Variations in access to domestic water supply in EN Nahud district, Sudan

Wood, Helen Frances

VARIATIONS IN ACCESS TO DOMESTIC WATER SUPPLY IN EN NAHUD DISTRICT, SUDAN

Helen Frances Wood

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DECLARATION

The material presented in this thesis has not been submitted either wholly or in part, for a degree in this or any other university and is the original work of the author except wherever acknowledged by reference or citation.

Signed:

ABSTRACT

VARIATIONS IN ACCESS TO DOMESTIC WATER SUPPLY IN EN NAHUD DISTRICT, SUDAN

The central aim of this thesis is to develop an understanding of variation in access to domestic water supply in a semi-arid, non-riverain area of Sudan. En Nahud District, in North Kordofan Province, was selected for study because it has existing water supply problems and contains distinct spatial variations in geology, which affects the potential for development of underground water resources.

Fieldwork in Sudan was carried out between July and December 1988, and information was collected from a range of sources using a variety of methods. The latter included: semi-structured household interviews conducted with women; key informant interviews; observation; and various published and unpublished articles and data sets.

In the thesis, the first chapter introduces the national and international context of this study. Past and present water supply development policies and projects in the Sudan are outlined, and set against the goals of the International Drinking Water Supply and Sanitation Decade. In the second chapter, the research methodology is discussed. Attempt was made to overcome the several spatial, temporal social and economic biases which have occurred in other studies. In the third chapter, the thesis is placed in the physical and socio-economic context of the Province, and the dynamic relationship between water supply and demand is outlined. The following three chapters focus upon the primary constraints which limit access to domestic water supply: water availability; at-source costs; and transportation costs. The components of each, and the way in which they operate to restrict access, are investigated in relation to varying family resources and requirements. The borrowing of carriage resources and the purchase of transportation services are examined as strategies for overcoming families' internal collection-capacity constraints. Finally, seasonal outmigration is discussed as an important response to inadequate access to water supply.

In its conclusion, this thesis shows clearly the importance of examining access to water at the family scale: inter-household variations, such as the ownership of carriage animals and varying labour resources, are shown to be influential in affecting household water supply strategies.

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GLOSSARY AND ABBREVIATIONS

ADS	-	Area Development Schemes
aesh	-	'bread' or staple grain
arit	-	small community which has broken away from a larger settlement to facilitate access to fields, but still owes allegiance to it
aseeda	-	sorghum or millet porridge
bahr	-	the Nile
battikh	-	watermelon (Citrullus vulgaris)
bir	-	deep, permanent well
birish	-	woven straw mat
butes	-	groups of houses just outside the main village
CAFOD	-	Catholic Fund for Overseas Development
caro	-	horse-drawn cart with barrel, used to transport water
dalu	-	scoop for raising water
dammer	-	dry-season outmigration
dar	-	'homeland'
darat	-	harvest season
DC	-	district council
dukhn	-	millet (Pennisetum typhoideum)
dura	-	sorghum (Sorghum vulgare); used generally of grain crops
eid	-	Islamic festival
ERRP	-	Emergency Relief and Rehabilitation Programme
ETMA	-	Environmental Training and Monitoring Programme for Africa
fantass	-	large storage tank
feid	-	old khor-bed, mainly silted

ful	-	groundnut (ful sudani)
fula	-	a primary surface water store
GAC	-	Gum Arabic Company Ltd
gammam	-	a well feature
gardud	-	high ground of sandy clay or gravel, produced by the weathering of rocks
gidad	-	locust
gimam	-	a well feature
girba	-	animal-skin container (for transport of water)
GPA	-	Gum Producer Association
guffah	-	basket (also used as a measure)
habbaba	-	fan (for a fire)
haboob	-	wind, sandstorm
hafir	-	large, mechanically-excavated surface water store
hamaraya	-	iron oxide cemented sands
harig	-	a farming system in which land is cleared after the rains have started by burning newly-sprouting vegetation with old, dry grass
hashab	-	gum arabic tree (Acacia senegal)
haskanit	-	a grass with spiny fruit (Cenchrus biflorus)
hodd	-	a basin or trough
hooridge	-	large, flexible water containers, characteristically used by commercial vendors
hosh	-	compound
idd	-	well-field
IDWSSD	-	International Drinking Water Supply and Sanitation Decade
IES	-	Institute of Environmental Studies (University of Khartoum)

INSTRAW	-	United Nations International Research and Training Institute for the Advancement of Women
IWP	-	Interim Water Supply and Management Project (CARE)
jammam	-	a well feature
jc	-	jerrican (abbr)
jebel	-	hill
KAEP	-	Kordofan Agro-Forestry Extension Project (CARE)
kazan	-	cistern
kerkade	-	roselle (Hibiscus sabdariffa)
khalla	-	area beyond the village and its cropped lands
kharif	-	rainy season
khor	-	wadi, seasonal watercourse
khreisha	-	rug
kisra	-	sorghum or millet pancake
KRDS	-	Kordofan Rehabilitation Development Strategy
lagai	-	type of tebeldi which, by the configuration of its upper branches, is self-filling
lagat	-	same as lagai
MADP	-	Ministry of Agriculture Development Project
mashakil	-	problems
mashish	-	a well feature
mayker	-	a wild 'food'
melish	-	a well feature
merissa	-	sorghum beer
MTD	-	Mechanical Transport Department

mukheit	-	a small tree (Boscia senegalensis)
mulhaa	-	sauce; meat or vegetable stew
nabak	-	a thorny bush (Zizyphus spinachristi)
NAW	-	National Administration for Water
NCDRWR	-	National Corporation for the Development of Rural Water Sources
NGO	-	Non-Government Organisation
NKWSP	-	North Kordofan Water Supply Project
NRWDC	-	National Rural Water Development Corporation
NWC	-	National Water Corporation
omodia	-	administrative unit (tribally-based)
PROWWESS	-	Promotion of the Role of Women in water and Environmental Sanitation Services
PVO	-	Private Voluntary Organisation
qoz	-	sand
racouba	-	hut (often open-sided)
ragabee	-	at some wells, a smaller lower-level basin specifically for animals to drink from
rahad	-	larger, seasonal pool, which sometimes last into early shita
rahud	-	small, rainwater pools that last for only a couple of days after a rainfall
raqaba	-	a wide, shallow depression which sometimes meanders round the countryside for a considerable distance
RC	-	rural council
RFPP	-	Regional Finance and Planning Project
Rusharsh	-	first rains
RWC	-	Rural Water Corporation

RWDC	-	Rural Water Development Corporation
sabaloka	-	a channelling system, whereby water is collected from a metal roof and directed to a storage tank (eg a barrel)
sania	-	a well feature
seif	-	hot, dry season
seraiya	-	cultivated area
shamla	-	rug
shita	-	cool, dry season
simsim	-	sesame (Sesamum orientale)
SMARWS	-	Social and Managerial Aspects of Rural Water Supply
SPWP	-	Special Public Works Programme
SSSUK	-	Sudan Studies Society of the United Kingdom
suq	-	market
tamad	-	shallow, temporary well
tashit	-	shallow, circular tray (various uses)
tebeldi	-	baobab (Adansonia digitata)
TFWI	-	Task Force on Women and the IDWSSD
thawani	-	a well feature
turda	-	a primary surface water store
VC	-	village council
VWC	-	Village Water Committee
WSARP	-	Western Sudan Agricultural Research Project

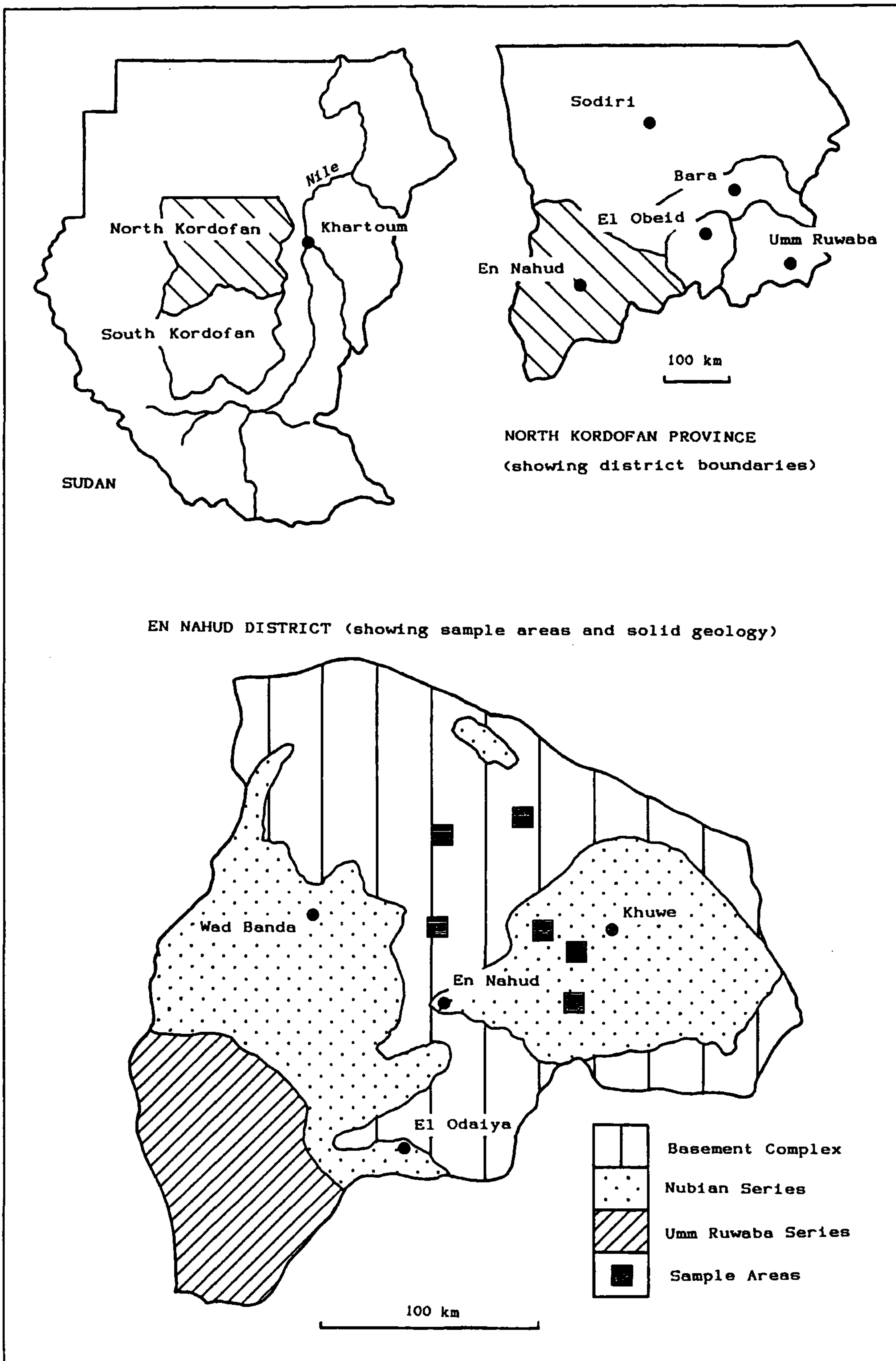

Figure 1.1: The Location of the Study Area

CHAPTER 1: INTRODUCTION

INTRODUCTION

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INTRODUCTION

Sudan is one of the poorest countries in the world. The 1980s was a devastating decade for the country, with economic, political and environmental catastrophes contributing to an escalation of its poverty.

Throughout the 1980s, Sudan's economy was supported by substantial foreign loans and gifts. Its balance of trade was permanently in deficit. From the early part of this century to the 1980s, exports were dominated by cotton, which accounted for more than fifty percent of export earnings (Economist Intelligence Unit, 1989). By 1986, however, cotton exports fell due to the combined effects of: droughts; irrigation problems; depressed cotton prices on the world market; and poor marketing. While export earnings were declining, the volume and price of imports were escalating, especially fuel. This placed further strains on the economy. Fuel shortages compounded the problems of an inadequate and inefficient transport system. Sudan was expected to capitalise on its own oil reserves during the decade, but production never started, mainly due to civil war.

Political turmoil, including two successful military coups, contributed to the resurgence of civil war, which has existed intermittently since Independence (1956). The financial cost of supporting the army has been a substantial drain on the economy, and much of the South is economically unproductive due to fighting and uncertainties about security. Other political decisions have contributed to a decline in international support and further economic problems. In particular, many western countries have withheld economic support due to concerns over human rights and corruption.

Environmental catastrophes in the 1980s, most especially drought (1984 and 1989) and floods (1988), compounded other economic and political problems. These floods came after two decades of almost sustained below-average rainfall (Chapter 3) and escalating desertification.

Meanwhile, a growing demand from an increasing population has placed ever greater strains upon the impoverished resource base, not least in terms of water supply. The poor state of the economy has contributed to many inefficiencies in extracting and delivering water, especially where there has been dependence on mechanical pumps or lorries, and there has been little money for investment. Much of the investment in rural water supply in the 1980s came come from international bodies and bilateral aid.

This chapter outlines the background to the development of rural water supply in the 1980s and demonstrates how and why investment followed particular courses of action. Initially, consideration is given to the broad aims of the International Drinking Water and Sanitation Decade (IDWSSD). This is followed by a brief history of water policies in non-riverain Sudan to the 1980s. The severe drought and famine of the mid-1980s is then described, and finally some of the water-related programmes which have been introduced in North Kordofan, where the study area is located, are outlined. Taken together, these provide a context for the rest of this thesis.

THE INTERNATIONAL DRINKING WATER SUPPLY AND SANITATION DECADE

Objectives of the Decade:

The 1980s were declared the 'International Drinking Water Supply and Sanitation Decade' by the United Nations. The goals were clean water and adequate sanitation for all by 1990 (McGarry - Foreword in Glennie, 1983). The declaration focussed awareness on drinking water and sanitation problems throughout the world, principally in the poorer tropical regions. This was justified on humanitarian and economic grounds (World Water, Nov 1980; Dec 1980). In the preceding decade, there had been a number of major water supply problems. Among the worst was the 'Sahel Drought', when rainfall deficiencies, compounded by rapid increases in population, contributed to many deaths (Glantz, 1976).

The designation of the IDWSSD was both symbolic and practical. It encouraged international support for various national water policies. Speaking at the launch of the IDWSSD in New York on 10th November 1980, the Sudanese delegate commented:

> *"Sudan's success in achieving the objectives of the International Drinking Water Supply and Sanitation Decade depends on its overcoming obstacles which are faced by most developing countries that are similar to Sudan... Those impediments and requirements necessitate expansion of technical and financial cooperation and provision of the necessary foreign exchange for the purchase of equipment and spare parts. We should also like to point out that the National Water Administration needs assistance concerning*

the management of the wells that have been drilled and the digging of new wells; $4 million are required in order to provide the necessary spare parts for the drillers and the assisting transport fleet." (World Water, Dec 1980: p.15)

Delegates from many other countries expressed similar concerns, among them the representative from Ghana:

"We should like to stress in particular the need for untied aid which would enable the developing countries, inter alia, to import the appropriate technology for the provision of necessary facilities to the greatest number of people at the cheapest cost." (World Water, Dec 1980: p.16)

Other African and Middle Eastern delegates stressed the need to increase supplies, but emphases varied geographically. The Chinese spokesman pointed out that:

"We have already solved the problem of water shortage for over 40 million people in regions where water is scarce and our Government has stipulated a decree on environmental protection, which signifies that greater concern is now shown on the problem of water pollution." (World Water, Dec 1980: p.15)

Latin American delegates expressed water supply and sanitation targets for both urban and rural areas, including the modernisation of existing sources. The representative from Ecuador said:

"Ecuador is moving... with the aim of providing its inhabitants with sufficient unpolluted drinking water and adopting sanitation measures that will have a positive impact on the quality of human life. In the process, dams and reservoirs are being built, as are wells and canals that will take the place of obsolete pipe systems. We are refurbishing old aqueducts; we are setting up pumping systems. All of this is designed to meet the growing demands of the inhabitants of cities and rural areas." (World Water, Dec 1980: p.16)

Examples of Projects:

Apart from influencing the water policies of individual countries, the IDWSSD encouraged water-related projects. To help illustrate the range of policies and projects being undertaken the following examples, all extracted from a single edition of 'Developing World Water' (1987), record some of the achievements half-way through the Decade.

Water Supply and Sanitation in Nepal:

Response to the IDWSSD in Nepal was rapid. In 1980, with 'active co-operation' from the World Health Organisation (WHO) and other agencies, a 'Ten-Year Plan for the Provision of Drinking Water Supply and Sanitation' was prepared: the first long-term plan for water and sanitation in Nepal. Emphasis was placed upon: community participation; self-reliance;

environmental protection; health education; and appropriate technology. The original water supply targets were to supply 67 percent of the rural population and 94 percent of the urban population with clean water by the end of the Decade. An interim report at the mid-point recorded substantial improvements in the piped water supply network and the use of handpumps: an extra 2,290,000 rural people were served and 225,000 in urban areas. Although these figures were slightly below the target levels, they were, nevertheless, substantial. Decade targets, however, were subsequently reduced due to financial constraints. In areas with suitable topography, especially in the more remote upland areas, gravity piped systems using natural springs and streams were established, and these proved particularly useful ways of supplying remote communities. The sanitation aspect of the campaign was then still at an early stage (Siddhi, 1987).

Appropriate Technology in Nginyang Division, Baringo, Kenya:

The Nginyang Division of Baringo District, Kenya, whilst being more than 1000m asl and with an average annual rainfall of more than 500mm, is subject to periodic droughts. The economy is dominated by semi-nomadism and, in general terms, has many characteristics similar to the semi-arid zone across central Sudan. In the early 1970s, the Anglican Church was involved in encouraging the settlement of people whose traditional lifestyles had been destroyed by environmental problems. This involved the construction of dams and water pans in areas of fertile soil to provide dry-season supplies for people, animals and small-scale irrigation. Initially, the project was unsuccessful: the catchment pans were too shallow, unprotected from livestock, and silted-up due to lack of maintenance. Extra funding was sought from various agencies[1] to rehabilitate some of the dams, and communities became involved in fencing provision to restrict livestock movements. The project was eventually expanded to become the 'Baringo Community Development Programme', which had funding from a British voluntary agency and the European Community. The new development embraced various community projects, such as improvements in health and appropriate education, as well as an extension of the original water supply objectives. Water supplies were secured by: roof catchments; micro-catchments for tree cultivation; and the creation of ditches within catchments to facilitate improved agriculture (Wallace, 1987).

Baldia Soakpit Project in Pakistan:

About two million people in Karachi live in squatter settlements. One of the largest of these is Baldia. Baldia receives some water from standpipes for a few hours per day, but the method of removing waste-water, including excrement, is rudimentary. These factors have been contributory to the area's high infant mortality (about one in nine children die within a year of birth). In 1978, UNICEF contributed funds to help remedy some of these problems. A number of pit latrines were constructed with sufficient capacity to avoid overflowing, which had been a frequent and unhealthy occurrence with the few pre-existing ones. The work involved substantial community input in organisation and construction, as well as training others to build their own soakpits. Extension work was also included in the project: women were taught the hazards of poor sanitation, and given training in basic health and hygiene practices. With limited investment in manpower and finance, the UNICEF project was able to make significant progress in reducing health hazards caused by poor waste-water management (Bakhtiari, 1987).

Water Storage in the Middle East:

Storing water in hot climates, especially in remote areas where engineering opportunities tend to be restricted by logistical and practical problems, has often proved problematic. In an effort to overcome some of these problems in Middle East countries, a private company[2] designed and built 'Hydroglas Sectional Water Tanks'. Panels could be assembled in a variety of ways to offer flexible storage units. The design meant that the materials could withstand high diurnal temperature extremes as well as ultra-violet and infra-red radiation, and were free from corrosion and the growth of algae, bacteria and fungi. The 'kit form' of construction allowed tanks to be sited in remote and inhospitable areas and, if necessary, the materials could be lifted by helicopters (Hawkins, 1987).

Women, Water Supply and Sanitation in the Decade:

In general terms, the range of projects carried out in the first half of the Decade achieved enough practical improvements to allow some modest satisfaction (Lowes, 1987). In this period, however, many of the successes were measured in terms of engineering achievements and increases in the physical volume of water provided, rather than in broader socio-economic terms.

At the outset of the IDWSSD there was an awareness of the involvement of women in water supply and sanitation, and this continued throughout. In developing areas, research has shown that women are often the principal collectors of water and that they expend much time and effort in this task, although exact figures vary (eg White, Bradley and White, 1972 (citing Dempsey, 1955); Carr, 1978; Badri, El Nujumi, Shabo, El Obeid, and Hassan, 1981; Glennie, 1983). Pastizzi-Ferencic, Ahooja-Patel, Bulajich and Meltzer (1989) commented that some women in developing countries spend up to six hours per day collecting water. Carr (1978 - citing McDowell and Hazzard, 1976) commented that water carriage is the single most burdensome task for African women in rural areas, and that an average of one sixth of all their energy is expended in water collection (see also Glennie, 1983). Montagu (1987) commented:

> *"This [burden] is a scandal which the United Nations has highlighted in the Decade for Water." (p.81)*

This awareness was formalised in the development of specific organisations in the Decade. In 1980, the UN established a 'Steering Committee for Co-operative Action on the IDWSSD', which:

> *"developed a strategy for promoting women's participation in water supply and sanitation activities that envisages involving women at the policy-making, management and technical levels for programming, monitoring and evaluation of existing or future Decade activities." (Pastizzi-Ferencic et al., 1989: p.6)*

In 1982, a 'Task Force on Women and the IDWSSD' (TFWI) was set up. After various administrative changes, its overseeing was finally handed to the UNDP/PROWWESS ('Promotion of the Role of Women in Water and Environmental Sanitation Services' project). The Task Force was managed in close consultation with another United Nations body, the 'International Research and Training Institute for the Advancement of Women' (INSTRAW). The Task force included representatives of all UN agencies working to promote women. From 1984, a number of specific projects were proposed or commenced under the aegis of TFWI. These included: courses on health and hygiene in Bangladeshi slums; community participation in low-cost sanitation schemes in India; training women in health education and handpump maintenance in Kenya; and training women about irrigation techniques and basic repairs in Niger and Senegal.

In commenting upon the accomplishments of the Decade, Arthur Brown, the Associate Administrator of UNDP, noted, concerning the shift in emphasis towards women:

> *"Community participation and women's involvement were seen as important from the beginning of the Decade, but recognition has grown much stronger and is now being translated into action. This was due in part to the fact that emphasis has shifted from centralised, high-cost services (such as piped-in water and sewage systems) to community based, low-cost services (such as handpumps and latrines)... women's involvement at the community level will take on new importance." (Brown, 1989: p.6)*

Contributions of the IDWSSD:

It is too early to evaluate the achievements of the IDWSSD, but some general observation can be made. Initially, there was concentration on improving water supplies in a technical sense. Water problems were perceived to be solvable by: increasing supply; raising quality; and improving sanitation. By the middle of the Decade, there was a broader interpretation of the methods required to meet the United Nations' objectives. More emphasis was placed on involving communities in decision-making and, in particular, on women's needs. One dimension of this was to obtain women's perspectives on water-related issues. This subject forms one of the principal themes of this thesis.

In order to relate the objectives of the IDWSSD to Sudan, it is helpful to outline the history of water policies and activities in the country.

WATER SUPPLY IN THE SUDAN

Policies of the Condominium Government to the 1940s:

Improvements in water supply have been a major objective of politicians and engineers in Twentieth Century Sudan. One of the first large-scale projects undertaken by the Government of the Anglo-Egyptian Condominium was an assessment of the potential for controlling the waters of the Nile Basin (Hurst, 1952). One reason for this investigation was to assess the best use of the Nile to supply both the needs of Egypt and to exploit the agricultural potential of the Sudan (Collins, 1990). Major engineering works on the Nile in the Sudan began with the Sennar Dam, on the Blue Nile, completed in the 1920s to feed a network of canals supplying the vast Gezira Irrigation Scheme, on the fertile clays between the Blue and the White Niles (Barbour, 1961). Further engineering works in the 1930s included the Jebel Aulia Dam, on the White Nile (Howell, 1988), which provided the twin advantages of giving greater control over water supplies to Egypt and improved scope for pump irrigation on the clays adjacent to the newly-created reservoir (Trilsbach, 1991). Although both the Gezira Scheme and the White Nile Pump Schemes were planted with a variety of cash, staple and fodder crops, their primary role was to provide cotton for export.

In the period up to the Second World War, the only large-scale water projects away from the Nile Valley were in the Gash Delta (Shepherd, Norris and Watson, 1987) although boreholes began to be introduced into North Kordofan from 1912 (El Sammani (ed), 1985a). Traditional water supply in areas like North Kordofan comprised shallow-wells, and water stored in surface pools and in *tebeldis* (Chapter 4). From the 1940s, however, a sequence of policies began which had wide-ranging implications for water supplies in rainfed Sudan, not least in North Kordofan.

Policies in Non-Riverain Sudan from the 1940s to the 1980s:

Water development programmes since the 1940s have had various objectives. Mohamed and Abu Sin (1985) identified four phases, which broadly accord with those identified by Al-Awad, Mohammed and El Tayeb (1985) and Shepherd *et al.* (1987).

Conservation Phase (1942-1956):

The first phase, sometimes referred to as the 'Hafir Decade', was one of environmental conservation and protection. The aim was to relieve pressures of overgrazing and overcultivation in degraded areas by opening up new ones. To this end, the Soil Conservation Section was established to construct *hafirs* and small dams in areas where water supplies were, hitherto, inadequate. It was hoped that the new sources would help to effect a redistribution of population and a change in migration patterns. However, insufficient water was provided and new water points themselves became centres of degradation because of insufficient land use planning.

Land Use Phase (1956-1966):

The second phase was more ambitious, perhaps reflecting optimism following Independence and realisation of the enormity of land use and water supply problems. The principal goal was to combat the shortage of drinking water in rural areas, but this was combined with attempts to structure land use and reduce environmental degradation in the vicinities of existing sources. The Soil Conservation Section was: enlarged; renamed the Land Use and Rural Water Development Department; and given responsibilites for setting-up and co-ordinating the policies. Achievements fell short of expectations due to overambition and inadequate financial resources, but some basic criteria for water provision were established.

