. The reason for the improper functioning is, that the head intakes are not correctly situated in an outerbend of the Gash river. The present outerbends are situated either upstream or downstream of the head intakes, or no outerbend exists at the location.

Due to this situation, eddies will develop directly in front of the intake, which cause settlement of the coarser bed-load sediment, with the effect that the intakes will become partly blocked. The important characteristics of the outerbend will be explained in chapter 5.

In the past, consultants have observed this situation and made proposals for repositioning the head intakes. This is incorrect because :

- the head intakes are linked to an established irrigation scheme;
- the river will create the same situation again after a number of years, as the Gash River is a river not regulated by river-training works, apart from the section near Kassala.

Moreover, weirs were constructed in the past at the downstream side of the head intakes at Salaam Aleikum, Tendelai and Metateib. The effect of the weirs in the not regulated Gash River is, that the river gradient will be reduced, the riverbed will rise and the Gash riverbed will become wider and shallow. A clear example is the situation at the mentioned locations. At Metateib it resulted in a complete bypass at the western side.



Due to the increasing deforestation in the upper reaches, the catchment area of the Gash, the amount of sediment transport will increase over the years. Apart from the fine material, which will settle in the irrigation fields and northern area, the coarser bed-load material will cause another problem, while settling in the meandering river. This coarser material will settle initially in the southern part of the Gash Delta and will then slowly progress towards the north. Due to the settlement of the coarse material, banks are formed and the Gash will create a more pronounced meandering feature, thereby widening the total meanderbelt (figure 5).

Meandering of a river is the forming of pronounced bends in the water course. The spurs at Kassala have prevented this situation at that location.

North of Metateib, the Gash is still flowing through a narrow riverbed, as the amount of the coarser bed-load material is limited. The meander-belt is accordingly smaller. The riverbed has the appearance as shown in figure 6.

The meander-belt is of importance for the location of the bunds on the embankment for preventing breaches in the bunds. The bends of the river will always remain within the meander-belt. Instead of widening the meander, it will create a breach in the river (within the belt) and a cut-off of the bend is naturally established (figure 5).

The characteristic of a river with a riverbed consisting of fine material, will be narrow and deep, with a limited meander belt. The characteristic of a river with a riverbed consisting of coarse material will be wide and shallow, with a wide meander-belt. Both characteristics apply to the Gash River in the Gash Delta. The first mentioned characteristic applies to the northern part, the second to the southern part (figure 7).

To understand the behaviour of a river course one should bear in mind that water always flows to the lowest point via a way that offers the least resistance. Due to differences in elevation and nature of the bed material, the watercourse will develop a kind of snaking pattern, the meandering feature. The water course will always try to find a balance between the cross- and longitudinal profile. For each point along the water course a series of relationships exist between the discharge, the amount of transported sediment, the width and depth of the riverbed, the roughness of the bed the grain size of the transported sediment, the current velocity and the river gradient.

If the Gash River could be completely regulated, then drawing water from the Gash at the intakes would not face too much problems. However, this is wishful thinking. For this reason river training works should be designed and constructed in such a way that the intakes are able to draw the required amount of water, without facing blockages at the entrance by the coarser bed-load material. The stretch of river between the various head intakes, which is not provided with river training works, will still be affected by the wild meandering feature.

The stretch of river, approaching the river training structures upstream of the head intake, could cause problems, and should be watched carefully. Extra river training structures could be found necessary.

Under 'crash programmes' should be understood all kinds of repairs on breaches, etc in areas outside the river training structures, located around the head intakes.



Damages to the river training structures and head intakes should be regard as maintenance repairs. When proper care of these structures are taken, less repairs will be needed.

An example is shown on photographs 1.1-9; 1.1-10 and 2.1-10. Prior to the flood season it was noticed that the pitched-stone protection on the heads of spur DE-6 and DW-6 had disappeared. Unfortunately, no repairs were carried out and the major part of spur DE-6 was eroded, causing erosion of the embankment between the spurs.

## SUMMARY

The mission was carried out by DEMAS (dredging, engineering and management studies) at the request of HVA-International, the implementing agency for the Gash Delta Project, during three periods between June 4th 1992 and October 21st 1992. Terms of Reference are given in Annex 15.