Anti-Thirst Campaign (1967-1969):

In the late 1960s, combatting thirst became the overriding concern. The 'Anti-Thirst Campaign' was promoted by the Rural Water Development Corporation (RWDC), which brought together all sections and departments concerned with water supply and managed to elicit widespread national and international support. The phase saw an enormous acceleration in the provision of water points. Directly linked to the campaign, 4,200 water sources were constructed in the most thirst-stricken areas of western Sudan, which embraced North Kordofan (Mohamed and Abu Sin, 1985). The emphasis was on the physical provision of water points in their own right, rather than wider environmental concerns. Criteria for spatial planning were not observed, partly because of the overambitious nature of policies and partly a result of political pressure (Mohamed, Abu Sin and El Tayeb, 1986).

Rural Development Phase (1970s):

The final phase was influenced by an underlying philosophy that water development could be a catalyst for wider development objectives in suitable areas. A Ministry for Rural Development was established, which incorporated the RWDC, then the only agency for the provision of new water sources. An intention was to encourage popular participation through 'self-help', which was also seen as means of raising local finance to supplement public investment.

Evaluation of Water Policies:

Shepherd *et al.* (1987) reviewed various factors which influenced the allocation of water sources in the 1970s. Demand for water increased at a faster rate than new sources could be provided, and this left scope for political manipulation. The authors discussed the trade in promises of water and the major influences on the geography of investment in water supply. They noted competition for sources at various scales: between provinces; between districts; between villages; and between urban and rural areas. They suggested that, at all stages of provision (conception, design and implementation), the influence of politics could be seen:

> *"The relatively wealthy Eastern District of Kordofan has been able to use its wealth and political influence over the years to acquire the best network of boreholes in western Sudan." (p.174)*
>
> *"Location decisions are not taken on the basis of real need, but on degree of pressure." (p.175)*
>
> *"Officers at the lower levels of the RWC [Rural Water Corporation] are an influence only on the process of execution; but they can face you with problems. So an MRA [Members of the Regional Assembly] instructs his village to be generous with the RWC team, otherwise they may not complete the work." (p.176)*

Mohamed and Abu Sin (1985) noted that improved sources tended to cluster and that clusters were separated by areas of deficient and unimproved sources. When provision was assessed at a national level, there was regional bias in favour of the core areas of the country. In Khartoum Province there was a borehole for every 41km^2 and in the Central Region one for every 65km^2. Furthermore, within provinces, settled agricultural areas were favoured at the expense of those dominated by pastoralism. In broad terms, water went where water was, so the pattern became entrenched.

Many projects were jeopordised by inadequate organisation of the main participatory bodies, including duplication of functions and understaffing:

> *"We must assume that this is a fair description of the formal structure of the Rural Development Department during this period. Nevertheless, it is worth considering how far it corresponded with the realities of day to day work. There was a clear imbalance between the number of sections identified in the organisation and available manpower; at provincial and national levels, simple arithmetic yields two professional officers or so per section. More important, there was an imbalance between the titles and assigned functions of the sections, and the work we know the department was engaged in." (Shepherd et al., 1987: p.117)*

Again referring to the 1970s, Shepherd *et al.* (1987) attempted to define the administrative hierarchy of the RWDC from the national level down to the provinces and identified conflicts in responsibilities and decision-making.

Despite the inadequacies of the administration, by the 1980s there was considerable knowledge about the water resources of non-riverain Sudan, including North Kordofan, and many water-related policies and projects had been implemented. However, in the mid-1980s Sudan suffered its worst ever drought and the inadequacies of the rural water system were clearly demonstrated.

DROUGHT IN THE MID-1980s

Background to the Drought:

The drought of 1984[3] came after a period of sustained low rainfall. Statistics from central Sudan show that from the mid-1960s annual rainfall was considerably less than the eighty-year average, with 1984 the driest year on record (Hulme, 1989) (Figure 1.2). This drought extended across the semi-arid Sahelian belt (Latitude 12°-16° N) (York, 1985), and included the Kordofan Region[4] of Sudan. With it came severe famine, which peaked in 1985. De Waal (1988) noted that this famine was of a severity unknown since 1913, and was distinguished from famines of the earlier decades as a "famine that kills" rather than a period of dearth. He estimated that the mortality rate was three times above normal, with the excess accounted for by the death of young children and the elderly[5]. There were many other effects besides the increase in the death rate. Trilsbach and Ahmed (1986) noted that:

> *"In Sudan generally, it was estimated that by the end of 1984 one in three of the population was affected by the famine, but in the provinces of Kassala, Northern Darfur and North Kordofan everyone felt some impact, ranging from starvation to escalating inflation." (pp.2-5).*[6]

By August 1985 it was estimated that fifty percent of the Sudanese population was affected by famine (Cater, 1986).

The 1984/85 crisis was not purely the result of the exceptionally low annual rainfall in that year, but combined with prolonged effects of desertification. This was caused by

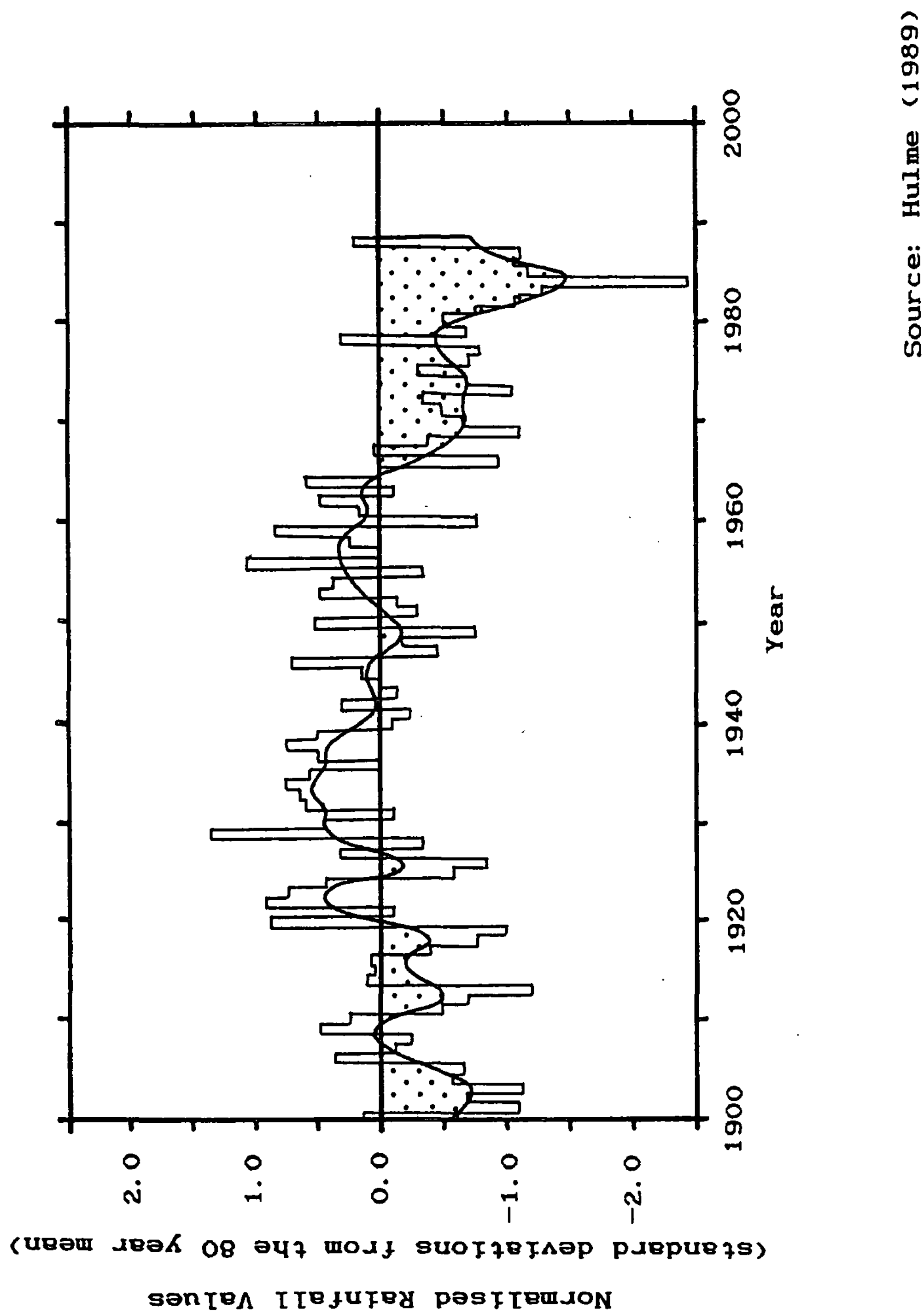


Figure 1.2: Generalised Rainfall Trends in Central Sudan

overgrazing, overcultivation, and deforestation (Ibrahim, 1978; 1984; Hulme and Trilsbach, 1991), partly in response to the years of declining rainfall, and also as a result of inappropriate farming methods. There were also wider level social, economic and political factors (Cater, 1986; Trilsbach and Ahmed, 1986), which contributed both to these long-term environmental problems and short-term effects of the drought.

Impacts on Production:

Crop Yields:

The harvest of 1984 was virtually non-existent in many areas of Sudan, including North Kordofan (McLean, 1985c) and Northern Darfur (York, 1985). This followed a series of successive years of poor harvests (York, 1985)[7]. In North Kordofan, the cereal harvest was reported to have been completely consumed by February/March 1985 and seed required for the next year's planting had been wholly or partially consumed. Grain prices in the market rose because of shortages and people were forced to sell livestock to purchase it. This flooded the market and contributed to a rapid fall in the price of livestock. Cereal prices peaked in July, prior to the seasonal harvest (McLean, 1985a; 1985b; 1985c) (Figure 1.3). McLean (1985c) anticipated that merchants would hoard grain once prices began to fall, causing prices to rise once more. This did eventually occur and was one factor which led to a declaration of a one year 'State of Emergency' from July 1987 (Gurdon, 1987).

Livestock:

Many animals were lost through death or sale. Significant factors in this loss of livestock included: lack of grazing in the vicinity of water sources; the need to sell more animals in the market due to their falling value and the rising price of food; disease; and the need to move to urban camps where most livestock could not be kept (El-Khalifa, Awadalla, and El Sammani, 1985; Trilsbach and Ahmed, 1986). It was reported that the average number of animals owned per sedentary family in North Kordofan decreased by almost 85 percent from early 1984 to February 1985, and by 92 percent by September 1985 (McLean, 1985c). It was noted that animal losses by camel nomads were such that former ways of life were no longer viable (McLean, 1985a). In February/March 1985 livestock prices were very low, but by May/June prices egan to rise again due to scarcity of livestock. By

Figure 1.3: Cereal Prices in North Kordofan in 1985 as a Percentage of the 1984 Average Price.

	Average Price/Melwa (LS)		
	Feb	May	Sep
Dura	249%	286%	185%
Dukhn	251%	272%	161%

Source: modified from McLean (1985c), p.10

Figure1.4: Livestock Prices in North Kordofan in 1985 as a Percentage of the 1984 Reported Prices (sedentary pop).

	Feb	May	Sep
Cattle	22%	54%	116%
Sheep	24%	47%	124%
Goats	29%	71%	176%
Camels	12%	49%	107%
Average	16%	55%	131%

Source: McLean (1985c), p.8

September/October prices rose further: pasture regenerated; animal condition improved; and those with resources sought to restock from a scarce supply (Figure 1.4). The recovery of prices, however, prevented most farmers from restocking (McLean, 1985c; Trilsbach and Ahmed, 1986).

Wild Foods:

One strategy adopted during the drought and famine was to consume and sell a greater number of wild foods[8]. This was apparent in the regions of Kordofan and Darfur (McLean, 1985c; Shohan, 1985; York, 1985; De Waal, 1987). De Waal (1987) distinguished between those which constituted part of the normal diet of some or all of the population and those which were 'distress foods' (such as *nabak* and *mukheit*) with lower nutritional qualities:

> *"Mukheit was eaten by 95% of those in northern Darfur who had access to it in 1985, and constituted the single most important factor in peoples' survival strategies. Two thirds of the people in all of Darfur ate mukheit in 1984-5." (De Waal, 1987: p.60)*

In Kordofan it was found that more wild foods were eaten in the South than in the North. However, use was thought to relate to their availability rather than the inhabitants' need of them; in En Nahud and El Obeid DCs, where *mukheit* grows abundantly, higher consumption rates were noted, especially after rains when their availability was greatest (McLean, 1985c).

Impacts on Population:

Migration and Labour:

Even before the 1984 harvest, large numbers of people began to migrate from North Kordofan, Northern Darfur and the Red Sea Hills (Cater, 1986) in search of food. Additionally, Sudan received thousands of refugees from drought-affected Chad and Ethiopia (Shohan, 1985; Cater, 1986). About 1.2 million people - 200,000 families - were estimated to have been completely destitute by mid-August 1984 in North Kordofan alone. Between August and October, many of these families moved to large urban centres: 40,000 to Omdurman; 22,000 to El Obeid; 19,000 to Umm Ruwaba; 10,000 to En Nahud; and 20,000 to Dilling; and others (especially men) went seeking work in northern, central and eastern parts of the country (Sudan Government, 1985)[9]. Others moved southwards into

South Kordofan with their animals: this led to an increase in land use conflicts between native farmers and the migrant pastoralists, most especially in the Nuba Mountains area (Trilsbach, 1989a). Similar southward movements occurred in Darfur, threatening the environment in receiving areas (York, 1985). McLean (1985c) reviewed the overall effects on nomads as follows:

> *"Nomads from the far north of Kordofan migrated further south than ever before to find pastures: some succeeded in maintaining the core of their herds and migrated back to their normal areas in the wet-season; others lost too many animals to allow viable migration and stayed to cultivate, or moved to a camp; some lost their animals in the north and went to Omdurman and El Obeid camps - the latter are now the most destitute people in Kordofan." (p.22)*

The excess supply of labour on the market led to a general reduction in wages (El-Khalifa, Awadalla, and El Sammani, 1985; Trilsbach, 1989a). At the Rahad Irrigation Scheme - the destination of many migrants from North Kordofan - wages fell substantially from the level of previous years[10]. Meanwhile, women who remained in refugee communities within the Province were exploited as cheap labour in the urban centres. It was reported that in El Obeid, women worked for LS1 per day in service jobs such as housemaids (Trilsbach, 1989a).

Malnutrition:

A number of surveys carried out in Kordofan, Darfur and the Red Sea Hills revealed high prevalence of severe and moderate malnutrition, as well as that discovered in refugee encampments in urban areas (Shohan, 1985). From surveys conducted in February/March and May/June, McLean (1985a; 1985b) observed higher rates of malnutrition among children living in villages in North Kordofan than those living in villages in the South of the Region or in nomadic groups. An apparent recovery in the nutritional status of children in North Kordofan, which was recorded in September/October, was thought to have reflected the death of the most severely malnourished children (Infant Mortality Rate was 310/1000 livebirths in the preceding six months), and the greater availability of foods in the latter part of the wet-season, even though that harvest was also generally poor (McLean, 1985c).

Impacts on the Environment:

The drought was responsible for a reduction in the amount of available pasture. This aggravated environmental degradation by encouraging overgrazing in areas where pasture was still available. Overall, this increased the susceptibility of the topsoil to wind erosion (York, 1985). In Northern Darfur, many trees were reported to have died, including gum arabic plantations which provided an important cash crop. Shortages of food and cash were associated with increased deforestation as many farmers resorted to cutting trees to sell as wood or charcoal in the markets. This was noted in Darfur and North Kordofan (York, 1985; Sudan Government, 1985), and among migrants to towns (El-Khalifa, Awadalla, and El Sammani, 1985).

Aid Relief:

The Government's request for international emergency assistance was extremely late (Shohan, 1985), and a paper presented in mid-1985 noted that, at that time, the volume received fell well short of estimated needs (El-Khalifa, Awadalla, and El Sammani, 1985). McLean (1985c) noted that in North Kordofan the general ration of *dura* increased as the year progressed, rising to 218 grams per capita per day. However, he also noted that:

> *"The fact that nutritional status deteriorated very seriously in North Kordofan, and that food aid had little if any effect upon rising cereal prices, show that the general ration was not nearly enough: 218 grammes/day is 44% of the recommended 500 grammes/capita/day. Furthermore, distribution was irregular, with some villages receiving aid for 6 months and some for 3 months." (McLean, 1985c: p.11)*

Furthermore, grain distribution was hampered by profiteering. Many villagers had to pay for grain rations. Commonly, contractors withheld part of the money allocated for delivery, and paid sub-contractors less than the true cost of distribution; villagers were then forced to make up the balance. Some contractors obtained money for a delivery which was not made, and villages had to contract their own lorries (eg Umm Saiyala in Bara DC) (McLean, 1985c). It was also reported that remote areas (which were often worst-affected) were neglected by contractors due to 'commercial interests': in May/June 1985, distributions in Sodiri DC were noted to have been well behind those in El Obeid DC. Spillages were also reported to have reduced significantly the amount of grain received. One estimate put this at 24 percent (CARE - cited in McLean, 1985b).

Supplementary feeding began in July in the worst-hit districts of North Kordofan: Sodiri and Bara (CARE); En Nahud (SUDANAID); and Umm Ruwaba (SCF(US)). The latter two programmes provided dry rations variously to families with young or malnourished children and to pregnant and lactating women, but more specific targeting was not feasible with dry rations. By contrast, CARE established wet-feeding centres but by September/October 1985 their geographical coverage was still very limited. With this exception, however, the programme was successful (McLean, 1985c)[11].

One positive repercussion of the drought was to stimulate a number of longer-term development projects by the principal aid agencies and other bodies, many of which had either expanded operations or originally started working in the area as part of the emergency relief operations. In North Kordofan, many projects were concerned with improving water supplies. Some of the principal ones, plus others which had begun earlier in the 1980s, are now outlined as they reveal some of the perceptions of the water supply needs of the Province, and account for improvements in physical availability.

WATER-RELATED ACTIVITIES IN NORTH KORDOFAN IN THE 1980s

Water-related projects have embraced a wide range of activities and have adopted many different methodologies. Some have focussed on the gathering of baseline data, either for use within a specific project or for general information. Others have concentrated on a specific water provision objective, such as providing sufficient water to improve stock routes, or the improvement of existing sources. Approaches have varied. Some have been mainly technical, geared towards the improvement or repair of machinery, whilst others have had broader aims, including the involvement of communities in water supply planning and implementation, and the provision of extension services. These activities are now described.

Descriptions of organisations and projects are presented under the headings of either Government or Non-Government Organisations (NGOs). It needs to be stated from the outset that the distinctions between them are not always clear.

Government Organisations:

National Water Corporation (NWC):

The Government organisation responsible for rural water has changed on many occasions: in name; in structure; and in ministerial affiliation[12]. Here, the authority is referred to as the National Water Corporation (NWC), which has a regional office in El Obeid, and is responsible for rural water throughout Kordofan Region. Its work concerns construction and maintenance of: wateryards, *hafirs*, open-wells, and, more recently, handpumps (with UNICEF). Applications for sources are received from rural councils or village representatives. They are then evaluated subjectively (according to criteria of: population; animal wealth; and nearest water sources) and considered in terms of their suitability for different types of source development. It was reported that the NWC favoured wateryards because they were more hygienic and 'communities preferred them'[13], however, they are not always geologically possible. After wateryards, preference was given to handpumps, then *hafirs*, and finally open-wells (for smaller communities)[14]. The latter two were less favoured for reasons of hygiene (A A Idris, pers. comm.[15]).

Budget proposals were submitted for each aspect of regional NWC activity, and the finance for the annual programme decided in Khartoum. The regional NWC always received less money than requested and there was a massive backlog of work to be done. It was reported that wateryard rehabilitation and construction were hampered by lack of funds, and that, consequently, the NWC preferred to hand over the rehabilitation work to aid agencies. However, because of this lack of funds, it was constructing fewer wateryards than it was rehabilitating, and rehabilitation work itself was also hampered by lack of pumps and engines etc. It was further stated that NWC proposals to store rainwater, especially on the Basement Complex *qoz* areas, had been thwarted by lack of finance (A A Idris, pers. comm.).

Kordofan Region Governorate:

The Governor's Office in El Obeid has responsibilities for many aspects of the Region's activities. These include the purchase of water lorries and their allocation to rural councils. A few lorries were purchased each year (15 in total 1975-78 and 20 in total 1978-88). Of these, seven went to En Nahud District[16]. Drivers were paid by the recipient rural councils but maintenance was carried out by the Government at the Mechanical Transport Department (MTD), in El Obeid (M Abdalla, pers. comm.[17]).

Gum Arabic Company Limited (GAC):

The Gum Arabic Company (established in 1969) is partly owned by the Government, which holds thirty percent of the shares. It specialises in the export of gum arabic, of which about sixty percent comes from North Kordofan. Production is practised by local populations and controlled by the Forestry Department. Since about 1974, however, gum production has faced many difficulties, most especially the lack of drinking water supply for gum collectors. Although it was the responsibility of the NWC (and its predecessors) to supply this water, lack of finance limited its ability to do so. Consequently the GAC took a role in water provision. It began to supply water lorries to Gum Producer Associations (GPAs) and regional government (channelled through the Forestry Department)[18]. Once given, the GAC had no control over the lorries, although it was reported that many maintenance bills were subsequently incurred, because the recipients (especially regional governments) could not pay them. When lorries were supplied to GPAs, the GPAs were requested to make a fund available from water delivery fees collected to cover future maintenance, but this was not requested when they were given to regional government, because they are supposed to provide water 'free'. A change of policy was, however, reported to have occurred, because of problems of certain groups receiving all the service: lorries were, therefore, given to rural council administrative officers, and GPAs had to decide with them how to make best use of these lorries (A H M Abdel Hai, pers. comm.[19]).

Besides supplying water lorries, the GAC has also been involved in cistern and well provision[20]. Some donations were occasionally given to GPAs in the form of payment for cement and its transportation (for cisterns); other inputs were paid for by the GPA. Applications for funding well-digging were received from village or small town officials (commonly presented by village delegations). Money was given after consideration of: the gum production potential of the area; the population density; and the costs involved[21]. To ensure the money was used for the specified purpose, it was directed, via the village delegation, to an official agency with a statement of the associated objective, so that there was some monitoring of expenditure. Applications for wells had mainly been made by village delegations, rather than GPAs, because most were constructed before the GPAs were established (ie pre-1982), and also because not all villages were represented by GPAs. In this way, securing a service depended upon a significant level of local organisation. It was also noted that contributions had been made toward the cleaning of *hafirs* but not their construction (A H M Abdel Hai, pers. comm.).

Ministry of Agriculture Development Project (MADP):

This project was established in the early 1970s for "Water Provision and Distribution by Tankers" (Soil Conservation Department, 1987). For the first decade the project suffered from lack of funding and administrative changes, but in 1984 received new impetus with funding from the Gum Arabic Company. The aims were to provide and distribute drinking water in areas which lacked alternative water sources in order to: increase production by releasing the time and effort spent on collecting water; encourage sedentarism in order to utilise local natural resources (especially gum trees); reduce the need to migrate to urban areas; and facilitate the improvement of services and 'development' in the area. The project focussed on areas of Basement Complex geology with an overlying *qoz* surface, and the specific villages selected were chosen on the basis of a socio-economic survey of a broader area. A wateryard for the project was established at Khuwe, following difficulties in obtaining sufficient supplies from NWC wateryards. The villages of Kul Yusuf and El Qubba were selected as project sub-centres because they were central to many surrounding, needy villages (Chapter 6). *Fantasses* were constructed there to provide a central, local water supply facility (Soil Conservation Department, 1987; M R Hassan, pers. comm.[22]; H K Hamid, pers. comm.[23]).

Kordofan Resource Inventory & Development Prospective by Rural Council:

The 'Resource Inventory' was proposed by the Government of Kordofan following the 1984 drought and was prepared jointly by them and staff of the Institute of Environmental Studies (IES), University of Khartoum, with funding from the Ministry of Finance and Economic Planning. The inventory included background information on: the agricultural economy; water resource potential; and drought impacts. It also presented guidelines for future development within broad geographical zones and by themes, including water supply

(El Sammani (ed), 1985a). Much information was presented in the form of thematic maps by rural council.

Kordofan Rehabilitation Development Strategy (KRDS):

The strategy was published in two volumes in 1986. The first volume was a 'Main Report' and the second was a 'Summary of Project Proposals'. Like the 'Kordofan Resource Inventory' mentioned above, the work was conducted by the Government of Kordofan and staff of the Institute of Environmental Studies. The first volume contained a summary of the earlier publication ('Kordofan Resource Inventory and Development Prospective by Rural Council') and the main points contained in the second volume. In the latter volume, details of specific 'projects' and 'project ideas' were recorded (including their financial and technical requirements). These concerned: food and cash crops; range and pastures; livestock, poultry and fish industries; forestry; water supply; and education and health (El Sammani (ed), 1986).

Non-Government Organisations (NGOs):

Many NGOs currently working in North Kordofan originally began work in the field of relief operations in response to the 1984 drought. Subsequently they have become more involved in longer-term development. The following section is not an exhaustive list of all NGO activity in the Province, but it includes some of the principal initiatives which have included an important water component.

CARE North Kordofan Water Supply Project (NKWSP) (1983-1985):

The NKWSP was a CARE/USAID-funded project implemented as both a general water resources development effort, to expand the number and quality of water supply facilities in rural areas, and an emergency response to the 1984 drought (McGowan and Burns, 1987). Seventeen wateryards were rehabilitated in the Umm Ruwaba and El Obeid Districts (CARE, 1987). One dimension of the project involved a baseline survey conducted by the Institute of Environmental Studies (Mohamed, El Sammani and Shadad, 1982), to provide a review of the environmental impact of existing water supplies and to recommend specific sites for rehabilitation. The results failed to provide specific guidance and had minimal impact on the project (Bjornson, 1985), but the survey did document, in broad terms, issues such as: financial costs of water; distance between a source of water and where it was used; and time costs. Unfortunately, although there was considerable superficial detail on these and other subjects in the form of tables, the information was analysed discretely and the inter-relationship between many potentially key variables was not established. Furthermore, there was substantial ill-advised categorisation, not least the classification of seasons into simple groupings of 'wet' and 'dry' (see Chapter 2), and presentation of information by the physiographic zoning of settlements, which masked distances from any specific village to a given source.

CARE Interim Water Supply and Management Project (IWP) (1986-1988):

The IWP followed on from the work of the NKWSP. The focus shifted to the districts of Bara and En Nahud, and was originally intended to concentrate on the rehabilitation of open-wells, *hafirs* and handpumps. Subsequent to revisions, in part to take advantage of supplementary funding by USAID and to accommodate NWC priorities, the project included the rehabilitation of wateryards. Eventually, the project rehabilitated: twelve wateryards; sixteen open-wells in eight communities (including two attempts which failed); three *hafirs* in two different communities, and included the installation of handpumps at two open-well sites. It also included an extension/health education programme which accompanied rehabilitation efforts at all of the village sites. An internal evaluation identified successes, measured in terms of quantity, accessibility[24], reliability and quality, but this was qualified by a recognition of possible longer-term problems of sustainability resulting from differences in perspectives on the part of the NWC and Village Water Committees (VWCs) (McGowan and Burns, 1987).

Regional Finance and Planning Project (RFPP) (1982-):

In 1982, a project agreement was signed between USAID and the Government of Sudan. It targeted Kordofan and Southern Regions, and the lessons learnt were to be applied to other areas in the future. The Project's ultimate goals were:

> *"to help those governments become more autonomous and to increase the development impact of regional projects." (Hassan, 1986: p.1)*

The project included: training; research studies; and model projects. The production of the 'Kordofan Resource Inventory and Development Prospective by Rural Council' (above) and the setting up of a documentation centre in Kordofan were part of the research component. However, several weaknesses were identified. Legal and administrative problems delayed its start and success appeared confined to aspects of the project which were directly related to finance provision (eg numbers of people attending training sessions). Those requiring organisational skill and effort (eg model projects component) were much less successful (Hassan, 1986).

A need was seen for fundamental revision of the project as a result of previous experience (Hassan, 1986). The main change was the use of NGOs for project identification and implementation tasks, with different NGOs working in discrete geographical areas within Kordofan and Darfur. 'Bottom-up' planning was to be initiated from the village level to incorporate traditions of self-help. NGOs were not to implement the projects directly but were to assist local communities in achieving their own objectives. Sub-projects fell into four categories: water resources development; community based agriculture and forestry; small-scale private sector development; and income-generating projects for women (Anon, 1986).

CARE was one of the NGOs involved. CARE initially proposed working in En Nahud, Gubeish, and El Odaiya Rural Councils, however, the latter was omitted for various reasons[25]. The first round of sub-project proposals was anticipated to consist principally of water projects, reflecting villagers' prioritisation of water development and water point renovation (Furfey and Dearth, undated). In its 'Life of the Project Work Plan' it was noted that the RFPP was:

> *"to assist with continuing the Government of Sudan effort to decentralise management skills. Through an intensive programme of village level extension work, local institution building, and sub-project development, the RFPP will accomplish the project goal of assisting community village and local organisations to become more autonomous and to increase the development impact of local level projects." (Furfey and Dearth, undated: p.1)*

CARE Kordofan Agro-Forestry Extension Project (KAEP) (1985-1990):

This was a low-input extension project, depending upon community participation. The main goals were to: establish self-sustaining village nursery gardens; assist in producing and tending gum arabic seedlings; and establish and assist in the management of a regionalised extension unit within the Kordofan Forestry Department. The project demanded that a village committee undertake primary responsibility for the instigation, establishment and management of its nursery garden. Site selection criteria included: clustering of sites; a reasonable discharge of waste-water from a water source; community cohesiveness; and the suitability of the environment for the growth of the seeds (CARE, 1987; KAEP staff, pers. comm.[26]). Projects were firstly implemented in Umm Ruwaba District and later in En Nahud District. A demonstration nursery was set up near El Obeid to produce seedlings for: schools; sale to the public; and reforestation of the highly degraded belt around the town. Extension included: training weeks; production of visual materials; and inter-agency co-ordination meetings in El Obeid. There was also involvement with schools to generate greater environmental awareness. By 1987, seventeen schools had established nursery gardens, managed by parent/teacher committees (CARE, 1987).

The CARE (1987) report noted that water supply for the initial projects in Umm Ruwaba District had come from wateryards rehabilitated in CARE's initial water project. It was reported that in Markib the tapstands which supplied waste-water for the nursery garden were provided by an earlier project (IWP); in other villages, however, KAEP provided the appropriate tapstands (eg at Khammas Halab and Khammas Hajar). Use of water from UNICEF handpump installations was also being considered (KAEP staff, pers. comm.).

UNICEF Water and Sanitation Project/UNICEF Village Handpump Programme:
UNICEF's work involved the co-incidental: construction of pit latrines; provision of handpumps; and health education. Before 1986, UNICEF was working in Sodiri; in 1988/89, it was to be working in Abu Zabad RC; and it was envisaged that work would next be in En Nahud RC (an expectation confirmed by A A Idris, pers. comm.[27]). In 1988, UNICEF decided to organise its activity by working systematically through rural councils to make best use of available resources. The choice of rural council and the siting of handpumps was decided by the NWC. In the Emergency Programme (1985-1987) only about a hundred handpumps were installed; in 1988, however, the number increased to total 500. Previously there had been insufficient vehicles etc, but in 1988 there was an injection of capital into the project. A social study was then being undertaken by a team

from the University of Khartoum on the impact of these handpumps (W Heustek, pers. comm.[28]).

UNICEF only worked with handpump technology[29]. The handpumps required a water level in the shaft not more than 50m below ground level[30]. They provided 'clean' water (unlike *hafirs* and open-wells) and did not have the same problems of fuel and spare-parts which beset wateryards. In villages containing handpumps, one man and one woman were trained in their care, and in each RC there were a few villages where parts could be obtained[31]. At the time of interview, problems reportedly centred around a shortage of tools for the trained mechanics. Additionally, there had been attempts to set up a handpump factory in Sudan, with private sector funding, but at that time there had been little success because acceptable profits were not expected (W Heustek, pers. comm.).

Special Public Works Programme (SPWP):

The SPWP was small-scale, and the ILO was executing it with funding from the UNDP and the Canadian Government (M. Mercereaux: pers. comm.[32]). The SPWP was being implemented in co-operation with Government departments, and, at the time of study, work had just begun. Programme components included: water; infrastructure; and afforestation. There were thirteen project villages and socio-economic surveys had been carried out in them. Ten were intended to include a water component, which would involve: *hafir* rehabilitation; cleansing; handpump provision; or the construction of new sources (eg a second *hafir* at Abu Sinun) (J Henttonen, pers. comm.[33]).

Area Development Scheme (ADS) (Mid-1988-1991):

At the time of study, the ADS had not yet been formulated. The UNDP had for several years channelled money into a number of Government schemes but with poor results, therefore, during the last planning period the Government and UNDP decided to use the money for rural development projects (M. Mercereaux: pers. comm.). The ADS in Kordofan was to cover about 400 villages and 100,000 people, with a headquarters in El Obeid (for communication and transportation reasons) (UNDP, 1988). In 1988, preparatory work was being carried out by an ADS team with the communities involved, but there was no project documentation at that time. A principle of the ADS was not to work through Government departments, but this had already proved a stumbling block (J Henttonen, pers. comm.). Activity to date appeared misguided.

Emergency Relief and Rehabilitation Programme (ERRP) (1985-1986):

The ERRP was established by Catholic agencies (CAFOD/SUDANAID) as a response to the severe famines which followed the 1984 drought. One geographical focus of the programme was En Nahud District within the El Obeid Diocese (SUDANAID, 1986a; 1986b). Activities included a 'Nutrition Intervention Programme (NIP)' and a rehabilitation survey. The latter documented a wide range of socio-economic information including: changes in numbers of animals, including those used for transportation; crop production and patterns, including watermelons; and water sources and their problems in the area. Furthermore:

> *"While the [rehabilitation survey] team did not put forward any detailed project proposals, they did suggest areas, such as water, in which a strengthened diocesan development office might wish to consider some microprojects. Their research material was also warmly received by other agencies who have, or are considering, an involvement in this part of Kordofan, as a useful baseline to this under-researched area." (McNally, 1986: p.8)*

SUDANAID has also been involved in occasional well-digging in Kordofan Region, but this has not been its primary thrust (T Hardiment, pers. comm.[34]). More details were not available.

SCF(US) Umm Ruwaba Programme (1986-1988):

The area of SCFs development work, Umm Ruwaba District, was related to its area for emergency relief operations in 1984/85. Water projects were one component of the development activity[35] (SCF, 1987). These commenced in 1986 with the rehabilitation of existing wateryards and the creation of neighbouring nursery gardens using waste-water; by 1988 eleven wateryards had been rehabilitated. Other projects involved the construction of open-wells, *hafirs* and cisterns (S El Habib, pers. comm.[36]).

Environmental Training and Monitoring Programme for Africa[37] (ETMA):

The ETMA programme was conducted jointly by Clark University and the University of Khartoum (El Sammani, 1981). Research in Sudan, conducted in the early 1980s, concentrated on two areas: El Khuwei (Khuwe)-Mazroub-Tinna in north-central Kordofan, and Messeriya area in South Kordofan. The project involved the collection of baseline data and trend analysis in the two areas, and community perception of ecological degradation and environmental change (El Sammani (ed), 1985b). Some of the information collected from the Khuwe area, and presented in a paper by El Sammani (1981), has provided useful background material for various themes explored in this thesis.

Restocking of the Gum Belt (1981-):
The project began in 1981 and was funded by UNDP and executed by UNSO. Eight centres were selected in the Kordofan Region, each centre embracing a number of smaller settlements (A A Hassan, pers. comm.[38]). In *shita* and *seif* [39] each centre is supplied with water by lorry.

Livestock Routes Project:
The project was intended to improve water supplies along the 'Northern Stock Route', which extends from Nyala to Omdurman. Supplies were especially poor in the area north east of El Obeid. The aim was to encourage cattle breeders in the west to send cattle to Omdurman and Kosti by increasing the number of wateryards. These wateryards were to be operated on a commercial basis with a charging policy geared towards maintaining sustainable supply; water charges were to cover operational and maintenance costs, repayments to the World Bank and some profit margin. Expectations were for minimal use initially but that it would increase because of the unreliability of alternative, cheaper sources, mainly NWC wateryards. Agreement was reached in 1986 and a total of 59 wateryards were expected to be operating by 1990 (F Linnemann, pers. comm.[40]).

Rangeland Rehabilitation around Permanent Water Supplies (RRPWS):
The project, carried out by UNSO, began in 1983. It was based in the general area of El Odaiya (Darag Ali and Mustafa, 1985). Its main objective was:

> *"To rehabilitate depleted rangelands... through proper range management plans, conceived and implemented by the local population on a self-help basis. A water provision component was included in the project, in order to create additional watering points for livestock in the surrounding villages to reduce pressure on grazing resources in the vicinity of El Odaiya town." (UNDP, undated: p.20)*

An undated project document, consulted in 1988, recorded the completion of two reservoirs and two (unsuccessful) deep-wells. The construction of the wells had required the blasting of 'hard rock' with dynamite and even then no water was found. The geological profile of the area is predominantly Basement Complex, and it can be surmised that the wells were being dug in this type of geology. This supposition can be supported further by the fact that the wells were reported to be in an area with low-capacity, shallow-wells. Furthermore, this thesis will show that such conditions are indicative of Basement Complex (Chapter 4).

CONCLUSIONS

The Need for Research into Access to Domestic Water Supply:

Until the 1980s, water supply projects in Sudan concentrated predominantly on increasing the number of waterpoints. Many projects were concerned as much with prestige as with the water needs of communities. Much investment was concentrated in riverain and urban areas and in rural areas with the highest existing populations; in effect, the geography of water supply provision became self-perpetuating and few resources were invested in 'water-poor' areas (El Sammani, 1978). There was little concern for broader considerations of supply, such as the time, effort and financial costs which restrict access to water, and the specific needs of women.

In the IDWSSD, however, research around the world brought these aspects to public attention (Pastizzi-Ferencic *et al.*, 1989). In Sudan, Baxter (1981) and Badri *et al.* (1981) drew attention to problems caused by the time and effort costs which women expended in collecting water, and specific conferences addressed these themes, such as 'Women and the Environment' (1981) (see Baxter (ed), 1981) and 'Women, Water Supply and Sanitation' (1988) (see INSTRAW, 1988). Furthermore, the drought of 1984 caused Sudan to be a major receiver of aid from a multitude of international agencies, especially in the central semi-arid belt, which includes North Kordofan and the study area. Following emergency relief work, attention was directed towards longer-term development with much emphasis on water supply. Community involvement in water planning was increasingly stressed, and some investigation of the impact of time, effort and finance costs began.

Much research to date, however, has involved listing ranges and averages for selected cost components of water collection and noted that the burden falls mainly on women. This thesis goes further by separating 'at-source' and 'transportation' costs. Time, effort and finance costs are examined in terms of their detailed variations, according to season and source-type. Furthermore, the costs are evaluated with reference to the restrictions which they place on accessing adequate supplies of domestic water for specific families and individuals. The approach has focussed on identifying family strategies for water collection over a complete year.

Organisation of the Thesis:

The research into "Variations in Access to Domestic Water Supply in En Nahud District, Sudan" is expounded in the remainder of this thesis. Chapter 2 outlines the aims in greater detail and describes the methodology adopted. Chapter 3 introduces the province of North Kordofan in terms of its physical, social and economic landscapes and, where appropriate, focusses on En Nahud District and the study villages. Chapter 4 identifies and categorises the principal sources of water in the study area, and shows the extent of water 'availability' to inhabitants of the study villages. The next two chapters explore, in detail, the time, effort and financial costs which restrict access to water: Chapter 5 concentrates on the costs 'at-source', and Chapter 6 explores costs relating to 'transportation'. Chapter 7 describes migration and, in particular, the special situation of *dammering* - the movement of people away from a home village for a period of a few months, in order to obtain sufficient water. The final chapter, Chapter 8, concludes the thesis and highlights areas where insufficient consideration has been made with respect to identifying constraints on water supply accessibility.

FOOTNOTES

1 Among them the World Bank.

2 BTR-Permali RP Ltd.

3 References to: the 'Very Dry Year'; the 'Drought of 1984'; or the '1984 Drought' are used in this thesis loosely to refer to the effects of the 1984 Drought and the subsequent famine.

4 Kordofan Region embraces the provinces of North Kordofan and South Kordofan (see Chapter 3).

5 De Waal (1988) noted that when mortality rates exceed 300 percent of the norm it is likely that a significant number of adults will die from the famine-related causes. This occurred in the Sudan famine of 1913 but was also thought to have occurred in parts of the Ethiopian Highlands in the 1984-85 famine.

6 Cater (1986) noted Darfur, Kordofan and the Red Sea Hills as the most drought-affected areas.

7 Holy (1980), referring to the Berti of Northern Darfur, discussed the impact of successive years of famine on grain reserves.

8 York (1985) noted that wild foods were a normal supplement to dry-season diet and were commonly sold in markets; what was different was the scale of use and sale. Conversely, Shohan (1985) noted that these were not normally used and that their marketing was unprecedented. De Waal (1987), however, distinguished two types of wild food: those commonly used and those indicative of distress.

9 Shohan (1985) noted that 16,000 had gathered around El Obeid in late 1984.

10 From 75pt per *guffah* of cotton, plus a sizable *dura* supplement, and reasonable accommodation in 1979-1983, to just 50pt per *guffah* with little or no *dura* supplement and poor accommodation in 1984 (Trilsbach, 1989a).

11 Some additional supplementary feeding programmes took place in Kordofan, serving the urban poor. En Nahud was one of the towns covered.

12 In terms of affiliation, from 1969 until 1973 it was part of the Ministry of Cooperation and Rural Development (El Bushra and El Sammani, 1977; Shepherd, undated). In 1973 it became part of the Ministry of Agriculture, Irrigation and Natural Resources. Between 1979 and 1988 it was part of the Ministry of Energy and Mining, although the Soil Conservation Section remained with the Ministry of Agriculture. From September 1988 it was part of the Ministry of Irrigation, although there was a campaign to return it to the Ministry of Energy and Mining. (A A Idris, pers. comm.).

In the 1960s the body was known as the Rural Water Development Corporation (RWDC). Administrative changes led to the disbandment of the RWDC in 1973, although some of its key personnel retained corporate status. In 1975 the Rural Water Corporation (RWC) was established. In the early 1980s it was renamed the National Administration for Water (NAW) (Shepherd *el* al., 1987) and, at the time of research, was known as the National Water Corporation (NWC) although it is not known when the name changed (El Sammani used NWC in his 1985 (ed) publication and in 1987 CARE also used NWC). To add to the confusion, other names have been used in various reports, including the National Corporation for the Development of Rural Water Sources (NCDRWR) (SCF, 1988); and the National Rural Water Development Corporation (NRWDC) (Nash, 1991).

13 Shepherd *et al.* (1987) noted the primacy of boreholes over *hafir* technology in the activities of the NWC:

"...since the early 1970s, geologists and to a lesser extent drilling engineers have dominated the RWC, propelled by the large foreign-financed drilling programme which began in the late 1960s, and which offered opportunities for foreign contracts and training." (p.185)

This has been at the expense of Basement Complex areas which are geologically unsuitable for this technology.

14 The order is such because the former two are more hygienic than the latter, but *hafirs* give more water than open-wells

15 Deputy Director for Water, NWC, El Obeid.

16 One each to the rural council's of Wad Banda, Suq el Gamal and En Nahud, and four to Khuwe Rural Council; the last two locations are both in the study area.

17 Governor's Office, El Obeid.

18 This programme began after the 1973/74 drought.

19 Secretary of the Board of Directors, Head of Economics and Statistics Department, Gum Arabic Company, Khartoum.

20 In order to obtain a cistern or a well, a village representative (or VWC or GPA) must first obtain approval from the GAC. If approved, a GAC official writes to the First Under Secretary of the Ministry of Commerce to give GAC, for example, 100 tonnes of cement for supplying the GPA for building a cistern. Approval is in the name of GAC. The GAC then passes this approval to the GPA together with a sufficient funding to undertake the work. The GPA must give GAC the documents to say that they have received it. This is a control measure. The manager in El Obeid (Mohamed Ali Adam) is then expected to monitor the construction and to make sure that approved developments span a broad geographical area.

21 A village delegation goes to the Regional Ministry of Construction to obtain an estimate for the GAC in Khartoum.

22 Soil Conservation Department, Ministry of Agriculture, El Obeid.

23 Clerk of the MADP wateryard, Khuwe.

24 'Accessibility' in this report was defined in terms of the time required to collect water. Accessibility is increased by improving the capacity of open-wells, and adding taps and improving water pressure at wateryards (ie at-source time costs). In this study, however, 'accessibility' is conceived in broader terms.

25 Firstly, this was because of the reduction in project life-span from three to two years (due to delays in signing the co-operation agreement). Secondly, because of CARE's commitment to clustering with advantages of established relations, acquired information and logistical efficiencies. Thirdly, Gubeish was described as more settled than the people of El Odaiya, and villages more geographically concentrated with advantages for all-year round participation and increased accessibility to training sessions. Fourthly, there was no desire to duplicate the efforts of UNSO in El Odaiya, where the UNSO 'management of grazing resources around permanent water supplies project' had had long-term input, used similar strategies and was planning to expand. Additionally, the Basement Complex geology is prevalent in El Odaiya RC, and UNSO has largely undertaken surface water development as a result. Water development according to CARE's favoured approaches (rehabilitation of wateryards, and open-wells) would be very difficult.

26 El Obeid office.

27 Deputy Director for Water, NWC, El Obeid.

28 Drilling Co-ordinator (Water Section), UNICEF, El Obeid.

29 There has been much research concerning handpump technology. Some of the initiatives in this field are discussed by WHO (1977), Arlosoroff (1983; 1987) (see also Chapter 4).

30 Wells could be drilled to a depth of up to 180m before reaching water, then if the water level rose to 50m it could be pumped.

31 UNICEF imported parts and sold them to rural councils at subsidised prices. People could purchase them from several stores in the rural councils. The first outlay was by the first officer of the rural council, and he sold them on at a 5 to 10 percent higher price to cover the cost of employing a store keeper.

32 UNDP, Khartoum.

33 ILO, El Obeid.

34 SUDANAID, El Obeid.

35 The full list was: wateryard rehabilitation; open-wells; outreach (Food for Work); forestry; school rehabilitation; baseline survey; Women in Development; agriculture; basic feeding programme; nutrition monitoring; immunisation; community-based health programme; oral rehydration treatment; traditional birth attendant; health post construction.

36 SCF(US), Khartoum.

37 This has also been called the 'Environmental Training and Management in Africa' programme.

38 UNSO/Forestry Department, El Obeid.

39 Definitions of seasons appear in Chapter 3.

40 Preussag, Khartoum.

CHAPTER 2: METHODOLOGY

INTRODUCTION

Research Aims:

The previous chapter has outlined the broad objectives of this thesis. This chapter presents a number of specific aims which derive from them. These are:

- to develop an understanding of the constraints on access to water supply
- to identify strategies to overcome these constraints
- to see how accessibility varies according to the socio-economic status of specific families and individuals
- to discover the strategies employed when both expected andunexpected variations in water supply availability and accessibility occur
- to suggest appropriate measures to improve accessibility to water

These can be elucidated by the following series of questions:

Under what conditions are various water sources used?

- Does 'social order' affect the choice of sources used at any given time?
- Does restrictive operation and management of 'modern' sources (in terms of prices, hours of opening and mechanical break-down) promote the use of 'traditional' sources?
- Is distance an important factor in source choice?

How is the source choice made by each family?

- How does source availability vary seasonally?
- What is the interplay between the resources which a family can access and the costs incurred in water collection?
- How important are the costs involved in transporting and abstracting water?

Have 'traditional' nomadic and transhumant movements continued?

- Have 'modern' sources of water encouraged greater sedentarisation?

- Has crisis-response out-migration occurred when 'modern' sources have failed?

Preparation:

This research commenced in October 1987 and, prior to visiting Sudan in July 1988, a number of tasks were undertaken to lay the foundations of field investigation. In addition to becoming familiar with the relevant literature, guidance and/or information was obtained from formal training, such as ESRC conferences, and contacts with various specialists. These included: academics (eg Dr A Trilsbach - on semi-arid environments in Sudan; Dr M Hulme - on Sudan climatology; and Dr R Walsh - on Sudan hydrology); field scientists (eg Mr G Booth - retired Kordofan Forestry officer); other students working in related fields (eg Mr P Tucker - University of Oxford); and teachers working in Sudan (eg Miss E Robinson, and Miss A Hulse - working in North Kordofan and Khartoum respectively). Visits were also made to specialist libraries at the University of Wales (Swansea) and the Institute of Terrestrial Ecology (Grange-over-Sands).

By the time fieldwork in Sudan commenced, the principal themes for investigation had been formulated; a questionnaire had been designed; a number of important contacts had been made; and the general geographical area for study had been defined.

SELECTION OF STUDY VILLAGES

Selection of The Study Area:

The study area was chosen by the combination of research objectives and logistical considerations. The author had a particular interest in the non-riverain areas of semi-arid western Sudan[1], which are marginal for human habitation. They present special problems for water supply because they lack perennial water courses and have limited, localised surface water retention capacity. These areas have been largely neglected by research in the past in favour of the riverain areas (Graham, 1969; Tinker, 1977; Shakesby and Trilsbach, 1982), which have traditionally been the focus of: settlement; easier communications; and irrigated agriculture, with more abundant official data.

To simplify administration, it was decided to confine fieldwork to one province. This left a choice between North Kordofan and Northern Darfur (Figure 1.1). The former was selected because: it was nearer to Khartoum, the project-base in Sudan, and therefore less time and fuel were required to reach it and expenses were minimised; it was safer than Northern Darfur[2]; and a number of reports and papers, which provided useful background material, were accessible before visiting the area (eg El Sammani (ed), 1985a; SUDANAID, 1986a).

Within North Kordofan, En Nahud District was selected for study[3]. It was known that contrasting geological zones within the Province afforded very different potentials for water supply and source development, and that En Nahud District contained both water-poor and water-rich geologies - the Basement Complex and Nubian Series respectively (Chapter 3). A smaller sub-area was subsequently defined to include approximately equal representation of the two zones. Additionally, En Nahud District Council was reputed to have reasonable quality official data.

Selection of Villages:

Sample settlements were selected before the study area was visited, although the initial choice was subsequently revised. The various stages of sample design and revision are now examined.

Initial Sample:

A variety of sampling methods were considered for selecting specific villages: specialist literature was examined (especially Dixon and Leach, 1978; Burgess (ed), 1972; Bulmer and Warwick (eds), 1983; Burgess (ed), 1984); and critical analysis made of the sampling practices of other researchers in Sudan (eg Mohamed, 1975; Beech, 1985; Bowyer, 1985; Hamdouk, Bashir and Abudiek, 1985; McLean, 1985a; SUDANAID, 1985a; Mohamed *et al.*, 1986). A stratified random sampling method was adopted, with two classes representing each of the geological zones. A 10km grid was superimposed upon a 1:2,000,000 geological map of the area and three squares on each geology were identified by random generation of co-ordinates. (Any square less than 10km from a geological unit boundary was rejected, to allow for probable error in its demarcation). The selected areas were then located on photo-reduced copies of the 1:250,000 Sudan Survey Department maps, and a village within or near to those areas was selected. The study sites identified in this way were: Hariri and/or Mustafa, Farag and Bur Islam on the Basement Complex and Abu Shura, Markib and Khammas Hajar on the Nubian Series (Figure 2.1).