The objective of the mission is to assess the condition of the head intakes and to make recommendations on measures which should improve the water supply through the irrigation canals to the fields.

In order to assess the present situation and problems properly the mission was divided over three periods, respectively before, during and after the seasonal flow of the Gash river.

It appeared that the head intakes are not functioning properly because they are not correctly positioned in relation to the outerbends of the Gash river. Repositioning the head intakes will not provide a long term solution to the problem because the river Gash will continue to change its course and riverbed, creating the same problems with the new intake after some time. Increased deforestation in the catchment area, increasing the sediment load of the river will only aggravate these problems over the years.

Also for practical reasons repositioning of intakes is not recommended : the present head intakes are linked to the established irrigation scheme.

Therefore, it is proposed to put properly designed river training structures in place near the present head intakes so that the intakes will be able to draw enough water to the irrigation system. Examples of the design of such structures are presented.

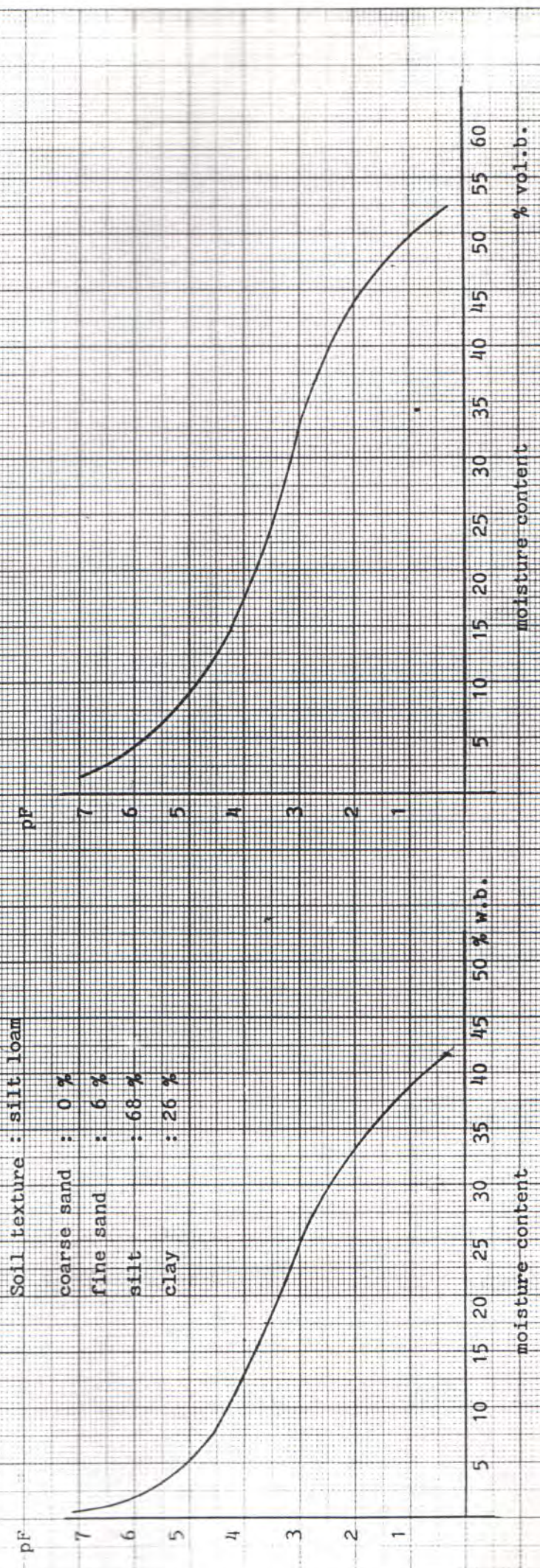
Before embarking on the design and construction of these structures a thorough understanding of river behaviour is essential. This understanding is currently not available within the GDAC, the organisation responsible for operating and maintaining the irrigation system, and it is therefore strongly recommended that any river training programme should include a course on the subject for the staff in charge of irrigation and civil engineering.