Amendments to the Sample:

The preliminary list of sample villages was amended on the reconnaissance and main data-collection trips (Figures 2.1 & 2.2). This was because of: inability to locate selected settlements on the reconnaissance trip; the small populations of some villages; expected difficulties of re-locating settlements; and gross exaggeration of the number of families resident in a settlement. These factors resulted in substitutions, and additional settlements being included in the study.

On the reconnaissance trip, Farag could not be located, therefore, Kalangei was selected from the map as a replacement. However, further problems were encountered in locating this settlement: no track existed and misleading directions were given. Eventually Wakeel was located - a village not recorded on the Sudan Survey Department map. Because there was insufficient fuel to travel on to Kalangei, and since Wakeel was located within the sample area, this village was selected for study.

It was also found that there was no village called Bur Islam - the name referred to a group of shallow-wells. However, Umm Samra was near to these wells and, as its inhabitants owned many of them, this village was also selected.

The populations and numbers of families resident in some villages also led to sample modifications. It had been decided to consider all settlements as potential study sites, irrespective of their populations. Firstly, this was because settlement size may be considered, in part, a function of water availability, since services and people are noted to be concentrated around reliable water sources (eg El Sammani, 1981; Mohamed, El Sammani and Shadad, 1982). Secondly, this was because some studies had purposely excluded such settlements from the sample frame (eg Mohamed *et al.*, (1986) included only settlements with 500-1000 inhabitants - ie about 70-140 families) yet it was families within these smaller settlements that were expected to have most difficulties in obtaining water

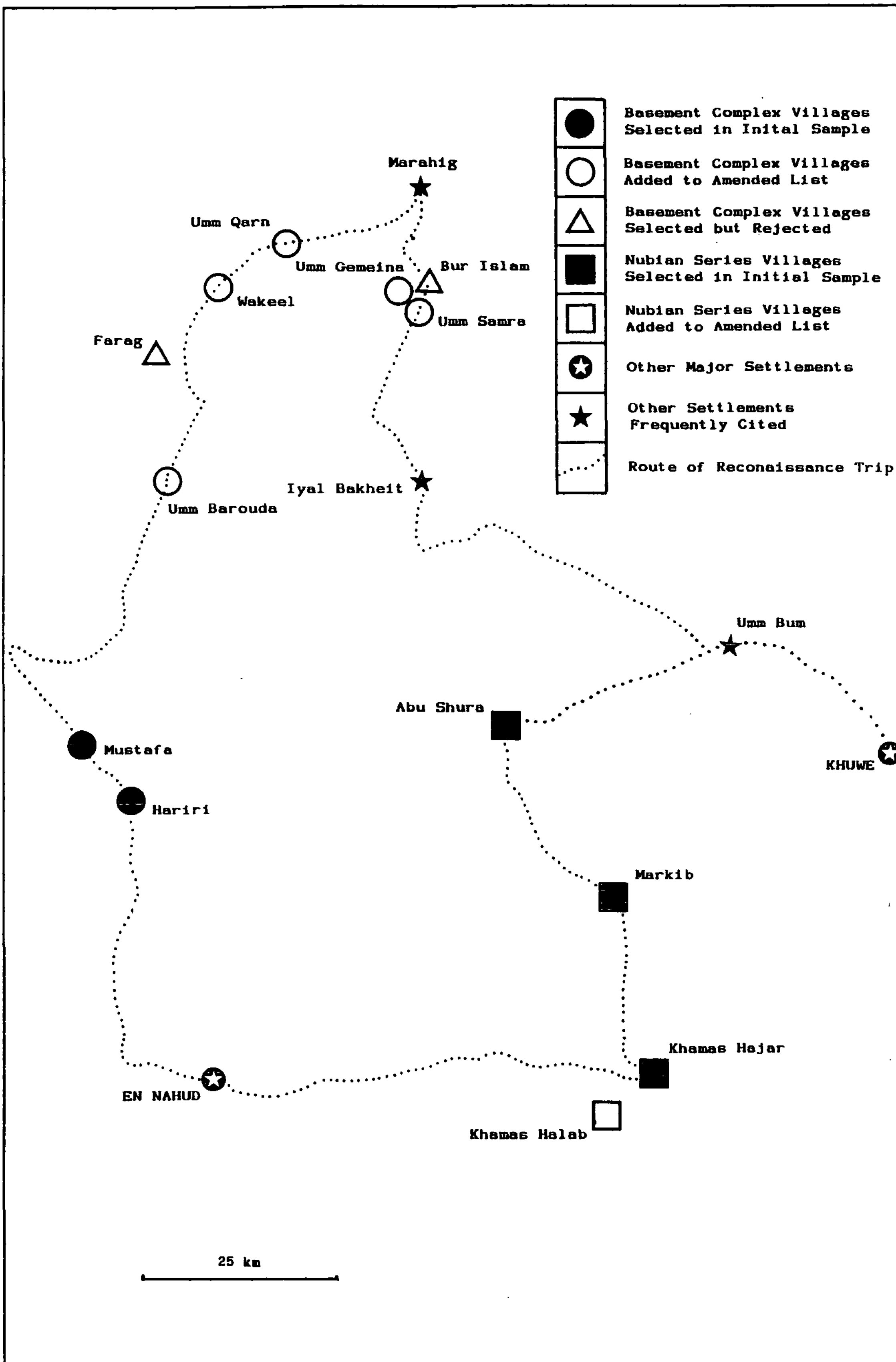


Figure 2.1: Villages Considered for Study

Figure 2.2: The Allocation of Interviews between Settlements and by Geological Zones.

Settlement	Number of Families Reported during Reconnaissance Trip	Initial Interview Allocation	Amended Number of Families	Number of Completed Interviews
Basement Complex				
Hariri	52	13	37	10
Mustafa	15	3	15	4
Umm Barouda	na	na	15	3
Wakeel	12	3	c.12-16	4
Umm Qam	c.10	3	7	3
Umm Samra	100	26	51	14
Umm Gemeina	na	na	4*	2
Total	189	49	c.141-145	40
Nubian Series				
Abu Shura	124	6	c.63-65	6
Markib	c.800	24	c.800	24
Kh. Hajar	c.700	21	165	7
Kh. Halab	na	na	c.300-400	14
Total	c.1624	51	c.1328-1430	51

* Number of families excluding the 'Arab' encampment

and require more varied annual water supply strategies.

To enable a realistic proportion of families to be interviewed in each sample settlement, but maintain the total number of interviews on both geologies, it was decided to combine each of the smaller two settlements with another in close proximity (Umm Qarn with Wakeel and Hariri with Mustafa) to make a total of eight study villages.

A further village (Umm Barouda) was added to the sample on the main data-collection trip. This settlement, like Wakeel, was not marked on the Sudan Survey Department map, but had been visited by the author on the reconnaissance trip to test a questionnaire. It was incorporated into the sample primarily because it appeared doubtful whether it would be possible to re-locate Wakeel in the October travelling conditions (below), and also because, even if Wakeel were re-located, it would have increased the population of this area-group to a size more comparable with other villages or village groups. This was further justified by a seasonal dependency of its inhabitants upon wells at Wakeel (similar to the situation in Umm Qarn which was already grouped with Wakeel).

Another amendment resulted from a grossly exaggerated report on the reconnaissance trip of the population/number of families resident in Khammas Hajar. Because the number of interviews to be conducted in each settlement was related to this number, the inflated figure meant that a disproportionately high number of interviews had been assigned to the village. Interviews had already been completed in all other study sites on the Nubian Series when this error was discovered, and it was impossible to return to them because of the limitations of time, fuel and other reasons. However, Khammas Hajar was found to be one of several 'Khammas' villages which fell within the sample area. It was reported that Khammas Halab, located sixty minutes away by donkey, had a population which, when combined with that of Khammas Hajar, totalled approximately the same population as had been inappropriately attributed to Khammas Hajar alone on the reconnaissance trip. Therefore, Khammas Halab was added to the list of sample settlements, and the number of interviews previously assigned to Khammas Hajar distributed between the two, according to their relative sizes (below).

A final additional village was included as a result of the misreporting of the population of Umm Samra. When this village was reached on the main data-collection trip, it was the last study settlement on the interviewing circuit. Unfortunately, it was discovered that there were only 46 families in the village-proper, compared with the 100-200 reported on the reconnaissance trip (read as 100 to allow for some exaggeration). Consequently, five other families were added from *butes* nearby, and the number of interviews conducted was proportionately reduced. After their completion, the study was extended to another nearby village - Umm Gemeina.

The revised list of sample sites, therefore, was: Hariri, Mustafa, Umm Barouda, Wakeel, Umm Qarn, Umm Samra and Umm Gemeina on the Basement Complex and Abu Shura, Markib, Khammas Hajar and Khammas Halab on the Nubian Series (Figure 2.1).

Timing of Fieldwork:

Three trips were made to North Kordofan between July and December 1988. The first two were undertaken in the wet-season (through into the harvest), and concentrated on the sample villages, whilst the third, in the cool, dry-season, was to the administrative centres of El Obeid, En Nahud and Khuwe.

The trips in the wet-season presented major problems for travelling, but the timing was critical as many families, especially on the Basement Complex, can only be found in their home villages at this time, because they migrate after the harvest (Chapter 7). Because no lorries or buses ran near many of the sample sites on a regular basis, these two journeys were made by landrover, with a driver and an assistant/translator. The first of these trips (three weeks, July-August) was to: provide general reconnaissance; locate the sample settlements; obtain basic village level data; and secure permission from *sheikhs* for a subsequent visit to conduct household interviews. The second trip (six weeks, September-October) was the main data-collection trip.

The third trip was essentially to: interview aid agency and Government staff; collect secondary data; and access documents. As most of this was centred upon the major settlements of El Obeid and En Nahud, which are located on major routes, it was possible to conduct this trip by bus and lorry, with an assistant/translator.

For the remaining time in Sudan, work was based in Khartoum: interviewing head-office personnel from aid agencies, Government departments and the Gum Arabic Company; obtaining reports; visiting libraries; consolidating aims and information already gathered; and logistical planning for fieldwork, such as obtaining necessary permits, buying fuel and other materials, hiring assistants/translators (and a driver), and landrover maintenance.

A second visit to Sudan had been planned for July to September 1989, after heavy rains in 1988 necessitated some reshuffling of initial work plans. However, this was thwarted by a military coup a few days before departure, and the closure of the airport, curfews, arrests, travel restrictions, and severe fuel and food shortages. After some time, the planned trip was abandoned. Even as late as Spring 1990, fieldwork would have been impossible: many aid workers had already left Sudan, and the departure of the remaining United States aid agency staff was imminent.

PRIMARY DATA

Household Interviews:

The definition of what constitutes a household or family has been a continuing problem for researchers (Culwick, 1954; Bowyer, 1985; Tully, 1988). The Sudan Census defined it as those who share a common cooking pot (cited in Culwick, 1954). Culwick (1954), however, objected to the use of the 'common cooking pot' definition because polygamous wives have different cooking pots and she disputed that a man can simultaneously be a member of two families. However, for the purpose of this study, a family is defined as the unit internally managed by a woman (commonly a wife). She is considered its head-female. In the case of polygamous marriages, the husband is considered a part-time member of each family. The terms 'family' and 'household' are used interchangeably.

A questionnaire had been prepared in England (Appendix A) after consideration of specialist literature (eg Moser and Kalton, 1971; Anker, 1981; Burgess (ed), 1982; Bulmer and Warwick (eds), 1983; Burgess, 1984), and examination of examples from other research (eg Trilsbach, 1983a; Harrell-Bond, 1986; Mohamed *et al.*, 1986). This was tested, refined and finally 'abandoned' on the reconnaissance trip. The questionnaire technique had appeared to command several advantages over personal interviewing practices. These were especially in the volume of data which could be collected over a given time period by employing and training field-assistants (estimated in this case to be over 200 scripts). It was reasoned that direct factual responses could be efficiently and quickly recorded through closed questions, and that explanatory information could be obtained by the use of open questions. However, in field-testing, and subsequently with interviewing experience, the problems associated with this method became increasingly evident. Although the questions had been designed to combine simplicity of expression and content (avoiding questions dealing with two themes etc), results were unsatisfactory: open-ended questions produced superficial, unclear responses and there was no notion of how various factors affecting water collection and so on (such as money, labour, distance to water, animals available etc) worked together to determine strategies and practices for acquiring water. Furthermore, cross-checks could only reveal a limited number of reporting or recording errors, and that only after the questionnaire-interview was concluded and correction impossible. It also became apparent, after testing and use of the personal interview technique, that the responses to questionnaire-style questions were at best oversimplified and at worse fictional (below) and that the important elements of the water supply strategy network could only be brought together upon discussion, and recounting, and by following up points of uncertainty.

Semi-Structured Interviews:

A semi-structured interview schedule was designed and briefly tested on the reconnaissance trip, using the abandoned questionnaire as a framework for the themes to be discussed. This became the primary data-collection method and, out of a planned 100, 91 interviews were wholly or substantially completed to form an information base[4]. One was subsequently rejected, and another partially ignored because of unresolved discrepancies between husband and wife's reports of sources used at various times of the year. Others were partially concluded. An outline of the semi-structured interview schedule, which formed the basis of dialogue, is reproduced in Appendix B.

Due to the author's inadequate standard of arabic[5] for conducting interviews, a translator was employed. On all trips this was a female student. Information obtained in interview was recorded in notebooks in the form received, together with observations, comments and ideas. The use of a tape recorder was considered but rejected[6].

The author endeavoured to follow the appropriate channels of approach in each village, noting the advice given in Burgess (ed) (1982) and Burgess (1984). Therefore, attempts were made to: negotiate access, not only with those in the highest social positions; develop an account of the research which was plausible to those involved; present an accurate account of the research design as best one could; establish a clearly defined role and work routine for research; and monitor one's own activities (Burgess, 1984).

On the reconnaissance trip, preliminary introductions were made: the *sheikh* was greeted and interviewed upon matters relating to the village and its history. This visit also gave villagers an opportunity to see the author and travelling companions and for some to ask questions about us and our work. This opportunity was greatest in villages where an overnight stay was necessary (ie Abu Shura, Markib, Mustafa, Wakeel, Umm Samra). Before leaving, permission was sought to return to carry out interviews with individual families.

On the main data-collection trip, the relationship with the *sheikh* was renewed and strengthened, after which interviewing began. It was decided to preserve interviewee anonymity, in order to allay fears of Government-informing, and thereby to foster an attitude of openness. Therefore, family names were not requested (although these would have helped in re-locating *hoshes* where revisits were necessary). Interviewees were told how the information was to be used and the purpose of the research. It was explained that the author was a student, and was not working for the Government or any aid agencies. Interviewees were told the subjects for discussion and informed that the author wanted to understand what their lives were like. It was made clear that the author was not going to bring medicine, food or a wateryard to any settlement, but that the work would be used to foster understanding of their lives. All interviewees were encouraged to answer honestly. It was made clear that they were at liberty not to answer any question, and that if they did not know an answer that it was preferable to say this rather than to give an incorrect reply.

Unfortunately, despite every attempt to explain the reason for the author's presence and the questions, almost inevitably suspicion, misunderstanding or perhaps misplaced hopes, arose. For example, in Umm Samra, a story came to light that we (the author, assistant and driver) were in the village to abduct children. This was relayed by three children in a *hosh* prior to their mother's return. It was hard to tell if this rumour was in general circulation in the village (general mistrust); amongst the children (to keep them from bothering us or from distracting them from their chores); or existing in this particular family only. In Wakeel, a different problem was encountered. The initial greetings and discussion with the *sheikh* and a group of men with him went well. However, in the middle of the household interviews there was a disturbing scene when a nephew of the *sheikh* burst into a *hosh*, angry that women were being questioned when the 'important men' had already been interviewed.

Although the purpose of the study had been clearly stated, expectations, or perhaps vague hopes that the author might improve villagers' medical and/or food and water predicament, were also articulated in the course of the study. Maybe this was not surprising, since for many people 'England' and 'education' were meaningless concepts, but 'CARE' and '*aesh* Reagan'[7] were known. However, it was also conveyed to the author that the translator on the reconnaissance trip had stated that she was the Head of the University of Khartoum, a fact which suggests some distortion in recall.

Allocating Interviews to Villages:

On the reconnaissance trip, trial interviews took 1-1½ hours each. On the basis of this experience, and allowing for additional time for: travelling around a dispersed village; the complexity of responses anticipated; and distances and terrain to be traversed, it was estimated that about a hundred interviews could be completed in the time available. Fifty were planned for each geological zone with fewer scheduled per day for Basement Complex villages due to the above.

It was decided to use reported and estimated numbers of families resident in each settlement as a basis for calculating the number of interviews to be conducted in each (Figure 2.2), rather than those quoted in the sugar distribution records[8]. The reasons for this choice were three-fold. Firstly, these records included people living in the '*wadi*' areas at a distance. Their incorporation into the study would have overstretched the time and fuel resources available[9]. Secondly, it transpired that selected study sites were located across four rural councils (these boundaries are not drawn on the Sudan Survey Department maps), and that these population records were held in respective council headquarters, far from the sample sites. Again, additional time and fuel expenditure would have been required to secure them. Furthermore, some sample settlements, such as Mustafa in En Nahud Rural Council, were discovered not to have been included in these records. These were *arits* (amalgamated with a larger village for sugar distribution - see Chapter 6). However, use of reported and estimated figures resulted in problems for interview allocation, due to misreporting.

The number of interviews to be conducted in each settlement was calculated after the reconnaissance trip by dividing the projected number of interviews which could be completed (ie 100) between the two geological zones, and then dividing each of the 50 interviews between the settlements in the respective zone according to the number of families resident in each settlement/group. (There was some degree of judgement employed in this process, since often the total population and total number of families reportedly resident did not appear to tally, and occasionally both seemed inflated). Furthermore, a minimum number of three interviews per village on the Basement Complex and six per village on the Nubian Series was set, so that the water strategies of residents in small villages could be recognised. The numbers of interviews calculated (above) were consequently rounded down to allow for any additional interviews arising from the minimum-allocations.

Interview allocations were, however, revised on the main data-collection trip, because of: misreported population sizes; settlement re-location worries; and family-outmigration since the reconnaissance trip, which variously prompted the inclusion of additional study settlements and/or the recalculation of existing allocations (Figures 2.1 and 2.2). One modification, resulting from exaggerated reports of the population and number of families resident in Khammas Hajar, and the late inclusion of Khammas Halab in the sample list, has already been examined. Others are now discussed.

In Hariri, it was discovered that the number of families resident had decreased from 52 to 37 since the reconnaissance trip: some families had left because they had insufficient grain for food and agricultural requirements. The number of interviews was, therefore, reduced by three (so that the same number of interviews were allocated per families-resident as elsewhere on the Basement Complex) and no additional sample settlement added. This was decided because: there was a smaller number of families in the village from which interviews could be obtained; the settlement form was highly dispersed; it was difficult to negotiate the gradients with a landrover; the distances, and 'thorny' *haskanit* prevented walking; malaria or other fevers were prevalent; there was a plague of locusts attacking the village crops at the time (October 1988); and the inclusion of unknown settlements was a complicated and time-consuming endeavour, and interviewing was already running behind schedule. To maintain a reasonable number of interviews on the Basement Complex zone, the numbers to be conducted in subsequent villages were derived by rounding up to the next whole number (rather than rounding down).

Umm Barouda had been included in the sample list primarily because the re-location of Wakeel study village seemed improbable. An interview allocation was devised according to the number of families resident (as above), however, this was increased to the minimum of three. In the event, Wakeel was re-located, but because of reduced numbers of interviews conducted in Hariri, and later in Umm Samra, the total number completed in the geological zone was still less than the fifty planned.

The inclusion of Umm Gemeina also deserves some consideration. It was discovered that the number of families resident in Umm Samra had been grossly exaggerated. The number of interviews was, therefore, recalculated as above and the settlement of Umm Gemeina included in the sample. However, only two interviews were conducted in Umm Gemeina: one in the village-proper, comprising a small sedentary population of four families; and one in the more substantial semi-permanent pastoral 'arab' camp associated with it. Attention was directed to Umm Gemeina despite the fact that some of the interviews in Umm Samra had been of a poor informational quality, partly due to: the demands of harvesting; possibly suspicion; and the inability of the interviewees to recall past events at all, or at least within a time-framework. Because there seemed little chance to improve the quality of information, interviewing in Umm Gemeina made best use of the remaining time and raised the total number of interviews conducted in the geological zone.

Therefore, the principal of maintaining a fixed ratio of 'number of interviews' to 'number of families' for all villages on the Basement Complex and Nubian Series respectively was generally adhered to.

Household Selection:

A quasi-systematic selection process was employed to identify households for interview, so that all parts of a settlement were represented according to the proportion of families resident within them. Different areas (referring to distances and directions from the centre) within the village were considered. This was done in case there were any unreported socio-economic divisions manifest in the physical organisation of dwellings. Purely random selection was not possible because of the complex settlement form.

In small settlements (Abu Shura and all villages on the Basement Complex) except Hariri, all parts of the village could be seen at one time, and selection could be performed easily. In larger settlements (Markib, Khammas Hajar and Khammas Halab) this was not possible, and selection practices were more complicated. First of all it was necessary to drive around the village to see its extent and form, noting any significant differences in the relative densities of households in different parts. Secondly, the settlements were divided into sub-sections for study. In Markib and Khammas Halab the *suq* was approximately central to the village, whilst in Khammas Hajar the central location was occupied by a brick and cement structure. Four 'quarters' were defined, radiating from these focal points, and a proportion of the settlement's interview quota was allocated to each in relation its estimated population[10].

In Hariri, some variation in sample practice was introduced. The village comprised a series of widely dispersed groupings of households, each out of sight of others. Households were selected with the aid of a crude map, drawn in consultation with villagers, showing: distances between groups; their relative locations; and the number of families per group. Letters were assigned to each household and these were picked at random from a hat (literally!). However, this ideal 'broke down' and some pragmatic modification was introduced since it was very hard to reconcile the 'map' with what was found on the ground (this had been expected to some extent, but in the absence of any better information the map had been adopted). Also other problems concerning the landrover, and interviewee illness or refusals had to be accommodated.

In all settlements, to avoid prejudice in selection, the houses in which interviews were to be conducted were identified without prior knowledge of the condition of the dwelling and inhabitants. This was achieved by picking out roof-tops from some distance.

Selecting Interviewees:

At the outset of the research, it had been planned to develop awareness of gender differences in responses by questioning (by questionnaire) a husband and wife in each family (head-male and head-female). This idea was subsequently dismissed for pragmatic reasons: it seemed that it would be impossible to ban husbands from interview sessions - indeed, trying to effect this could have been detrimental to the whole project as suspicion and resentment would have been exacerbated by it. Also, there was the danger that if it became known that the both husband and wife had been asked the same questions this too would have bred suspicion and hostility (rather than the openness desired), and resulted in refusals or conditioned-responses. Furthermore, attempting to interview two people in one household increased the probability of a revisit and posed the problem: what to do if the man was absent? (Women were never discovered to be long-term absentees at the time of interview, unlike men performing wage labour activities).

After the reconnaissance trip, therefore, there was some redesign: one third of the household-interviews in each village were to be conducted with husbands (or head-males) and two-thirds with wives (or head-females). However, whilst in the first study village on the main data-collection trip, this was revised, yet again, to a wholly female respondency, with additional information sought for the water sections from the main water collector(s) where these were not the interviewee. The redesign took account of the following factors: women were generally more co-operative (and apparently truthful) than men, and would take time to answer (perhaps this was because they derived less social-triumph from tricking a researcher, or because both the researcher and translator were female); women (wives and/or daughters) were largely responsible for water collection in one or more seasons, and were responsible in all cases for its management in the home; also, other subjects of discussion, such as the absence of people (mainly men) at different times, and children's schooling, may be regarded as more 'female concerns'. A main factor, however, was the number of interviews scheduled. Since the questionnaire had been abandoned, the number of interviews anticipated would not have constituted a sufficient basis for the discernment of any gender trends and interviews with men and women would only have served to confuse, rather than elucidate, aspects of water supply in the light of the observations made above.

Having decided whom within each family to interview, the realities of the field situation had to be met and dealt with. These included the following problems: the temporary absence of the 'interviewee'; illness, or refusal to take part in discussion; and cases of memory failure or deliberate untruthfulness, resulting in clearly contradictory responses. When the interviewee was not at home, revisits were made whenever possible. Where the wife of the man responsible for the household had died, it was found that the eldest daughter had taken over her mother's role, therefore, it was with this person that the interview was conducted. When a woman was too ill to be involved in interview, refused to continue after the first few questions, or was providing blatantly contradictory factual data for no apparent reason, another household was substituted. In one case in Hariri, however, a sick woman was urged by her husband to begin an interview, but was unable to complete it. It happened, fortuitously, that the husband was essentially responsible for water collection and farm labour recruitment (a relatively big concern) and, therefore, some questions were answered by him in his own right, others on behalf of his wife, whilst others remained unanswered. Some degree of apparent misreporting was detected concerning child age and schooling in this case.

Analysing Interview Data:

Because interviews, rather than controlled questionnaires, were employed for data collection, statistical analysis was generally inappropriate. Greater emphasis was placed upon household case studies, exploring linkages between a wide variety of water-related factors (a qualitative approach). Simple tabulation of information was useful for comparable material.

Key Informant Interviews:

The purpose of conducting 'key informant interviews' was outlined by Tremblay (1982):

> *"In using key informants, one chooses them strategically, considering the structure of the society and the content of the inquiry. Furthermore, in the interview itself, although the informant is given latitude to choose his own order and manner of presentation, there is a systematic attempt on the part of the researcher to cover completely the topic under analysis. When we use key informants, we are not randomly sampling from the universe of characteristics under study. Rather, we are selectively sampling specialised knowledge of the characteristics." (p.98)*

Sheikhs:

A structured interview sheet, with questions aimed at acquiring basic information about the study villages, was drafted in England and revised in the field (Appendix C). These interviews were conducted on the reconnaissance trip (except in Khammas Halab, Umm Qarn, Umm Barouda, and Umm Gemeina) and revised on the main data-collection trip, where possible before and after undertaking household interviews. They provided a framework of understanding within which household interviewee responses could be interpreted and questioned.