It is recommended to update and to extend the topographical chart which was prepared by DEMAS in 1986, so that it will cover the Gash river course up to the last intake. This chart is needed to determine areas near the intakes where detailed surveys have to be made for the design of the river-training structures. Also detailed drawings of each head intake should be made and be kept up to date with any modification.

It can be concluded that a comprehensive river training programme is a prerequisite for an adequate and controlled water supply to the irrigation scheme and thus for agricultural and forestry development in the area.



Fig.(2) Soilmoisture characteristic  
well drained Tograr soil (Misga 14)

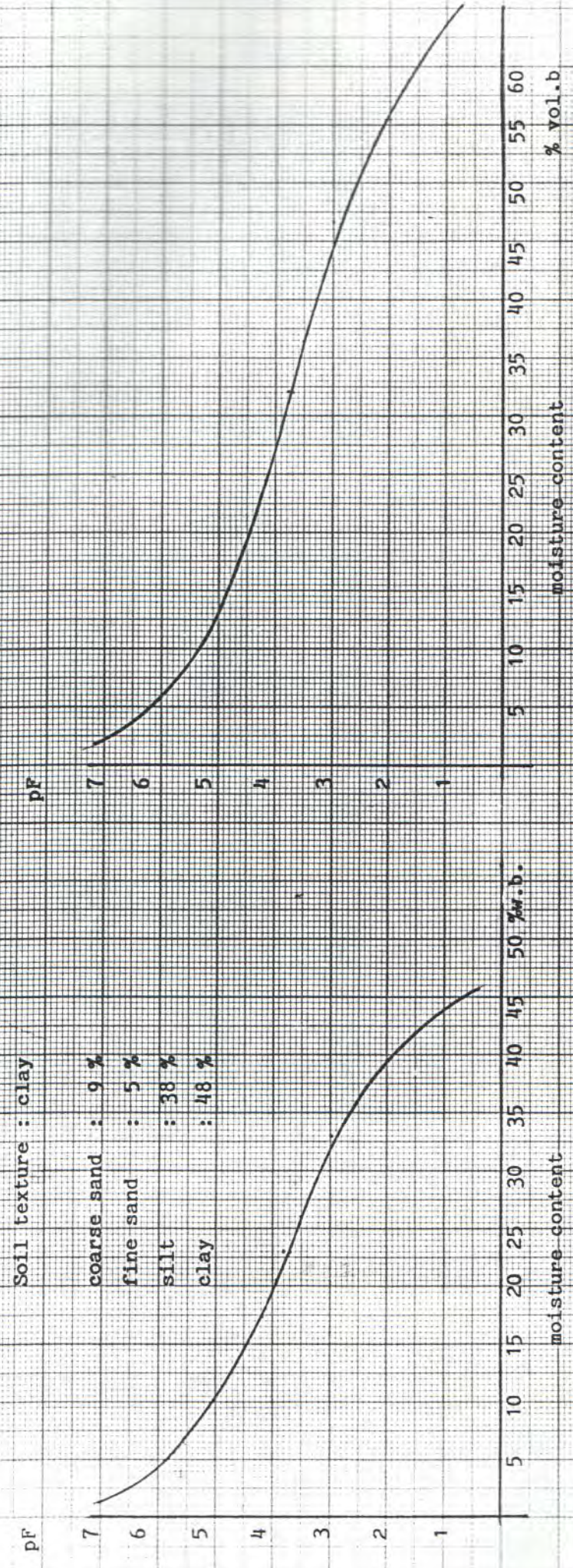


1/3 bar = pF2  
1 bar = pF3.0  
3 bar = pF3.5  
5 bar = pF3.7  
10 bar = pF4.0

15 bar = pF4.2



Fig.(1) Soilmoisture characteristic  
Mekali soils (Mekali 3)



Available moisture between Fieldcapacity (pF2) and  
wilting point (pF4.2) = 325 mm/100 cm soil column

15 bar = pF4.2

- 1/3 bar = pF2
- 1 bar = pF3.0
- 3 bar = pF3.5
- 5 bar = pF3.7
- 10 bar = pF4.0