Other Key Informants:

Other key informants included: owners of water sources; wateryard officials; police; merchant lorry crews; rural council and district council officers; and aid agency, and Government department and corporation staff. A list of basic points for discussion, relating to the management of different water source types, had been devised for the 'gatekeepers' after the reconnaissance trip (based upon field observation and points raised in the literature, especially by McGowan and Burns, 1987). Topics raised in other interviews were less predetermined.

Observation and Photographic Record:

The importance of observation is well recorded in the literature (Culwick, 1954; Trilsbach, 1983a). For example:

> *It is commonly recognized that the most valuable tool for fieldwork in the Developing World is the eye." (Trilsbach, 1983a: p.90)*

In this particular study, observation helped to educate the author in an awareness of villagers' lifestyle, and prompted questions. However, many things which were of relevance remained 'unnoticed'. Some of this lack of 'seeing' derived mainly from an overwhelming with new visual stimuli; the constraints of a time schedule; and an unwillingness to force entry into different areas of an interviewee's *hosh*. The interview schedule had been deliberately planned to allow time for 'watching', however, the many problems associated with the main data-collection trip reduced this significantly. However, the dangers of observation were also borne in mind. Sight and knowledge inform each other (Pocock, 1981): visual stimuli are interpreted by existing knowledge (with all its limitations), and this can be misleading.

Many photographs were taken during the course of the two village-based fieldwork trips. These provide a permanent record of water collection at various sources/source types, as well as of villages, terrain etc. Where appropriate, these are used to illustrate the text.

Sources of Statistical Data:

In addition to data collected in the study villages, a wide variety of data existed in manuscript and published form. These were of varying usefulness for the study. The principal sources require further description.

National Water Corporation:

Prior to arrival in Sudan, the author had obtained lists of the wateryards, *hafirs* and Government-constructed open-wells in North Kordofan, together with selected supporting information. These were checked[11] with the NWC in El Obeid and further information obtained by interview. These source-lists provided important background information to water supply provision in the area, and were being charted at that time by P Tucker for his own Ph.D. research. However, the many traditional sources used by the population (such as pools, *tebeldis*, cisterns, and deep- and shallow-wells) had not been constructed by the Government and were, therefore, excluded from their records. This has presented a serious problem for research which has tried to evaluate water supply deficits (Mohamed and Abu Sin, 1985). Records of break-downs and dates of establishment for selected wateryards used by residents of sample villages were also obtained. This allowed some assessment of operation and verification of reports of break-downs and contingency strategies obtained in the study.

Western Sudan Agricultural Research Project (WSARP):

Completed questionnaires from WSARP agricultural surveys in En Nahud District in 1987 and 1988 were made available to the author at the El Obeid station. Watermelons were one of the crops which had been included and data were available concerning production inputs and outputs. These were of interest because of the importance of watermelons in the water supply strategies of interviewees in many of the sample settlements. However, the usefulness of the data was limited because of the apparent roadside bias[12] in the sampling practices adopted and the commercial, rather than subsistence, emphasis of the study.

District and Rural Councils:

En Nahud DC, and En Nahud and Khuwe RCs possessed information concerning population, schools, water sources (Government-constructed) and medical facilities within their boundaries[13]. Also, and most importantly, RCs were found to keep records of Government water tanker deliveries to villages in their administrative areas[14]. In Khuwe, however, the complete set of records were locked in the office of an official who was at that time indefinitely absent. Working-records were obtained from the driver of the one operational lorry in Khuwe at the time of the visit (Other RC lorries were based in Umm Bum and Iyal Bakheit). Subsequently, data concerning the movement of two lorries (stationed at Iyal Bakheit) were posted to the author in England. An attempt was made to locate on a map those settlements which reportedly received such deliveries in 1987/88. Although some problems were encountered, a general picture of spheres of operation was, however, constructed (Chapter 6).

CARE:

Information sheets, completed for evaluating the impact of the IWP extension programme upon behaviour concerning water-related health and sanitation practices by women, were also accessed. Data were transcribed for Markib (one of the study villages) and for Khammas ad Donkey (situated close to two other study villages). Pre-intervention survey results, however, were not available and, therefore, these results were of limited use.

UNICEF:

The importance of handpumps is becoming increasingly recognised as the problems and limitations of high-tech 'solutions' (such as wateryards) have become increasingly apparent (World Water, 1979; Arlosoroff, 1983; 1987). Advantages relate to the possibilities of local operation and maintenance and limited environmental pressure[15]. UNICEF has been very active in this sphere, and a list of their various sites and basic data were obtained from the El Obeid office (for the period 1986-88). None of these were located in En Nahud District, but some discussion of their role in the future development of water resources in the area will be made in this study.

Climate Data:

Although this study focuses upon strategies for obtaining sufficient water supply, the climatic context is not ignored: the physical component of the rural water system is rainfall (Chapter 3). Climate data was obtained from the 'Early Warning System Bulletin', and courtesy of Dr M Hulme (Climatic Research Unit, University of East Anglia).

SECONDARY DATA

Published Material:

Various reports have been useful in constructing a social, economic, administrative and political awareness of 'North Kordofan' and water supply issues within the Province, and also for women's activity in various areas. They include: publications by aid agencies (eg CARE, 1987; SCF, 1988); conference and workshop papers (eg Baxter (ed), 1981; INSTRAW, 1988); and publications by staff of the University of Khartoum, (eg El Sammani (ed), 1985a).

Books and articles have also been consulted on numerous themes. These include: rural development (eg Chambers, 1983); semi-arid environment (eg Ibrahim, 1984; Grainger, 1982; Trilsbach, 1987); rainfall (eg Trilsbach and Hulme, 1984; Walsh, Hulme, and Campbell, 1988); geology (Abdalla, 1986; Vail, 1988); nomads (Khogali, 1986); water policy (Shepherd *et al.*, 1987); water supply (eg Hulme, 1986; Trilsbach, 1983b;

Graham,1969, 1973; Hulme and Walsh, 1983; White *et al.*, 1972); agriculture (eg Tothill (ed) 1948; Ahmed, 1988; Coughenour, Frankenberger and Skartvedt, 1985); health (Feachem, McGarry and Mara (eds), 1977); famine/nutrition (eg De Waal, 1988; McLean, 1985a; 1985b; 1985c); and socio-economic spheres (eg Ismail, 1981; Tully, 1988). Methodological texts, mentioned above, were also consulted, most importantly Burgess (ed) (1982), Bulmer and Warwick (eds) (1983), and Burgess (1984). Other relevant works are mentioned at appropriate points in the text.

Theses:

Theses were consulted in England and in Sudan. They covered topics such as: rainfall/climate (Hulme, 1985); water supply (Bland, 1981; Mustafa, 1982; Ahmed, 1982); rural change (Trilsbach, 1983a); agriculture (Lado, 1985); and nomadism (Khogali, 1980).

Maps:

There is only one series of maps covering Sudan (scale 1:250,000), although work has begun on a second. These were surveyed by the Sudan Survey Department in the 1930s and are, therefore, outdated and certain areas were simply marked 'unsurveyed'. Steep dune systems, discovered during the course of fieldwork, were unmarked, as were some settlements (eg Umm Barouda and Wakeel) and water points, whilst other villages marked on the sheets were not found on the ground (eg Farag). However, in the absence of an alternative, these maps were used for general orientation.

LIMITATIONS OF FIELDWORK

Problems of Mobility:

Many problems were encountered, especially in the course of the main data-collection trip. These transformed what had appeared to be a realistic interview schedule, which included time for observational research, into one stressed by the limitations of time and illness. Many of these problems related to the condition of the 'road' and vehicle maintenance, as well as the amount of time which interviews demanded.

Problems of locating study villages on the reconnaissance trip have already been mentioned. Other problems included a bout of bacillic dysentery suffered by the author, and severe floods which destroyed many homes, especially in Khartoum and Atbara (Hulme and Trilsbach, 1989; Trilsbach, 1989b), and stranded the landrover for up to seven hours at one time in North Kordofan (Plate 1).

Record heavy rains in August were followed by a forecast of heavy rains in early September, and this delayed the start of the main data-collection trip by one week. Further delays resulted from the translator resigning on the scheduled day of departure. Floods were then encountered *en route* to the study area, and in one place (Aradeib, near Er Rahad), where a *wadi* was in full flow, a difficult and lengthy detour was necessary, in the course of which the landrover became stuck innumerable times. This delayed arrival in El Obeid, the regional centre, until Thursday night. Friday is the Muslim holy day when offices are closed. The following day, after fuel had been secured (with difficulty), the assistant became ill with malaria and was advised by a doctor not to move for a further one to two days! Consequently, before reaching the first study village the project was already over three days behind schedule; the two 'contingency days' incorporated had been taken up; and the translator was working with the handicap of poor health. The author also suffered septic wounds from thorns and mosquitoes, and whilst these did not delay the work they added to discomfort and tension.

More pressing concerns were presented by: the lack of any track in many areas (especially on the Basement Complex *en route* between Hariri and Marahig wateryard); steep gradients; incorrect directions; attempts to follow a 'direct route' marked on the Sudan Survey Department map; two villages of the same name; and the growth of grass to above waist-height since the reconnaissance trip, which totally obscured animal tracks and 'camouflaged' whole villages. The most taxing problem concerned the re-location of Wakeel. Worry increased when no bearing could be taken from the arc of mountains to the north, east and south, and the only pass to the east (and the next study village) could not be identified. Eventually, however, the settlement was reached by employing the angle of the sun; estimated distance from the mountains; and the keen eyesight of the driver. Additional stress was caused by the fear of becoming stranded because of: the limited amount of fuel which the landrover could carry; the inability to purchase it anywhere before El Obeid (if

Plate 1: Floods caused problems for rainy season travel.

indeed it was available there); and much greater fuel consumption than on the reconnaissance due to the growth of grass and the wetness of the sand. Furthermore, there was a time-constraint on the work (because of vehicle hire and, more especially, the translator's own commitments).

Vehicle problems occurred throughout the trip. Much time was spent in En Nahud in the purchase of a '*qoz* terrain' replacement tyre and in fitting this in place of the 'town tyre' spare, which had been used as an interim measure to replace one which had split. Later, *en route* to Hariri, the landrover refused to start and the author and her assistant managed to borrow two donkeys (and a guide!) and undertake some interviews for one day whilst men from the surrounding area were found to help push-start it. The next day was spent returning to En Nahud to enable the battery to be recharged. Further problems with a broken dynamo, two punctures, and water in the engine (when driving through unskirtable floods) added to mounting problems of delay and concern.

Interviewing Problems:

Interviews were not devoid of problems. Many of these were mentioned in contributions to Bulmer and Warwick (eds) (1983). These were both psychological and physical, and had to be considered in evaluating the data collected. Misreporting was identified, despite action taken to inform interviewees of the purpose of the work (above). Presumably some untruths were founded on: a disbelief of the stated aim; belief that some benefit could be secured; the 'Evil Eye' taboo; practical joking by men involved in, or interrupting, interviews; and differing perceptions of the importance of questions between the interviewer and the interviewee. Others were due to recall problems.

Deliberate reporting error ascribed to the 'Evil Eye' taboo has been noted in the literature, when responses demand the numbering of possessions (most notably children and animals) (Briggs, 1975; Trilsbach, 1983a). In this study, it was commonly noted that the figure for the number of people reported to be sleeping in the *hosh* on the night of the interview was different to the number derived by adding up the relations and associates subsequently listed. Steps were, therefore, taken to eliminate this by numerous cross-checks in discussion. Numbers of animals reported (*vis-a-vis* an affirmation of ownership of different animal types) were treated with some caution since verification was often impossible. In all cases where inconsistencies were discovered, reassurances were repeated concerning the nature of the research and the non-response option. This was sufficient to resolve many of the problems. The joke-motivation for untruths was more difficult to combat. In only three cases, however, were interviews abandoned before completion because of multiple untruths and perhaps these inconsistencies were associated with deeper recall problems.

Other practical and/or physical problems also were encountered. In Hariri especially, major obstacles were presented by illness of numerous potential 'interviewees' and the disruption to interview sessions caused by locust-swarms and efforts to scare them off. Also, in Umm Samra (at the end of the interviewing schedule) the demands of harvesting reduced the availability of potential respondents in mid-October. In many cases interviewees were occupied concurrently or intermittently with other household chores. Language differences caused other difficulties in dialogue (although the translator was from North Kordofan and had worked for aid organisations in this capacity before). These problems involved words used both by the translator and by interviewees: for the translator, some words were new and responses often tended to simplification (eg 'good') when descriptive or evaluative replies were sought; whilst for the interviewees, there were problems in understanding the words which were used in questioning, and in remembering what was asked. Therefore, there was often tiring repetition and clarification.

These psychological and physical problems encountered in interview meant that the average time required for an interview had been underestimated: one interview took four hours and some others over three. The length of time and division of attention may have affected the reporting accuracy. Furthermore, most topics of discussion related to previous seasons and some questions even concerned the Very Dry Year of 1984. Responses recorded may have been affected by poor recall ability. Time-frameworks were particularly noted to be confused among respondents in Umm Samra.

Absolute verification was often impossible. However, where external events or source-characteristics were described, some form of confirmation could be obtained by: observations; corroboration; or consensus.

Collecting Official Data:

The final trip to North Kordofan was made to El Obeid (the regional centre), En Nahud (the centre of both the district council and the province) and Khuwe (the centre of one of the study area's rural councils). Interviewees were generally English-speakers (to some extent), operating in official capacities. These two facts, together with use of public transport, meant that many of the stresses of the main fieldwork trip were removed. The problems which did occur related to the temporary or long-term absence of intended interviewees; 'brush-offs' and 'put-offs'; and reports that the information was 'not available'. These were counteracted wherever possible, but generally people were friendly, hospitable and helpful.

CONCLUSIONS

Chambers (1983) noted six types of bias which "impede outsiders' contact with rural poverty, and with the deepest poverty in particular" (p.13). These are: spatial biases; project biases; person biases; dry-season biases; diplomatic biases; and professional biases. These were all addressed in the present study.

A self-perpetuating focus of attention upon projects has been identified as one type of bias. Projects are atypical cases of activity, and include most especially national showpieces (Chambers, 1983) such as the Gezira Scheme. Political, economic and academic attention has focussed on such projects on the Nile and its tributaries. The current research, however, focuses upon the non-riverain *qoz* lands of western Sudan which have largely been neglected in these respects.

Overlapping urban, tarmac and roadside biases were also highlighted by Chambers (1983). Study settlements in the current research, however, were identified by a stratified random sample without regard to such features. Furthermore, households were selected within villages quasi-systematically to be from all parts. In obtaining the ***sheikh's*** permission to undertake household studies freely, with no restrictions upon household-selection, diplomatic biases which mitigate against contact with the poor were also addressed. Thus any geographical variations in wealth-status were captured in the sample.

Several types of person bias were noted by Chambers (1983). These included biases towards: the elite (those who are less poor, more fluent, more influential and monopolise visitors' attention); the male (with most local government staff, researchers etc being men and having greater status than women); the user-adopter (those who are attending a school or clinic); and the active, present and living. In the current research, the 'elite' were certainly not ignored: their co-operation was sought and information collected from them on topics of specialist knowledge. However, the household interview was the primary research tool and such interviews covered all types of families. Furthermore, these interviews were conducted with women, by women (the author and translator) in their own homes, and discussion related not only to those active and present at that time.

The problems of wet-season travelling are well documented in the literature (eg Briggs, 1975), however, the timing of this research was crucial. Many families, especially those living on the Basement Complex in settlements without perennial water supply, leave their home villages after the harvest, and return only at the beginning of the next wet-season, to re-plant crops. Therefore, had the study been conducted at a different time, those families experiencing the greatest lack of access to water in their home villages would already have left. Indeed, it was noted that some villages are all but deserted after harvest. Chambers (1983) has pointed out that many studies in countries with marked wet-dry tropical climates have suffered from an unwillingness to cope with the most difficult conditions, especially of travelling in the wet-season, and that 'dry-season bias' was a factor which often compromised the value of research.

The benefits associated with employing personal semi-structured interviews rather than questionnaires have already been clearly stated. Interviews promoted greater insight into the strategies employed and problems faced by families in their attempt to access water: discussion, recounting, and follow-up of points of interest or uncertainty were important in this process. This went some way to combatting the 'professional biases' described by Chambers (1983) who noted that, in specialisation:

> *"There is neither inclination nor time for the open-ended question or for other ways of perceiving people, events and things... Specialisation prevents the case study which sees life from the point of view of the rural poor themselves." (p.23)*

Various key informant interviews, combined with a variety of secondary data sources, provide a contextual framework, and supportive information for the more detailed household reports. Therefore, despite the problems described, the approach is vindicated.

Before investigating the principal aims of this thesis in detail, it is necessary to identify the problems associated with an imbalance between the supply of water and its demand. This is covered in the next chapter, with specific reference to the Province of North Kordofan and the study area.

FOOTNOTES

1 This has been defined according to latitude in Chapter 1, but other definitions exist. These include reference to average annual rainfall and vegetation zones. For discussion of this see Trilsbach (1983a: pp.2-3).

2 Darfur was subject to violent tribal clashes at the time.

3 En Nahud District covers 51,634 sq km (Ahmed, 1988).

4 A further two interviews were conducted with nomadic families in the vicinity of Hariri, employing a modified interview format, and four water-collection charts were completed with families in Marahig, in addition to those interviews noted.

5 Although the author's proficiency in Arabic was inadequate to conduct interviews, it was, however, very useful and well received for pleasantries, and later for monitoring key words in interviews.

6 The tape recorder was rejected for several reasons, including: the possible arousal of villagers' suspicions; limited carriage space; probable loss or damage *en route*; the number of tapes and batteries which would have been required (even if interviews had taken only 1½ hours this would have required over a hundred cassettes for the main village interviewing trip alone); problems in transcription; and the difficulties envisaged in taking the tapes out of the country.

7 'Reagan's Bread' - this was a popular phrase to describe the large amounts of food aid which were received from the USA in the years following the 1984 drought.

8 Sugar distribution records were also outdated (1986).

9 An example of this is found in the inclusion of Humeir Mogdim, Humeir Sah'hal and Gad el Haboob with Khammas Halab, reportedly linked by ties of allegiance to the *sheikh*. Also, in the particular case of Khammas Halab, two of the three associated settlements had their own wateryard and, therefore, a different water supply to Khammas Halab.

10 Khammas Halab was the only village which had a regular street plan, designed after a fire in 1986 destroyed one third of the village (see Plate 6). This rational organisation of space facilitated even areal coverage. In the other two settlements, the pattern of routeways was more complicated, with paths winding in various directions. In Markib especially (the biggest settlement) it was necessary for the author to prepare a rough sketch of some of the paths, quarter by quarter, to assist in this process, and to allow return visits to be made where the 'interviewee' was absent.

11 Lists of wateryards by maintenance centre were accessed in arabic; lists of open wells were translated and the status of *hafirs* confirmed.

12 Explained in the conclusion to this chapter.

13 Some summary details for Abu Zabad RC were received in 1991.

14 In En Nahud, the records of such deliveries prior to 6th April 1988 were held in the DC office; thereafter, the information was available in the RC offices.

15 One handpump served about 200 people.

CHAPTER 3: AN INTRODUCTION TO NORTH KORDOFAN PROVINCE

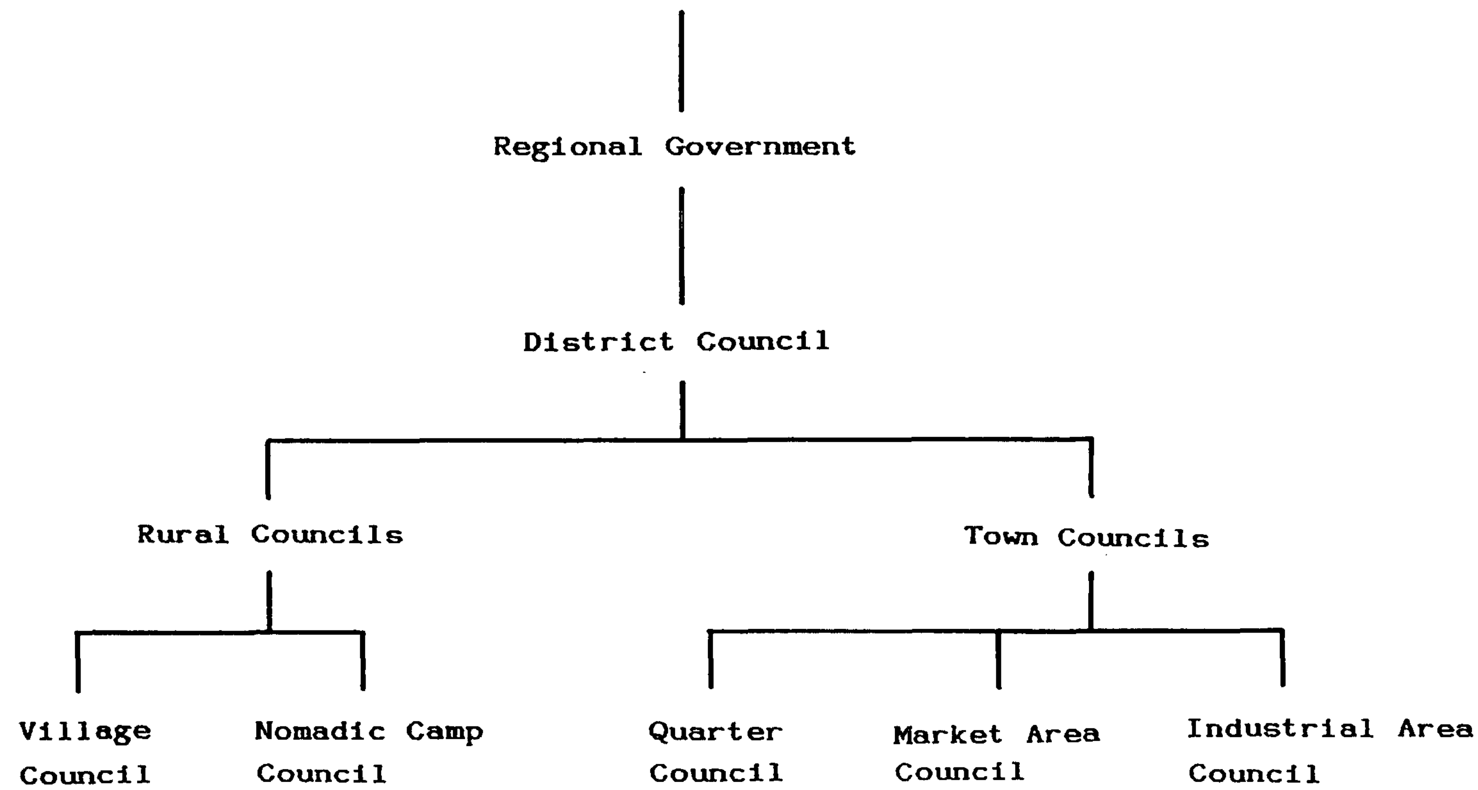
INTRODUCTION

This Chapter introduces the principal physical, social, and economic features of North Kordofan which affect the delicate balance between water supply and water demand. It is useful, however, at the outset of this Chapter to provide a brief geographical overview of the Province, and of En Nahud District in particular, as a context for analysis.

Kordofan Region, containing the provinces of North Kordofan and South Kordofan, was created by legislation in the early 1980s. Each province is divided into district councils, which are further sub-divided into both rural councils and town councils. Additionally, there are village and nomadic councils within rural councils, and quarter, market area and industrial area councils (where appropriate) within town councils (Figure 3.1) (El Sammani (ed), 1985a; Salih, 1986; Teraifi, 1986; SCF, 1988). The study area falls within En Nahud District, in North Kordofan Province.

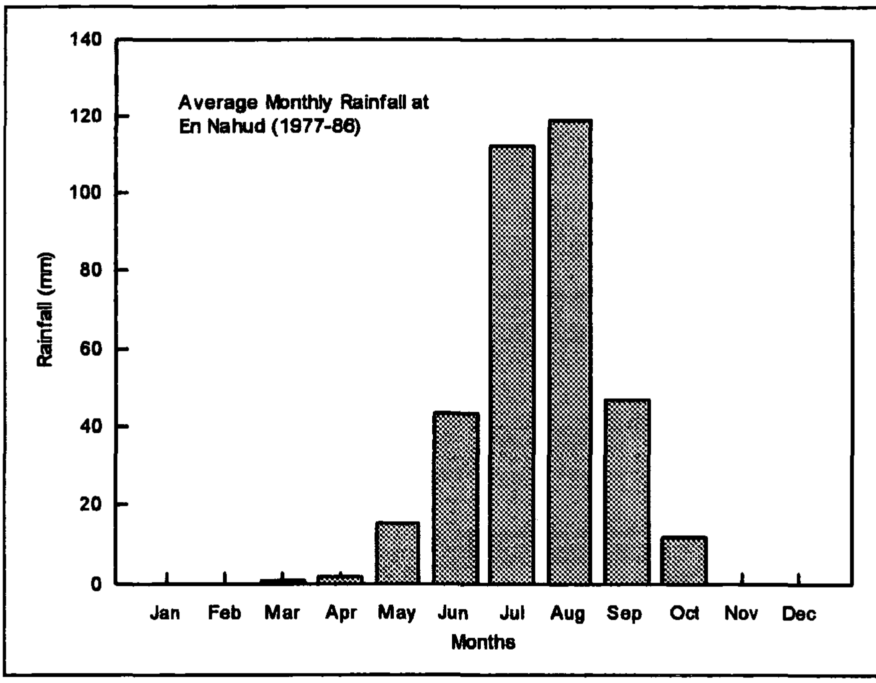
North Kordofan is one of the largest provinces in Sudan[1]. Because of its distance from the Nile, biological and economic activities are dependent upon water supplies derived from ancient (exogenous and local) and recent (local) rainfall. En Nahud District lies in the south western corner of North Kordofan, in the semi-arid belt of Sudan (Latitude 12° -16° N). In this climatic zone, the temperature ranges from a minimum of c.10°C in January to a maximum of c.40-45°C in April. CARE (1987) has noted that mean annual rainfall varies from 350-650mm, however, this is markedly seasonal, with 90 percent of the rain falling between July-September (El Sammani, 1985a). The climatic diagram in Figure 3.2 provides an illustration of the seasonal dimensions. Furthermore, dramatic annual variations are also distinguishable in the period of climatic record (below).

There are no perennial watercourses and few major *wadi* systems in North Kordofan (the Khor Abu Habl is the main exception), however there are none in En Nahud District. Sub-surface water supplies are geologically restricted. Deep regional aquifers occur in the Nubian and Umm Ruwaba Series, mainly in the south of the District, but the Basement Complex to the north is essentially 'water-poor'. These underlying geologies are, however, substantially mantled by undulating *qoz* sand deposits, which attain some relief in the northern part of the District. Communications throughout the District are difficult, but concentrate in the south with the primary axis of communication running east-west through



Source: SCF (1988)

Figure 3.1: Local Government Structure



Source: Data obtained from the Sudan Meteorological Office

Figure 3.2: Monthly Rainfall Distribution at En Nahud

En Nahud town.

In the 1983 census, the population of En Nahud District was recorded as numbering more than 486,000, of which the vast majority - 83 percent - were classified as 'rural settled'; 9 percent 'urban' ; and only 8 percent 'nomadic'. The distinctions between these categories are, however, somewhat arbitrary (see Chapter 7), and there are well-documented definitional problems associated with census information (Briggs, 1975).

The economy is agrarian in character, involving crop production, forestry, and livestock raising. Traditional rainfed farming is the dominant activity throughout the Province and is characterised by: a dependence upon family labour; cultivation of relatively small plots of land; minimal inputs; and the production of both staple and cash crops (El Sammani (ed), 1985a).

SUDANAID (1986a) describes the economy of the area in the following terms:

> *"Contemporary agricultural production in the Province exists in a context of peasant emiseration and indebtedness, with a stratum of shopkeepers and merchants deriving profit from peasant production. The terms of trade for the peasant continue to worsen." (p.iii)*

In En Nahud District, field crops were noted to include: millet, sorghum, groundnuts, and sesame, whilst the crops grown in *jubrakas* (where these existed) were more varied and included: *lubia*, cucumbers, okra and sesame as well as early maturing varieties of millet and sorghum; groundnuts were a major cash crop. Women play an important role in agricultural activities, planting, weeding, harvesting and winnowing cash and staple crops, and cultivating *jubrakas*. The scope of cultivation is determined largely by soil-type, rainfall characteristics, and the availability of drinking water. Crop production has been severely affected by the prolonged periods of poor rainfall (excepting 1988).

Gum production is also important in the Province (Chapters 1 and 6). The area falls within the 'Gum Arabic Belt' where the *Acacia senegal* and *Acacia sayal* predominate. *Hashab* tapping takes place between November to February, following crop harvest. The trees were traditionally incorporated in an effective rotation system, however, much of the acacia woodland has become severely degraded (CARE, 1987).

Animal husbandry is a traditional and important part of the economy, and is practised both by village-based families and nomads (whose existence is largely unrecorded in the census). Animals represent the stored wealth of a family, and provide an important dietary element as well. These include: sheep, goats, camels, cattle, donkeys and chickens. Among the sedentary population, goats are particularly common, and the importance of donkeys for carriage has been noted (SCF, 1988; SUDANAID, 1986a). Various nomadic groups visit the District (below); the traditional rational of nomadic system has been described by Asad (1964) in the following way:

> *"(a) by choosing to be pastoralists herding appropriate kinds of livestock in a marginal environment they make use of resources that might otherwise remain idle, and (b) by organizing the use of unpromising natural resources for the maintenance of growing herds they are able to satisfy their needs and produce large numbers of surplus animals for sale. Both (a) and (b) are connected."(p49)*

Animal herds have been decimated and traditional lifestyles disrupted by the impact of drought and desertification in the 1980s: traditional nomadic movements have been significantly altered and destitute families have 'dropped out' of nomadism (Khogali and El Sammani, 1986). This is discussed in greater detail below.

Spatial mobility within the Province and District takes a variety of forms including nomadic movement, wage labour migration (temporary and long-term) and *dammering*. The form and impetus of these movements is discussed below and in Chapter 7.

En Nahud town has a permanent population of more than 32,000, accounting for some 75% of the 'urban' population in the District (Stern, 1985; SUDANAID, 1986a). Its amenities include: large well-fields; schools - including a secondary school for boys and one for girls; *suqs* for animal, crop and other commodities; mosques; a hospital; two private pharmacies; and branches of banks, and Government and aid-agency offices (CARE, 1987). The settlement expanded rapidly after the establishment of colonial rule as the administrative and commercial centre of the District, and contains a mix of ethnic groups (SUDANAID, 1986a). In the dry-seasons, it attracts seasonal immigrants who collect water from the well-fields and find employment in the town. In the Very Dry Year of 1984/85, however, it has also became a focus for large numbers of environmental refugees. In the months of August-October 1984, 10,000 destitute families from the North reportedly moved to En Nahud (Sudan Government, 1985), and 620 displaced families from the South were recorded in the town in August 1988 (CARE, 1988). Elsewhere, public and private services are limited.

To introduce the supply and demand balance, this chapter is divided into two main parts. Firstly, the physical features which affect the supply of water are described, with attention focussing principally upon climate and hydro-geology. Secondly, selected characteristics of the society and economy are outlined, focussing upon those aspects, such as population growth, which affect the demand for water. The subsequent chapters of this thesis explore the inter-relationships at a greater scale of resolution and introduce a variety of complexities.

WATER SUPPLY: THE PHYSICAL LANDSCAPE

Ancient Climates:

There is considerable evidence that, on a geological timescale, North Africa has been affected by many climatic changes. In particular, evidence has derived from: lacustrine and fluvial deposits (eg Butzer, 1983; Adamson, Gasse, Street, Williams, 1980; Nicholson and Flohn,1980); fossil sands and stabilised dunes (eg Warren, 1970; Nicholson and Flohn, 1980); vegetation (pollen) and soil features (eg Butzer, 1961; Wickens, 1975); and from artefacts and archaeological remains (eg Butzer and Twidale, 1969). These indicate that during the last 20,000 years of the Quaternary there have been five main climatic episodes, with wet phases (pluvials) in the areas of the modern day Sahara and Sahel between c.11,000-8,000 BP and c.6,000-4,000 BP (Figure 3.3). This subject has been well researched, and Hulme (1985) has provided a useful review of the relevant literature.

The pluvials are extremely important in an understanding of the current water supplies of North Kordofan. Much of the water penetrated surficial deposits and, where underground aquifers existed, was stored. Large-scale exploitation of these underground water supplies has occurred in the Twentieth Century with the construction of deep boreholes (Chapter 1). In this way, ancient rainfall has provided an important water resource to supplement contemporary rainfall.

Figure 3.3: Recent Climatic History of the Sahel.

Period	Description
20,000 - 12,500 BP	major aridity and coolness
11,000 - 8,000 BP	first major humid phase
7,500 - 6,500 BP	brief period of aridity
6,000 - 4,000 BP	second major humid phase
4,000 - present	increased aridity

Source: Hulme (1985), p.40

Hydro-Geology:

Geology (solid and surface) has a profound effect upon the sub-surface storage of ancient and recent rainfall in aquifers (shallow and deep), and upon surface water supply. It affects: the location, type, and dimensions of water sources; storage volume; water quality; and yield. Therefore, it is important to identify the characteristics and spatial extent of the principal hydro-geological formations.

There are three main sub-surface geological formations in North Kordofan: the Basement Complex; the Nubian Series; and the Umm Ruwaba Series. These formations, together with surficial deposits, and a description of the hydro-geology of the Nahud Outlier, are examined below with primary reference to publications by: Andrew (1948); Rodis, Hassan and Wahadan (1963; 1968); Rodis and Iskander (1963); El Bushra and El Sammani (1977); El Sammani (1978); Vail (1978); Mohamed *et al.*, (1982); El Sammani (ed) (1985a); Abdalla (1986); Iskander (1986a; 1986b); and Vail (1988). Many of these texts refer to the area now described as Kordofan Region[2], consequently, although some information can be disaggregated for North Kordofan, other details can only be presented at a regional scale.

Basement Complex (Pre-Cambrian):

The Basement Complex is the oldest and most extensive rock unit in North Kordofan and provides a platform for overlying younger sediments. It extends along a NW-SE tongue, forming the axial part of the Sodiri Mega-anticline (El Sammani (ed), 1985a; Iskander, 1986a) (Figure 3.4). It comprises igneous and metamorphic rocks, which have been strongly folded, faulted and subjected to various 'climatic vicissitudes', resulting in local weathering and jointing (to depths of up to 50m and 150m respectively within the Region). The rocks either outcrop as isolated or groups of inselbergs or are mantled by surficial deposits (especially aeolian sand). The Basement rock surface contains five shallow broad basins which have been filled with sedimentary rocks of the Nubian and Umm Ruwaba Series. Channels between one and ten kilometres long and up to fifty metres deep have also been identified from gravity survey data in the west of the Region and in east Darfur Region (Rodis *et al.*, 1968). Furthermore, where well-log data are abundant, considerable local relief has been revealed on the surface of the Basement rock.

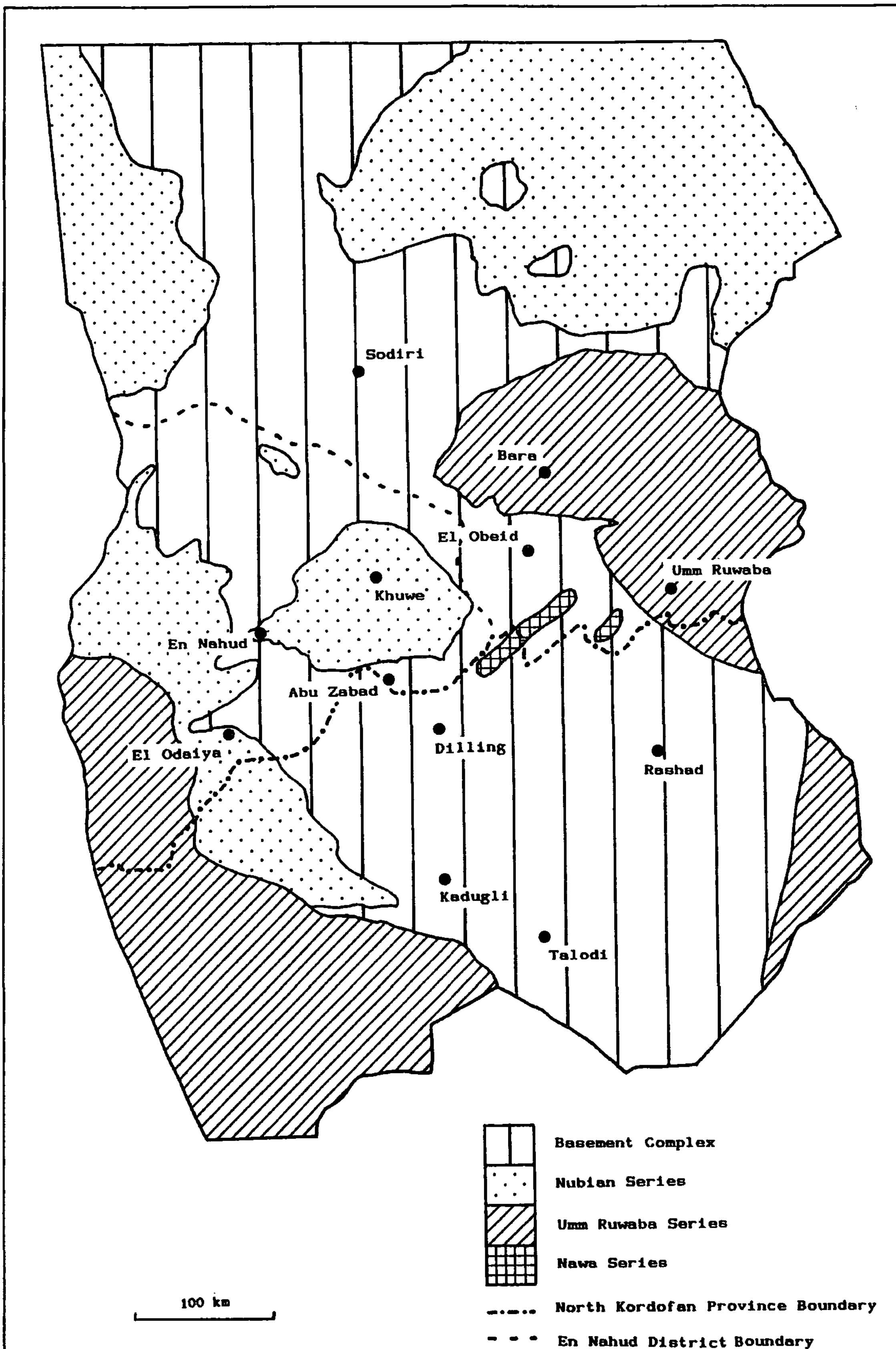


Figure 3.4: Solid Geology of Kordofan Region

The rocks are virtually impermeable except where they have been locally weathered or creviced. Rodis *et al.* (1963; 1968) noted that water moves downwards to these creviced and weathered zones from pools which collect surface runoff, and from saturated surficial deposits and sedimentary rocks (although it was also noted that the impermeable surface deposits which allow water to collect in pools largely prevent percolation of water (Rodis and Iskander, 1963)).

Relatively few wells (dug or drilled) which penetrate Basement rocks provide water in sufficient quantities to meet demand: many are dry for part of the year or supply so little water that they are abandoned. Rodis *et al.* (1968) noted that the period of water yield generally increases from north to south, coincident with improvements in average annual precipitation: in North Kordofan, seasonal replenishment was often insufficient to sustain 'perennial' well supplies. Exceptions included wells located in topographic lows at which demand was moderate, and locally in the centre of the Region where creviced Basement rocks were interconnected with Nubian and Umm Ruwaba groundwater bodies, although at many such wells yields were so low and static water levels so deep that they were reportedly almost uneconomical to use (for example, well 420 at Wad Banda). Chemical analyses of water from weathered Basement rock indicated that it was commonly 'brackish or salty', containing large quantities of dissolved-solids (3,000 - >6,000ppm) (Rodis *et al.*, 1963; 1968). Consequently, the Basement Complex is generally poor in terms of underground water supplies and the area influenced by it in the current study has been defined by El Sammani (1978) as one of the main 'gaps in the water provision map' (Figure 3.5).

Nubian Series (Mesozoic):

The sedimentary rock of the Nubian Series comprises mainly loosely to well-consolidated and well-stratified sandstones, mudstones, and conglomerates with hard, ferruginous and silicaceous layers. These are of continental and near-shore marine origin and the strata are flat or dip slightly to the north (Rodis *et al.*, 1963; 1968). The Nubian Series occurs principally in four broad depressions in the Basement rock surface and extends westwards underneath the Umm Ruwaba sediments in the extreme south west and locally underlies Umm Ruwaba sediments in the south east (Figure 3.4). Main outcrops occur in flat-topped

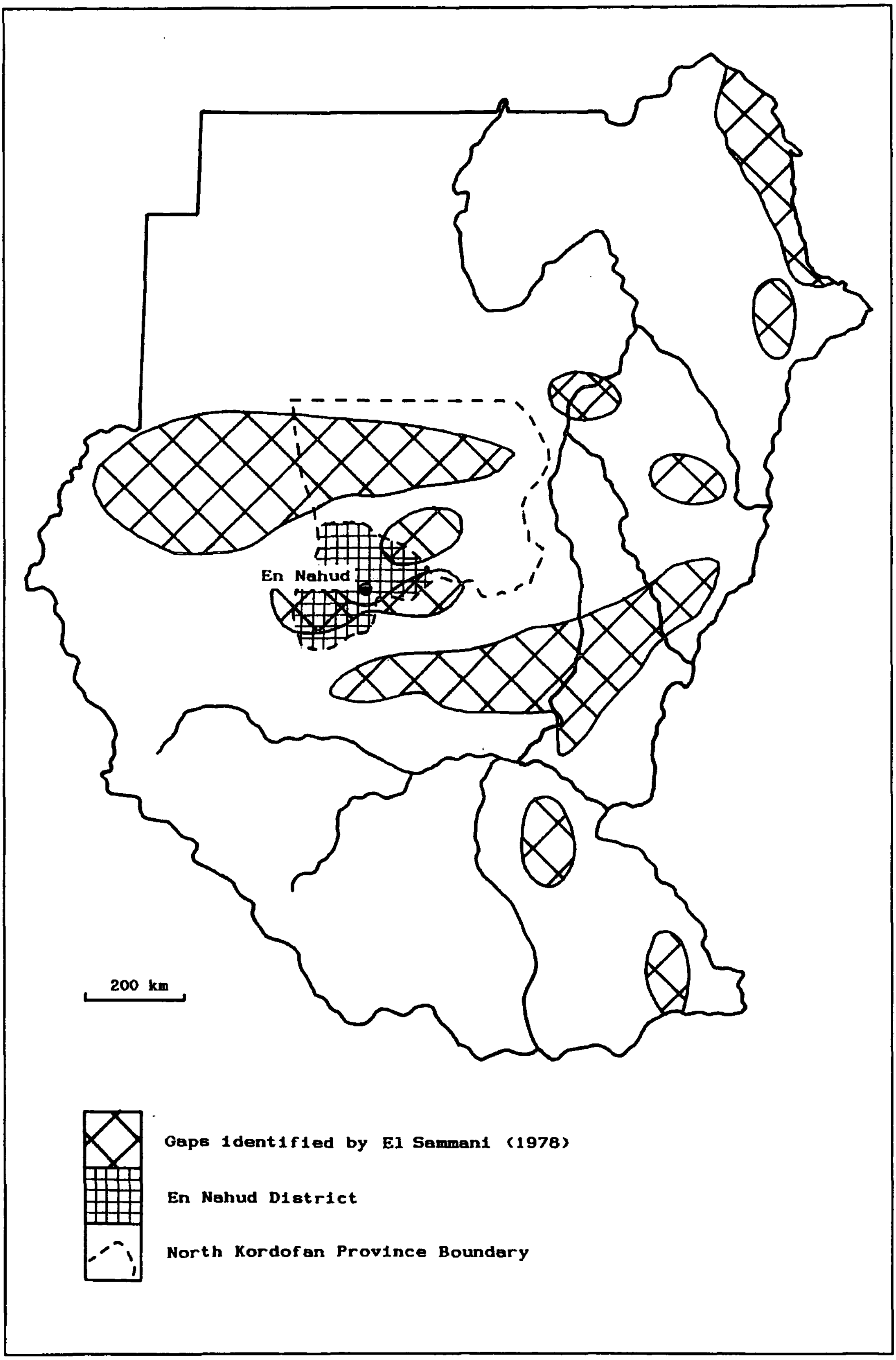


Figure 3.5: Gaps in the Water Provision Map of Sudan

plateaux in the Nahud Outlier (which provided the zone of Nubian Series sampled in this study), the Iyal Bakheit Outlier, the large western troughs (Wad Banda/Suq el Gamal) and the extensive Sahara Basin. However, the rocks are not extensively exposed at the land surface: surficial deposits and laterites partly mantle them.

Most of the Nubian Series is made up of sandstone. The more permeable sandstone and conglomerate beds are the main aquifers (although some water is also found in crevices and bedding planes of consolidated mudstones which lie in the zone of saturation). Rodis *et al.* (1968) noted that individual aquifers were commonly of limited areal and stratigraphic extent because of the many facies changes which occur, but that contiguous water bearing zones were sometimes more than 30m thick and extended for over 50km. They also commented that:

> *"[Nubian] ground-water bodies... generally terminate against basement rocks where the strata are less than 60 metres thick. A typical example of this termination is the ring of unsaturated Nubian strata that surrounds the ground-water body in the central part of the Nahud outlier." (p.J15)*

Thirty seven percent of boreholes in Kordofan Region tap aquifers in the Nubian Series (Anon, 1987). Rodis *et al.* (1968), reported that single boreholes tapping the Nubian aquifers generally yielded between 3,150-5,400lph, although yields of 13,500lph were not uncommon (eg at En Nahud). Data available at that time suggested that in many places the aquifers were capable of sustaining considerably greater withdrawals, although there had not been adequately detailed investigations to comment further. Water typically is of good chemical quality with a low dissolved-solids content, ranging from 100-340ppm (average 200ppm), and low hardness (60-264ppm) within the Region. However, exceptions to this good quality occur locally, for example, Rodis *et al.* (1968) noted a high fluoride content in water extracted from a well at Hamrat el Wiz.

Umm Ruwaba Series (Tertiary-Quaternary):

The sediments of the Umm Ruwaba Series comprise mudstones, sandstones and conglomerates of lacustrine and fluviatile origin (Rodis *et al.*, 1968). Although the Series does not exist in the study area, it is of considerable importance elsewhere in the Province and, therefore, merits consideration (Figure 3.4). In the south east of North Kordofan it overlies the irregular surface of the Basement rocks, filling a major trough known as the

Bara Basin (El Sammani (ed), 1985a; Iskander, 1986). Where it occurs in the extreme south west of the Province (and Region), however, it overlies the Nubian Series and in places is hard to distinguish from it. This area is the northerly tip of the Baggara Basin. Outcrops are rare because the sediments are covered by a thin but almost continuous veneer of surficial deposits. The Umm Ruwaba sediments are generally less consolidated than the Nubian, lie flat and, unlike the latter, are often dominated by mudstones (Rodis *et al.*, 1968).

The main aquifers are the more permeable sandstone and conglomerate beds where these lie in the zone of saturation. Aquifers are generally confined in North Kordofan. As with the Nubian Series, individual aquifers are generally of limited areal extent and stratigraphic thickness because of the commonness of abrupt lateral changes in lithology. The Umm Ruwaba Series contains productive aquifers except in several localities in the east central part of the Province. Aquifers are absent where: the underlying Basement Complex rocks rise above the zone of saturation; where the Umm Ruwaba meets Basement Complex and feathers out; and where there is an absence of permeable strata in the zone of saturation. Where Umm Ruwaba and Nubian Series rocks are associated, they contain groundwater bodies which are 'essentially continuous hydraulically' (Rodis *et al.*, 1968).

Forty seven percent of boreholes in Kordofan Region are drilled in this formation (Anon, 1987). Individual boreholes yield from 2,700-6,750lph, but yields of 12,000lph and higher are not uncommon. The chemical quality of the water in the Region is good to fair with total dissolved-solids ranging from 420-3,000ppm (average 1,050ppm), and is generally better in the west than in the east (Rodis *et al.*, 1968).

Surficial Deposits (Quaternary):

Surficial deposits include residual desert soils and active dunes; *qoz* sand; alluvium; slopewash deposits; and lagoonal deposits.

Desert soils cover the northern part of the Province. They are coarse and unconsolidated, and derive from prolonged weathering of the underlying bedrock. They are usually less than 6m deep. Most of the finer material has been blown southwards from the Sahara and deposited as sand (Rodis *et al.*, 1968).

Qoz sand deposits (The Kordofan Sands) exist largely in the form of stabilised dunes, but also include sand sheets and active dunes (Plate 2). They are located in the central belt (which includes the study area), mantling Basement Complex and Umm Ruwaba Series rocks. They mostly comprise unconsolidated quartz sand, derived mainly from aeolian denudation of the residual desert soils on the Nubian strata to the north. Deposits are red in colour, up to 45m (Rodis *et al.*, 1968) or 100m (Iskander, 1986a) thick and have a gently undulating surface. In inter-dunal areas they are locally covered with thin bedded clay and silt (usually less than 1m thick).

Alluvium is found in *wadi* and *khor* channels mainly in areas underlain by impermeable Basement rocks (or clay plain deposits in the south of the Region). It is rare in the central belt of the Region because of the permeable character of the *qoz* sands. Alluvium usually consists of unconsolidated inter-bedded sands, silts, clays and gravels and is generally less than 15m thick and 500m wide, occurring in ribbons which may extend the length and breadth of the channels. Underground water bodies are generally perched.

Slopewash deposits comprise unsorted coarse angular sand, gravel and boulders, transported only a short distance from their sources and deposited in aureoles around the footslopes of *jebels*. Locally they attain a thickness of over 30m, and a breadth of several kilometres. Most wells in slopewash deposits tap water derived directly from runoff from the *jebels* and local precipitation (Rodis *et al.*, 1963).

Lagoonal deposits were noted in the 'Kordofan Resource Inventory' (El Sammani (ed), 1985a) as existing near En Nahud, Awadalla, Suq el Gamal, and El Quleit. They originated when large lakes contracted to form a series of small lagoons as pluvial episodes gave way to the semi-arid inter-pluvials. Deposits comprise diatomaceous earth, fresh water chalk, and limestone with abundant mollusca.

Desert soils and *qoz* deposits do not provide dependable sources of water although when *qoz* is thick and impermeable clay layers are present, small 'short-lived' aquifers may exist (Rodis *et al.*, 1968; Vail, 1978). By contrast, the less extensive alluvium and slopewash deposits are 'the most important' contributors (Rodis *et al.*, 1968). The water is prone to evaporation and the deposits are generally only considered water-bearing in parts of the Province where average annual precipitation exceeds 150mm. Perennial groundwater

Plate 2: The area of Hariri has considerable dune relief.

bodies are found where they are underlain by impervious rock and there is an average annual precipitation of above 500mm (Rodis and Wahadan, 1963). Therefore, in southern North Kordofan, they are ephemeral and depend upon seasonal infiltration of runoff for recharge. They yield water with a good to fair chemical quality (<1,500-3,000ppm) (Rodis *et al.*, 1963; 1968).

The Nahud Outlier:

The Nahud Outlier is described here in some detail as it is the principal source of groundwater for villages studied on the Nubian Series. According to Rodis and Iskander (1963), it stretches for some 160km eastward from En Nahud town in the west, and for about 105km from north to south (Figure 3.4). It underlies an area of 10,360km² and is an erosional remnant of the formerly more extensive Series. It is underlain and surrounded by Basement rocks but there is no recorded evidence of Basement rocks outcropping in the Outlier. The surface relief is undulating *qoz*.

There is no inflow or outflow of surface runoff from the Outlier; all surface runoff drains into the numerous clay swales, but some sub-surface flow probably occurs. Strata dip very gently towards the centre of the basin and rocks thicken from a feather edge to about 150m in the centre. When saturated, the more permeable rocks yield water freely to wells. The principal zone of saturation underlies an area of 5,180km² and has a maximum thickness of 30m.

Thirty four wells drilled in the area underlain by the principal zone of saturation (1920-1961) were successful. Well depths ranged from 90-150m, and average yields were of 4,546lph (pumped on average 10hpd). The water had a low dissolved-solids content. Wells drilled outside the area underlain by the principal zone of saturation were unsuccessful. Withdrawals from the principal zone of saturation were increasing steadily at the time of Rodis and Iskander's study (1963). In 1963, no quantitative evaluation of recharge was possible as hydrological data were insufficient. Evaporation and transpiration were high and infiltration from swales low, however, even a very low average annual rate of recharge would produce significant increases in the stored volume because of the large surface area of the Outlier.

Climatic Seasons:

There are three main climatic seasons: (in sequence) the warm, wet *kharif*; the cool, dry *shita*; and the hot, dry *seif*. Other periods may also be defined, most especially *rusharsh* (the period in which the first occasional showers of the rainy-season fall) which precedes *kharif*, and also *darat* (the harvest) which follows *kharif*.

Some authors do not distinguish between *shita* and *seif*, but group them together into what they term 'the dry-season' (eg Bein, 1981; Mohamed *et al.*, 1982; Mohamed *et al.*, 1986). The current study, however, revealed important differences between *shita* and *seif* in terms of: the available water supply (actual and effective); demand for water by people and animals; and the resources available to families for accessing the supply. The distinctiveness of *shita* and *seif* was noted in study settlements on both the Nubian Series and the Basement Complex, although the nature of seasonal differences varied between the two areas.

In the present study the uniqueness of *darat* in terms of associated water strategies was not initially appreciated, especially on the Nubian Series geology where there were few implications for water supply due to the provision of wateryards with normally perennial supplies. However, on the Basement Complex, in settlements where water availability or accessibility generally presented significantly greater problems, distinct strategies were associated with this time period, in terms of the sources used and collection practices. In some cases it was also possible to identify specific strategies for *rusharsh*.

Where previous studies defined three or more seasons, the exact months attributed to each varied (Figure 3.6). This can be explained by: latitudinal or longitudinal differences between the areas examined; different conceptions of *darat* and *rusharsh* as either distinct seasons in their own right or as sub-periods of another season; and real annual variation in the occurrence of climatic features, which distinguish the seasons. Definitions used in this study are also illustrated in Figure 3.6.

The synoptic conditions which account for the climatic seasons have been described by various authors (eg Barbour, 1961; Hulme, 1985) but they are not directly relevant to this study. However, aspects of changing precipitation characteristics do require further examination.

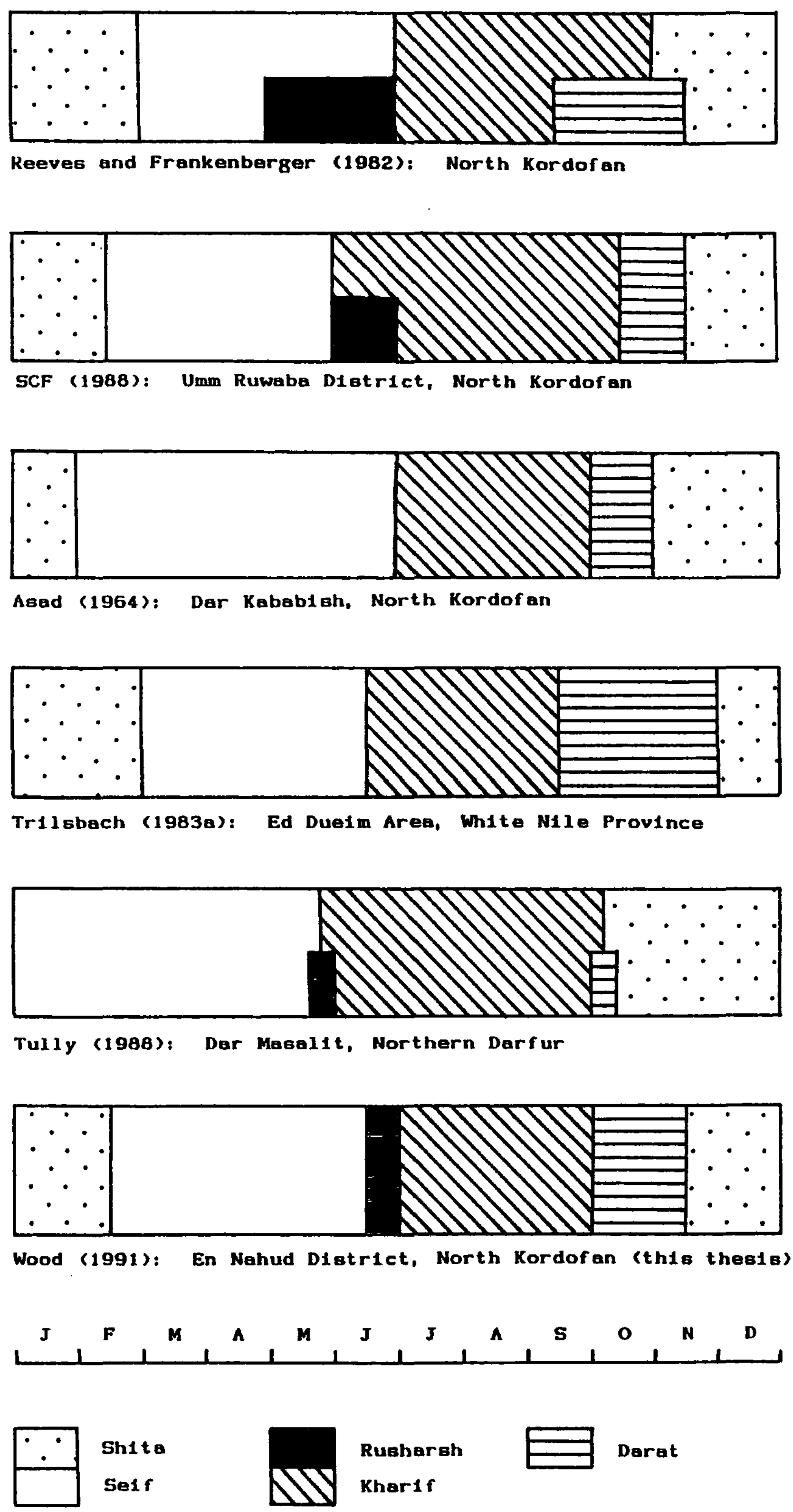


Figure 3.6: Variations in Definitions of Climatic Seasons

Rainfall Trends:

One dimension of climatic variability - seasonality - has already been discussed, however, longer-term changes in the climate, involving variations in a wide range of rainfall parameters, have been reported by researchers working at various regional scales such as: the Sahel (eg Nicholson, 1979); Sudan (eg El Tom, 1972; 1975); and central semi-arid Sudan (Hulme and Walsh, 1983; Trilsbach and Hulme, 1984; Walsh, Hulme and Campbell, 1985; Eldredge, Khalil, Salter, Nicholds, Abdalla, and Rydjeski, 1987). The most obvious long-term trend which the studies have revealed has been a period of below average rainfall since the mid-1960s and especially during the 1980s (Hulme, 1989). This has affected the Sahel in general and has been particularly marked in central Sudan (Figure 1.2).

In addition to annual rainfall trends, changes in secondary rainfall parameters, such as rainfall intensity; wet-season structure; and spatial variability have also been recognised (Hulme and Walsh, 1983; Trilsbach and Hulme, 1984; Hulme, 1985; Walsh *et al.*, 1988). These have included: fewer heavier rainfall events (variously defined: eg over 40mm (Walsh *et al.*, 1988) and over 50mm (Hulme and Walsh, 1983)) which generally display a positive correlation with annual totals; contraction in the length of the wet-season, with a greater likelihood of mid-season breaks, and with fewer 'significant' falls (greater than 10mm) (Hulme and Walsh, 1983; Walsh *et al.*, 1988), and fewer light falls (less than 10mm) in the north (Trilsbach and Hulme, 1984); and considerable spatial variability of rainfall over a variety of time-scales, ranging from 48 hours to 5 years (Trilsbach and Hulme, 1984).

Analyses of the best available data for the study area, relying mainly on meteorological records from En Nahud and El Obeid, tend to support the above trends. Using rainfall records from En Nahud, Figure 3.7 shows that there has been a decline in the number of heavy rainfalls, although those which have occurred have displayed a greater than average magnitude, and Figure 3.8 confirms the long-term decline in annual rainfall.

The changing rainfall trends are particularly important for this study as increasing dryness and rainfall unreliability have direct and indirect effects upon water supply. The exact hydrological consequences vary spatially according to the interplay of: the physical environment; the precise nature of rainfall decline; and the human response to it.

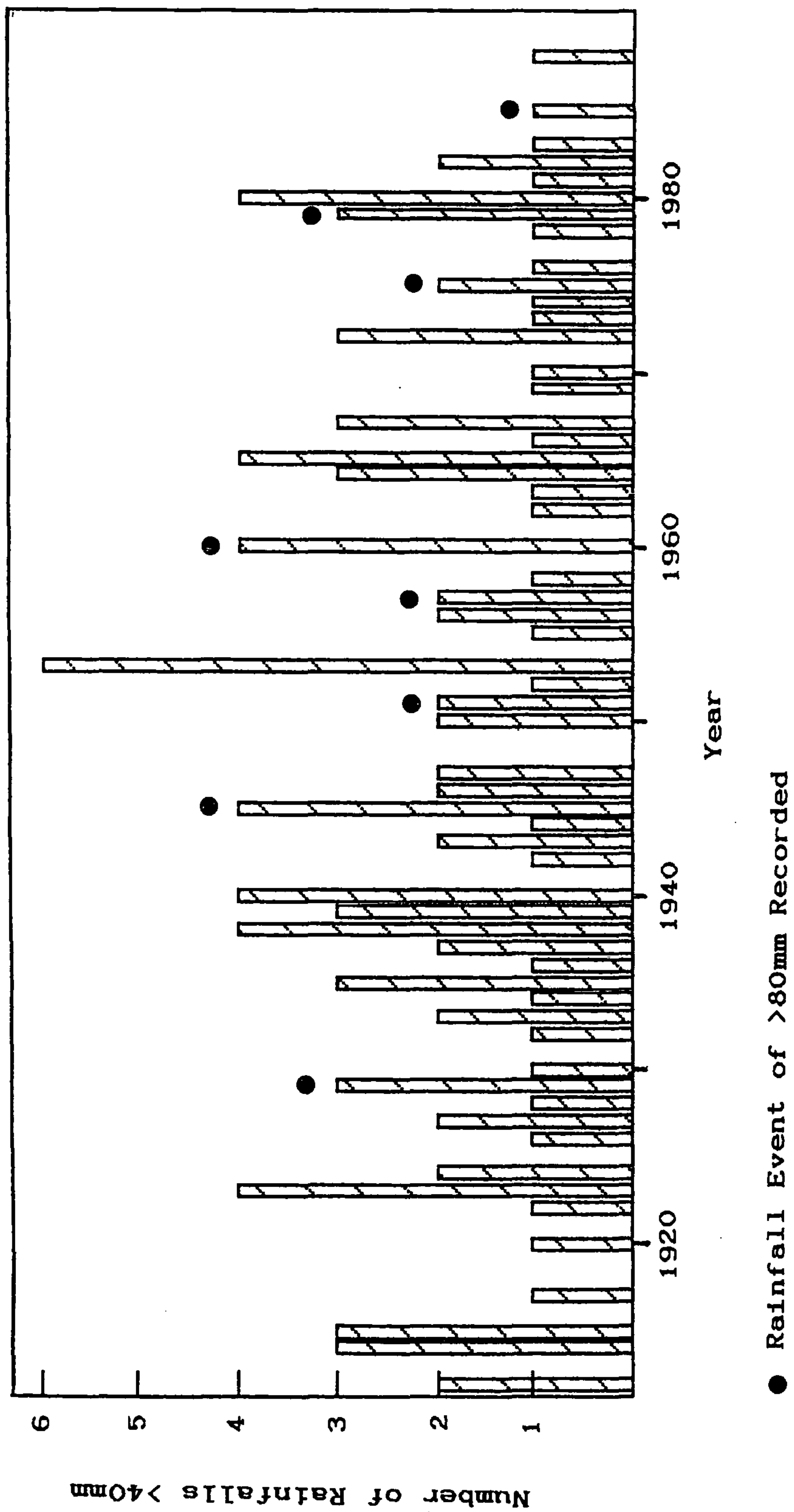


Figure 3.7: Variations in Rainfall Intensity at En Nahud

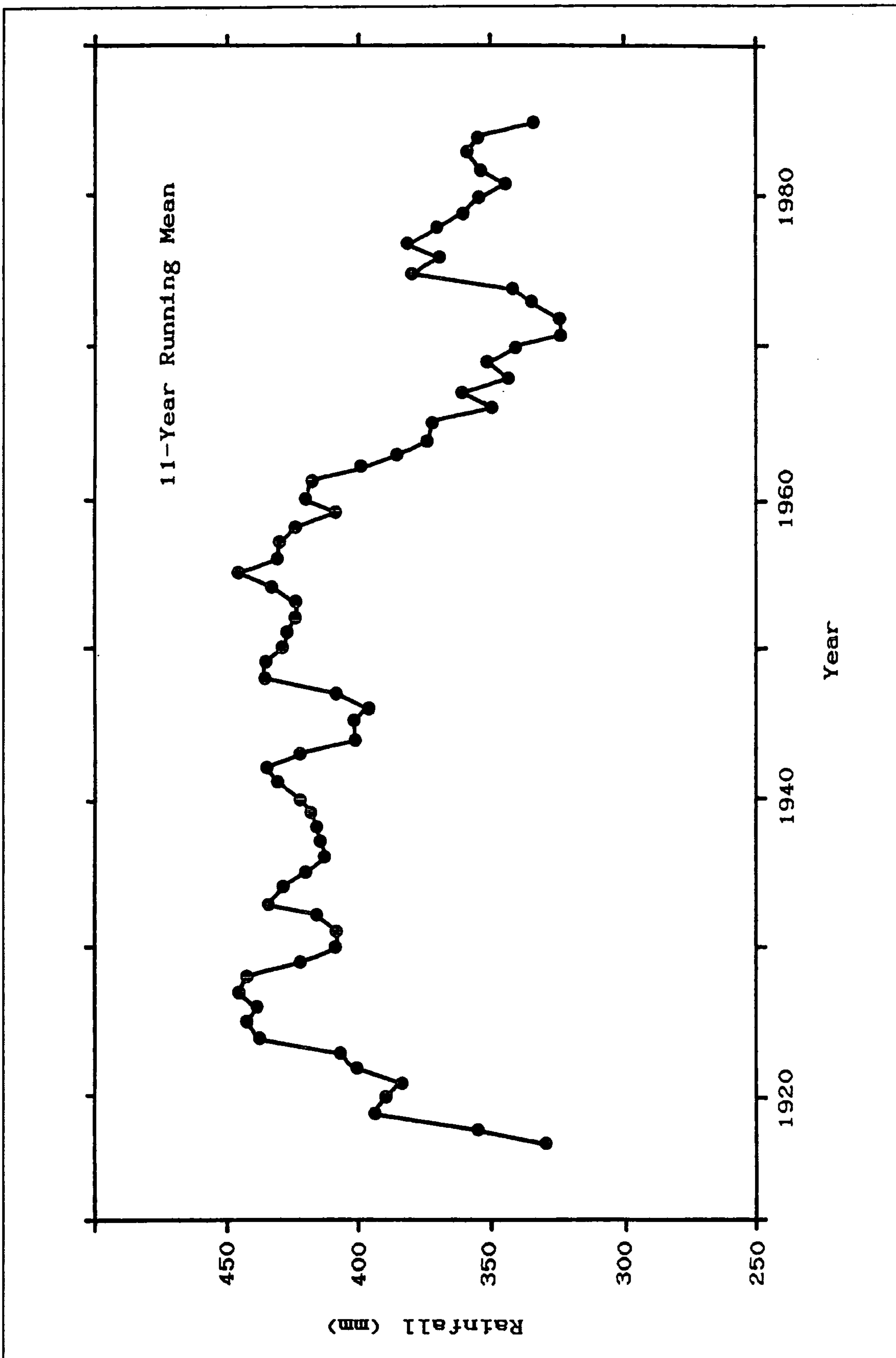


Figure 3.8: Annual Rainfall Trend for En Nahud

> *"... a range of possible hydrological responses could result from a rainfall decline depending on the precise nature both of the semi-arid environment and the human response to climatic change." (Hulme and Walsh, 1983: p.6)*

In general terms, it is possible to identify both direct and indirect effects of changing rainfall upon water supply.

Direct Effects upon Water Supply:

Direct effects are caused by changes in the characteristics of rainfall *per se*.

Decline in surface water supply (overland and *wadi* flow) is associated with a reduction in rainfall intensity, especially in the number of heavy rainfalls. This results in a decline in the amount and frequency of overland and *wadi* flows, because infiltration capacities are exceeded on fewer occasions. This is counteracted to some extent locally by the effects of compaction (resulting from livestock and raindrop impact on bare ground) which reduces infiltration capacity and enhances 'Hortonian' overland flow. However, in broad view, the latter effects are far outweighed by those relating to reduction in heavy falls (Hulme and Walsh, 1983; Walsh *et al.*, 1988).

Decline in the survival of surface water supply storage (*fulas* and rainfed-*hafirs* etc) in the dry-season is also caused by the decline in the amount and frequency of overland and *wadi* flows which feed them. Increased demand and siltation have some impact on the duration of supply, but it has been shown that even freshly excavated *hafirs* have suffered early exhaustion in the last few years (Hulme and Walsh, 1983; Walsh *et al.*, 1988). Prolonged sunshine, effecting higher evaporation rates, also reduces surface storage.

Decline in sub-surface water storage (groundwater recharge) is caused by a number of rainfall factors. Changes in daily rainfall magnitude-frequency are particularly important, since heavy falls are essential for the principal methods of recharge: rainfall infiltration and percolation; infiltration of *wadi*-water beneath the channel bed and in alluvial fans; and infiltration of overland flow at the base of inselbergs.

Localised, shallow, perched aquifers, which are tapped by springs and shallow-wells, depend upon annual recharge and hence are directly affected by rainfall changes. By contrast, larger, regional, deep aquifers, which are tapped by boreholes, have longer-term storage and are more protected against short-term fluctuations in rainfall and runoff. Therefore, fluctuations in the water level and yield at boreholes are less apparent (except where fed by seepage from the Nile) (Hulme and Walsh, 1983; Walsh *et al.*, 1988).

Spatial variability of rainfall also has implications for aquifer recharge. For example, Trilsbach and Hulme (1984) noted:

> *"... localised five-year rainfall deficits or surpluses can seriously impede or enhance the recharging of specific aquifers, which will then have consequences for domestic water supply and irrigated agriculture dependent upon groundwater (Walsh, 1983). This is especially true when 'perched' aquifers are tapped for water, which is commonly the case where hand-dug wells are predominant." (p.296).*

Examples can be cited of declining water supply at sources tapping shallow aquifers, where this is clearly unrelated to an increase in abstraction. These include the reduction of water levels in a 16m well at Umm Gidad (White Nile Province) despite decreased usage of the water because of the pollution (Walsh *et al.*, 1988); and the failure of springs in mountain front locations in the Talodi area (South Kordofan), where the supply is derived directly from runoff and *wadi*-flow from the inselberg slopes (Hulme and Walsh, 1983).

Decline in traditional water storage potential (*tebeldis*) is more difficult to explain. The disappearance of the *tebeldi* trees from the vegetation composite has been variously associated with: decline in regeneration due to the relative dryness of the recent years and cyclic change from steppe back to desert (Blunt, 1923); disappearance because of the susceptibility of their shallow root system to drought (SUDANAID, 1986a) and disturbances in the ecosystem (Muktar and Bushara, 1987); reduced size and number of *tebeldis* due to overuse and desertification (Mohamed *et al.*, 1986); and other reasons as yet unclear - perhaps associated with the grazing of goats (Newbold, 1924b; 1929). Hollowed *tebeldis* provided the most important traditional means of artificial water storage, and their demise or decline has greatest impact where perennial sources are absent (see Chapter 4). Despite these general comments, the reasons for their demise are not clear. Field interviews revealed that in Umm Barouda there were once 70-80 *tebeldis* but that most had died or become useless "because of the Very Dry Year, and the people who cut their leaves and branches for animals". The decline was supported by observation: many dead *tebeldis* were seen *en route* to Umm Barouda, north of Abu Khazm, and in Wakeel it was reported that *tebeldis* used to exist, although none remained at the time of the visit. In the absence of further evidence it is difficult to say whether their disappearance is a direct or an indirect effect of rainfall changes.

Indirect Effects Upon Water Supply:

Indirect effects are caused by varying human responses to changing rainfall.

Decline in access to water supplies is associated with diminished ability to meet the various time, effort, and financial costs involved in abstraction and transportation (Chapters 5 and 6). As will be seen, crops are important sources of revenue for purchasing requirements such as water, as are animals which may also be used for transportation. The drier climate of the recent period, and in particular the changes in wet-season structure, have had serious effects upon crop yields and grazing quality. This has been caused in part by: a shorter growing season and an earlier decline in soil-moisture levels after the end of the wet-season; irregularity in the timing and structure (mid/late-season breaks) of rainfall, which has made cultivation risky; and the decline in significant daily falls (greater than 10mm), which has resulted in serious problems for maintaining soil moisture levels over a sufficiently long and continuous period to facilitate good crop yields, or the growth of adequate pasture, to last until the following wet-season (Hulme and Walsh, 1983). Trilsbach and Hulme (1984) noted the importance of falls of greater than 10mm in maintaining soil moisture, and that they are well correlated with annual rainfall totals in central Sudan. Therefore, the degree of risk associated with the cultivation of crops which were considered 'safe' in the 1930s and 1940s (when the British administration was conducting numerous experiments into optimal farming practices) has increased greatly (Hulme and Trilsbach, 1991). Responses to reduced yields and adverse terms of trade (SCF, 1988) have included agricultural intensification and extensification and labour migration from rural areas to towns and agricultural schemes. These in turn have serious implications for future crop production and increase land disputes, with the encroachment of agriculture upon traditional grazing land.

Decline in the capacity of surface stores can be indirectly related to changing rainfall intensity. Changes in vegetation cover (by natural and anthropogenic causes) have locally increased the likelihood of wind and water erosion, despite the reduction in the number of heavy rainfalls. This is because bare surfaces are more easily eroded; soil compaction has locally reduced infiltration capacities; and increased peak magnitudes of overland and *wadi* flows have increased erosive potential. This can result in increased siltation rates in surface water stores, as was reported in a *rahad* near Marahig, in the study area.

Decline in water quality and increased health risks have indirectly resulted from an increase in demand from immigrants, and local movements of people and animals in search of water and pasture. This has put pressure upon both the quality and quantity of water. Open shallow-wells are especially liable to contamination by livestock; at El Humra (North Kordofan) the aquifer became so polluted that two wells had to be abandoned for human use (Walsh *et al.*, 1988). Furthermore, reduced yield or failure of supplies at traditional water points can prompt the use of poorer quality water supplies (eg as has been observed in White Nile Province where irrigation canals, containing *bilharzia*, have been utilised (Walsh *et al.*, 1988)).

Water, Society and Economy:

Annual rainfall is marginal for human existence throughout North Kordofan. The nomadic lifestyle represents a sensitive adaptation to the seasonal and spatial variability of water supply and vegetation development associated with rainfall patterns. However, as will be seen, changing socio-economic and political expectations and policies have partly undermined this lifestyle and a more sedentary existence, combined with a rapidly increasing population, has created new pressures on a variety of natural resources. In terms of water supply, this has been associated with greater dependence on (finite) water derived from ancient pluvials.

WATER DEMAND: SOCIAL AND ECONOMIC LANDSCAPES

Population:

The 'effective supply' of water at a given source can be judged only when the available supply is compared with the demand for it. This demand is affected by: population growth; migration; and changes in mobility, especially related to sedentarisation.

Population Growth:

Since the First National Census of population was conducted in 1955/56, there has been a rapid increase in population. Figure 3.9 illustrates the trend for Kordofan Region. The patterns require little interpretation. The approximately two-fold increase by the mid-1980s and regional growth rate, variously reported at about 3.95 percent pa (Salih, 1986) and about 2.1 percent pa (Khogali and El Sammani, 1986), has obviously increased demand for resources, including water, whilst supplies from contemporary rainfall have decreased. This has resulted in a significant reduction in overall net water supply per capita.

Sedentarisation:

The localised effects of reduced net water supply have been exacerbated by increased sedentarisation, which has created concentrations of demand. This trend can be traced back to the Nineteenth Century.

The dominant tribe in En Nahud District today is the Hamar. In the Eighteenth and Nineteenth centuries, the Hamar was a loose confederation of tribes of varied origins (Ahmed, 1988 - citing Cunnison, 1966). In the period before the Turkiya (which began c.1821) they migrated into Kordofan from Darfur and occupied the area now known as En Nahud District (or Dar Hamar, which literally means 'the homeland of the Hamar') (SUDANAID, 1986a - citing MacMichael, 1912, and Henderson, 1935; Ahmed, 1988 - citing Pallme, 1844). Although evidence is sketchy, it appears that in the 1830s they were essentially camel nomads. However, during the Turkiya there were new opportunities for trade, and the Hamar were in a position to exploit this by supplying gum arabic. This was achieved by encouraging skilled workers from other parts of Kordofan to the area, and new settlements were established, supported by water stored in *tebeldis* and cultivation of watermelons (Ahmed, 1988). By 1867 they were described as "the richest of all nomads in this part of Africa" (SUDANAID, 1986a). However, during the Mahdiya (1883-98)[3] their primacy was destroyed and their camel herds lost. This forced a change to a more sedentary lifestyle. The scale of the transformation during the Nineteenth Century was confirmed by MacMichael who, in 1912, described the Hamar at that time as "practically sedentary" (cited in SUDANAID, 1986a). This was further encouraged by policies of the Condominium Government (1899-1956), such as the provision of permanent water supplies.

Figure 3.9: Population Trends in Kordofan Region.

Year	Population	% of 1956
1956	1,762,000	100%
1973	2,098,000	119%
1978	2,361,000	134%
1979	2,388,000	136%
1980	2,414,000	137%
1981	2,441,000	139%
1982	2,467,000	140%
1983	3,075,000	175%
1985	3,250,000	184%

Source: Various

Effects of Desertification and Recent Droughts:

Whilst the population of North Kordofan has increased and become more sedentary, and hence less adapted to the marginal environment (Chapter 7), rainfall has declined and, especially since the 1960s, there has been a sequence of environmental crises in which local resources have failed to meet local demands. The long-term human responses to both desertification and drought have taken many forms, but those concerned with the redistribution of demand (animals and people) need more systematic examination.

Traditionally, a number of nomadic tribes have passed through the Province. These include: Kababish, Hamar, Hawawir, Kawahla, Shenabla, Hawamza and Dar Hamid, and Mejanin (Khogali and El Sammani, 1986; El Sammani, 1981; Mohamed *et al.*, 1982). These and other tribes such as the Ma'aliya were reported and observed in the study area.

Since the late 1960s, and especially since the mid-1980s, traditional nomadic movements have shifted southwards as pasture and water resources in the north of the Province have become exhausted earlier in the dry-season due to the effects of drought and desertification (El Sammani, 1981; Khogali and El Sammani, 1986; Trilsbach, 1989a). Previously they began moving northward to the edge of the semi-desert at the beginning of the rainy-season (July), to make use of available water and pasture. As the dry-season set in and pools dried up, they moved southward again to their respective tribal *dammering* centres, where they remained from November to May/June. A further brief southerly movement was made from these centres to about the latitude of El Obeid (13° 11') when the early rains fell there, however, as soon as the rains became established in the semi-desert and desert the nomads began moving northward. This pattern has changed: the main journey to the semi-desert has been severely shortened; the period of stay in *dammering* centres reduced to days or weeks; and the movement south extended, even as far as the Bahr el Arab. El Sammani (1981) noted that Khuwe and Mazroub were *dammering* centres at the southerly end of the Hamar and Mejanin migratory routes. However, now they have additionally become watering centres *en route* to dry-season grazing in the Nuba Mountains.

Additionally, some transhumant routes became curtailed due to loss of livestock: fewer months were spent away from home; distances ranged became shorter; and family responsibilities for crops and animals sometimes altered.

Khogali and El Sammani (1986) noted that people have 'dropped out' of nomadism because of sophistication (as a result of education or wealth) and destitution (when the number of animals remaining is insufficient for subsistence). Destitution may result in temporary or permanent sedentarisation, in the same or a different region, depending upon such factors as the extent of the livestock losses and alternative labour opportunities. In North Kordofan, they noted that 'drop out' was considerable (Khogali and El Sammani, 1986; Trilsbach and Ahmed, 1986). Loss of livestock resulting from death and enforced sale associated with the drought has already been mentioned in Chapter 1.

In the study settlements of Markib, Khammas Hajar, and Hariri the movements of nomads were described and/or their presence witnessed in 1988. It was discovered that in the Very Dry Year many nomadic Kababish came to live around Markib to utilise the relatively more abundant water and grazing. At the time of study, three families still remained, living within the village. In the course of an interview with one of these families, a wish to return to Umm Badr in Dar Kababish was expressed, but the family's animal resources were deemed insufficient to return to their former lifestyle[4].

Labour Migration:

Besides seasonal relocation of family units, there has been labour migration from study settlements. This can be a response to drought-related stresses, or essentially independent of them. Interviews indicated that this involved only males in 1987/88. They left their families for periods of time ranging from a few weeks or a season (temporary) to several years (or permanently). They worked both within En Nahud District and in places as far away as El Obeid, Omdurman, Khartoum, the Nile area, and the Gulf. This migration strategy has had the commonly perceived advantages of increasing monetary earnings (to improve purchasing power in the growing competition for water etc) and reducing short-term demand (Chapter 7).

Settlement Characteristics:

The association between settlement and water supply availability has been noted by many authors (eg El Bushra and El Sammani, 1977; SUDANAID, 1986a).

Influence of Water Supply:

Settlement location and form; size of population; and the permanency of residence through the year are related to the distribution, location and type of water abstraction points, and their supply characteristics (reliability and capacity/yield). These, in turn, are affected by many factors including: hydro-geology and rainfall (primary limitations); local communities' and Government policy, and resource availability (secondary factors).

The traditional water sources, upon which settlements were founded include: *tebeldi* stores, natural seasonal pools, lakes, streams, springs, open-wells, and crops of watermelons etc (El Bushra and El Sammani, 1977; El Sammani, 1978). Blunt (1923) asserted that the siting of ninety percent of the Hamar settlements was originally determined by the location of *tebeldis*. Furthermore, Pumphrey (1933) noted the coincidence of *tebeldis* and cultivable land.

Settlement form was shaped by the type of water source (Graham, 1969; El Sammani, 1978). Linear settlement forms were associated with *wadi* courses; non-geometric with water course systems; clustered with foothills and *tebeldi* groves; and dispersed, with clay plains in which wells could be readily sunk (El Sammani, 1978). Availability of, and access to available water sources throughout the year has been a major factor in determining settlement size and the permanency of residence. Bayoumi (1963), Mohamed and Abu Sin (1985) and Hulme (1986) have noted the limiting effect of availability of water supply and farm land upon settlement size.

El Sammani (1978) noted that forms of development, such as agricultural, commercial, servicing, communication etc, have been influenced by the distribution of traditional water sources. The construction of large mechanised *hafirs* and boreholes in the Twentieth Century has led to the expansion of cultivation, settlement and attendant development, however, existing patterns of population distribution and settlement have been greatly emphasised. Water has been widely perceived as the key to 'development' (El Bushra, 1967; World Water, Jan 1979; July 1980; Mustafa, 1981).

In En Nahud District, water supply, settlements, major routeways and other forms of development are essentially concentrated on the Nubian Series in the south of the District. Here substantial aquifers exist and have been tapped since the turn of the century by deep mechanical boreholes. By contrast, the Basement Complex area of northern En Nahud District is essentially devoid of these resources, and use of traditional water sources continues to be associated with traditional patterns and types of settlement. These contrasts in settlement characteristics between the two geological zones are now outlined further using both field and documentary evidence.

Settlements on the Basement Complex:

In the *qoz*-covered Basement Complex area (including the so-called "Problematic Area" of western Dar Hamid RC and north eastern Hamar RC (El Sammani, 1978)), more modern water points are generally precluded (in the first instance) by geology: mechanised *hafir* construction is complex and expensive because artificial lining techniques must be applied in the absence of natural clay, whilst sub-surface water can "hardly be tapped by open-shaft wells" (El Sammani, 1978: p.100).

Field observations supported these reports. Only one wateryard[5] and a few widely dispersed well-centres (including Wakeel - a study settlement) were identified. Study settlements in this area were commonly located near to one or more *rahads* with a very limited number of *tebeldis*[6], and the inhabitants planted watermelons. Some were also visited by water lorries and/or had shallow, seasonal wells nearby. These local and more distant *rahads* and smaller rainwater pools provided the main sources of *kharif* supply for all residents.

Most settlements on the Basement Complex are nucleated (Plates 3 and 4), with some additional families living outside the main villages for some/part of the year in the surrounding areas. Hariri, however, was a totally dispersed settlement comprising a reported thirteen groups of 1-6 *hoshes*, located 5-30 minutes from each other, by donkey travel, throughout a dune complex. There, the shortest distance to *rahads* (rainy-season supplies) was one hour by donkey (reported by the *sheikh*[7]) and the longest exceeded six hours (ie no local seasonal supply). All settlements sampled on this geology were significantly smaller than those on the Nubian Series (see Plates 3 and 4; Figure 2.2).

Some families remained in their villages all year. These included those living at water-centres (such as Wakeel and Marahig) and, elsewhere, those who obtained water

Plate 3: Wakeel, a small, nucleated settlement on the Basement Complex, with a well-field a few minutes distant.

Plate 4: Umm Qarn, a small, nucleated settlement on the Basement Complex, lacks a local, perennial water supply.

either locally from tankers, *kazans*, or *tebeldis* at a high financial cost, or who collected it by animal from wateryards and wells at some distance. Those families which did not have access to the necessary financial, human, or animal resources to obtain a sufficient supply or moved to water-centres (wells, wateryards and watermelons areas), perceived advantages in relocating (see Chapters 5, 6 and 7).

Graham (1969) noted that public services (schools, health facilities etc) are limited or absent in communities where transhumance is practised, because these services require a reliable, adequate water supply. This pattern was supported by field observations and information obtained from the Regional and District Councils and NGOs. Existing public services were limited (Figure 3.10) and prospects for their improvement slight.

Settlements on the Nubian Series:

Because of the concentration of wateryards on the Nubian Series, many settlements either contained one or were located close to one. These provide a potentially perennial supply. Three of the four study settlements had local wateryards - Markib, Khammas Hajar and Khammas Halab - whilst Abu Shura was three hours distance by donkey from two wateryards (Plate 5). These wateryard settlements also had many *tebeldi* trees which had been hollowed for water storage in the past, but which had become largely redundant since the construction of local wateryards. Similarly, where *rahads* existed in the vicinity (eg near Khammas Halab) these were now normally ignored as potential sources of domestic supply.

Wateryard settlements were nucleated, with some additional families living in nearby 'satellite settlements'. Larger populations were found in wateryard settlements than in non-wateryard settlements (see Plate 6; Figure 2.2).

Supply from wateryards was relatively plentiful and, in theory at least, perennial, although both long- and short-term disruptions of supply were caused by a combination of mechanical failures and shortages of spare parts and fuel (Chapter 4).

Wateryard settlements supported a fully sedentary lifestyle, and enabled services such as schools, and health facilities to become established (Figure 3.10).

Plate 5: Abu Shura, on the Nubian Series, is a nucleated settlement, smaller than wateryard settlements located in the same geological zone.

Plate 6: Khammas Halab, a wateryard settlement on the Nubian Series, arranged in a grid pattern following a fire in 1986.

Figure 3.10: Public Service Provision in Study Settlements.

Settlement	Primary or Intermediate School	Health Facility	Fixed Market	Perennial Water Supply	Veterinary Facilities	Police Station
Basement Complex						
Hariri						
Mustafa						
Umm Barouda						
Wakeel			●	●		
Umm Qarn						
Umm Samra						
Umm Gemeina						
Nubian Series						
Abu Shura						
Markib	●	●	●	●		●
Kh. Hajar	●	●	●	●		
Kh. Halab	●	●	●	●	●	

Economy:

One important strategy for obtaining water is to purchase it and hence the role of cash (or assets for exchange) in the economy is a critical component in any analysis of access to water. Economic opportunities, however, are not uniform either within North Kordofan or En Nahud District. Factors such as geology, water supply, soil, and NGO/Government policy disproportionately favour some communities, whilst family resource differentials within those communities provide relatively greater opportunities for some families. These factors are analysed in detail elsewhere, but here it is helpful to outline, briefly, the main economic activities in the study area.

Economic Assets:

Crops produced in the study area are mainly *dura* and *dukhn* (sorghum and millet); *simsim* (sesame); *ful sudani* (groundnuts); *battikh* (watermelons); *kerkade* (roselle); and some salad crops in well- and wateryard-centres. They represent a source of: food for the year; seed for the next planting; and also a potential source of revenue or economic assets. The cost of food and of delivery of water by *caro* is often greater when crop stocks, and hence cash potential from the sale of surplus, is limited prior to the next harvest (SCF, 1988). It is important to note that, in economic terms, crops are annual assets, whilst livestock and possessions (eg gold, silver, rugs) constitute stored (capital/long-term) assets, although crop reserves sufficient for two or more years were maintained in a similar environment prior to the onset of the drought in the mid-1960s to buffer against poor harvests (Holy, 1980; see also Ibrahim, 1984: p.66).

Livestock include goats, chickens and donkeys, with some households also possessing sheep, cattle, and one or more camels. Animals can be sold to provide a direct source of income but, perhaps more importantly, provide carriage, products such as milk and hides, and breeding stock (Trilsbach, 1983a). As they represent a family's stored assets (Tully, 1988), the sale of animals is generally avoided except in times of extreme financial hardship when the harvest is insufficient to offset outgoings; this situation has become more common as a result of the long-term drought (Holy, 1980). Three examples in which animals were used as an economic asset were discovered in Hariri: some chickens were sold in En Nahud for the purchase of water and other commodities; animals (chickens and/or goats) were given directly in payment for water obtained from a merchant lorry; and goats and chickens were to be sold, together with crops, as the planned means of obtaining money for the education of a child. Those who had the most problems obtaining water were sometimes described as 'the poor'; 'those without animals'. It should be noted that the number, age, sex, and quality of livestock assets vary through time. Declines were caused by death, sale, poor veterinary provisions, and poor nutrition associated with fewer offspring (Trilsbach, 1983a), and increases by purchase, and live-births (the potential number of which varies according to gestation periods of the animal types considered).

The making of *birish* (mats) and *habbaba* (fans) etc is also sometimes undertaken in the slacker times in the agricultural calendar to generate additional income. However, this often requires some financial outlay for the purchase of materials and a substantial input of time for little financial reward (see SCF, 1988), and hence income-generating potential is often limited. However, it was discovered that many things which had originally been made or acquired by the family for domestic use (including *shamlas* and *khreishas* (rugs), gold and silver etc) were commonly sold to meet needs at times of financial stress.

Taking paid employment is an obvious means of generating income, but labour is also required in the family domain for all activities including: cultivation; water collection; house renovation; marketing; child-minding etc. In selling labour, a distinction was made between employment in a career-type job and wage-labouring. The former was considered more desirable than working on the family's own land, whilst employment in farming or looking after animals was clearly seen to be a strategy of necessity rather than of choice. By their absence, family members working elsewhere sometimes placed considerable extra labour burdens on those remaining, and/or affected the success of the harvest due to insufficient weeding (Holy, 1980; Mohamed *et al.*, 1982; Tully, 1988). The peak shortage of cash and food coincide with the peak agricultural season before harvest; working on other farmers' fields reduces the labour which can be devoted to one's own fields, and reduces yields obtained (SCF, 1988).

Economic Investments:

Apart from the purchasing of day-to-day requirements, there are further aspects of financial outlay which have potential long-term benefits, most especially related to education and health.

Financial costs for elementary schooling include the registration fee and the purchase of books and clothes. Additional expenses of travel, a bed, and accommodation are incurred when the school is not relatively local, and children need to be boarded there. However, the costs are not only financial, for they also include loss of the child's labour. Children of seven years or more usually make a positive contribution to immediate family productivity. For those families where the child boards, his/her labour is completely lost for the period when school is open. By contrast, the families of day pupils retain the labour after school has finished, for such tasks as water collection. As the level of schooling increases from elementary, through intermediate to higher secondary and university, the number of establishments decreases and the average distance for a student to travel increases, as does the need to board. Furthermore, registration fees are greater at each stage.

In the study, it was discovered that the financial costs and loss of labour associated with elementary education were greater for families living on the Basement Complex (plus Abu Shura on the Nubian Series). This was because elementary schools, catering for both boys and girls (separately or co-ed.) existed in Khammas Hajar, Khammas Halab and Markib. Furthermore, a boys and a girls intermediate school was available at Khammas ad Donkey, thirty minutes distance by donkey from Khammas Hajar and Khammas Halab, and a boys intermediate school had just opened in Khammas Halab. Few settlements on the Basement Complex have sufficient water supplies to support such services.

It was also discovered that many children never attended school and that many that did, left before completion. Reasons given for this varied but included: lack of finance to continue; the need for labour at home; the child's preference; failure to pass exams; being required at home; and marriage (girls). Lack of finance, although not always the stated reason, may reasonably be assumed to account for more cases of incomplete education than was actually noted as pride etc operate to obfuscate. Furthermore, there were many examples of children obtaining several years of primary (and even intermediate) education and then returning to the family home and continuing as 'one of the family' with no (apparent) financial benefit accruing to the outlay on education. This was especially so for girls, for whom teaching is the only really acceptable 'employment' opportunity and requires a minimum of intermediate level education. However, long-term financial benefits may be derived in two ways. Firstly, remittances may be received if the example of education is carried forward to the next generation, and the children obtain 'better paid' employment. Secondly, many studies from around the world have noted a particularly strong inverse association between a wife's education and infant mortality (eg as noted in Sudan by Farah and Preston, 1982). If this applies in the study area, education may generate financial benefit to the family in the next generation through improved health and child-survival, whether or not 'paid' employment and remittances are secured. This is because children are an important part of the rural economy as a source of labour (Hall and Ismail, 1981), although there are other perspectives upon this issue. Hall and Ismail (1981) noted:

> *"Because of the important role that children play in the working life of the rural community, many village people, particularly when they have no contact with the towns, are hostile to the idea of education for both sexes out of fear that their children might grow away from them and no longer wish to remain in that environment and help with the work." (p.129)*

Health benefits (with ramifications for the productivity of labour) clearly accrue to expenditure on medicine/professional care only when diagnosis and treatment are correct. In the study villages, 'health facilities' (eg dispensary; dressing station; health part-timers unit) existed in wateryard settlements on the Nubian Series, but on the Basement Complex these facilities were lacking and people had to travel considerable distances to reach them or were forced to try to purchase medicine in the market without obtaining a diagnosis or prescription. A woman from Wakeel, for example, travelled to Marahig with her ill daughter to obtain medical help. Meanwhile, a man from Umm Samra also travelled to Marahig to buy medicine in the market there for his mother who was suffering pains. The man purchased a vial of penicillin solution for injection, but he purchased no needle: he may have been unaware of the need for one as the label was written in English, or an old needle may have been reused. For many, it was effectively impossible to obtain medicine.

It should be noted, however, that not only medicine but food, water, shelter, and clothing all affect the quality of life and health and, therefore, have ramifications for the productivity of labour.

Economic Stress:

Considerable stress arises when crops, animals, possessions or labour resources are overstretched by sale. This increases the likelihood of future shortages of requirements such as food, seed, and carriage. The sale of animals, for example, can place stresses upon a family in terms of: access to water; general poverty and economic vulnerability; and nutritional deficit. These variously derive from, for example, loss of: carriage potential; breeding potential; and animal produce. Similarly, a family may sell its labour to such an extent, and at a critical time in the agricultural calendar, that it is unable to plant, cultivate or weed its own land satisfactorily. In this way, the yield potential is reduced. Sale of labour can also result in certain water sources becoming 'inaccessible'. In Chapters 5 and 6, it will be shown that different sources are associated with different abstraction and transportation costs (time, effort and money). Any absence of a key individual, such as a man to climb up a *tebeldi*, can force the adoption of alternative strategies for water collection. These normally involve greater financial expenditure and less effort cost.

Conversely, absence of family members whose potential productivity is not realised at home may contribute greatly to the domestic economy if gainfully employed in wage-labour or 'employment' elsewhere, both by contributing funds and demanding less of the family's resources.

CONCLUSION

This chapter has illustrated the conflicting trends of reduced supply of water and greater demand for it. Economic and social conditions favour some families more than others (at inter-/intra-village scale), and facilitate greater opportunities for acquiring water (and other requirements). For example, families with stronger resource bases are better able to obtain water in times of shortage, due to increased ability to pay for more expensive local supplies and/or transportation, or to expend more time and effort on collecting water from more distant or favoured sources. These themes are explored in subsequent chapters of this thesis.

Both direct and indirect effects of drought appear to have greater impact in areas underlain by the Basement Complex, due to: the greater unreliability of water supplies, because of the importance of surface water stores and shallow-wells (which depend upon annual rainfall replenishment); and few opportunities for occupational diversification *in situ*.

Labour migrations from the Basement Complex area, however, were found to be shorter than from the Nubian Series area, both in terms of distances ranged and time absent. This can be explained, in part, by the greater internal labour requirements of the family unit, and the relative lack of infrastructural and social development, which facilitates such movement strategies, on the former (see Chapter 7).

Previously, families were buffered to some extent from poor harvests by reserves of crops and animals. However, the prolonged period of drought since the mid-1960s (relieved only intermittently) has exhausted these reserves. Families reported selling possessions and animals etc in the Very Dry Year; all had fewer animals than before 1984/5. This situation has been noted by other researchers (SUDANAID, 1986a; Holy, 1980). Ibrahim (1991) noted that:

> *"The three years between the last two famines were far too short a time to bring about rehabilitation of livestock, natural vegetation cover and the economic conditions of rural households. Most households had sold everything they had, even their clothes, to be able to buy food." (p.338).*

FOOTNOTES

1 North Kordofan covers 247,114 sq km (Ahmed, 1988).

2 The area now termed Kordofan Region was previously known as Kordofan Province.

3 1883 was start of Mahdist influence in Kordofan. In the wider context of Sudanese history, the Mahdist period is often referred to as the period between 1881-98.

4 Other Kababish families who had come to Markib at the same time were said to have left when they heard that the Government had brought food to Dar Kababish, apparently regardless of their animal wealth.

5 It is thought that the wateryard at Marahig was constructed tapping water held in a faulted zone of the Basement Complex.

6 For example, in Wakeel there were no *tebeldis* and in Hariri only one or two 'good' *tebeldis*.

[7] Considerably shorter than noted in any household interview. The minimum in these was more than two hours. Not all variation can be explained by the dispersed village morphology although inconsistencies may have been partly due to variations in the terrain.

CHAPTER 4: WATER AVAILABILITY

INTRODUCTION
- **Type of Water Sources**

SUB-SURFACE WATER SOURCES
- **Wateryards**
- **Open-Wells**

PRIMARY SURFACE WATER STORES
- **Channelled Water Supplies**
- **Surface Ponds**

SECONDARY SURFACE WATER STORES
- **Cisterns**
- **Tebeldis**
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PROBLEMS AFFECTING WATER AVAILABILITY
- **Physical Problems**
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CONCLUSIONS

INTRODUCTION

The physical availability of water for abstraction (ie the existence of water sources) is a function of the geographical distribution of abstraction 'points' and water supply (from ancient or recent rainfall, held in deep or perched aquifers, or direct precipitation). Where these coincide in space and time, 'primary water sources' occur. These include various shafts, which tap underground and sub-surface supplies, and depressions and excavations which collect seasonal rainfall and runoff. 'Secondary sources', by contrast, occur where abstraction points are not coincident with primary supply, and they include various stores which derive their water from primary sources. The actual availability of water for abstraction, however, may be limited by usership-restrictions imposed by a source-owner. Characteristics of water supply have been considered in previous chapters, but here attention is directed towards identifying the range of different types of water sources, and examination of the actual availability of water for abstraction. This involves consideration of water points with respect to their: site and situation; capacity and yield; ownership and usership; past, present and future roles in water provision; and non-structural limitations to supply.

The next two chapters investigate variations in 'access' to those water supplies which are 'available'. It is, therefore, useful at this juncture to make a clear distinction between the 'availability' and 'accessibility' of water, and to describe the relationship between the two, as used in this study. 'Availability' embraces both the physical presence of water at a water point and the permissibility of abstraction from it, as determined by the source-owner. 'Accessibility', concerns a family's ability to meet the several costs (time, effort and money) of travelling to and from and abstracting water at those sources where water is 'available'. This is influenced by the resources which the family can command and competing demands made upon them. Detailed studies of water availability are important because they identify the framework in which families make decisions concerning which source(s) to use at different times, and which resources to employ in water collection.

Many studies of rural water supply in Sudan have, in some measure, described the various source-types and general seasonality of supply at them. However, many of these may be considered inadequate for several reasons. Firstly, they have failed to compare definitions with those supplied elsewhere in the literature. Secondly, they have focussed upon governmental source types (especially wateryards and *hafirs*), giving little attention to traditional wells, cisterns, open water sources, *tebeldi* stores and watermelons. Furthermore, many have failed to discuss the material conditions of these sources, and (except for cursory mention of wateryard break-down, and occasionally of *hafir* siltation) non-structural factors which affect water availability, such as owners' restrictions.

Types of Water Sources:

The lack of comparison and analysis of documented definitions of water sources has been noted. In this section, an attempt is made to provide such an analysis, and to relate it to information derived from official sources (government and aid agency) in administrative centres, and reported and observed in the study area. For this purpose, water sources have been classified as 'sub-surface' and 'surface', with the latter category sub-divided into 'primary' and 'secondary' sources. (Refer to Figures 6.1 to 6.3 for the relative location of sources in the study area).

SUB-SURFACE WATER SOURCES

To avoid confusion, the terms 'borehole' and 'well' are not used interchangeably in this study. The former is used to refer to narrow, machine-drilled, cased, mechanically-operated shafts, associated with wateryard development. The latter refers to wider, manually-constructed shafts which are commonly open and from which water is raised by more 'traditional' methods. Those shafts constructed and equipped with handpumps are considered separately under that heading.

Wateryards:

Wateryards comprise four basic structural components: boreholes; pump-houses, enclosing diesel engines, pumps, and the boreholes; water storage tanks; and some form of distribution network. Occasionally there is also a nursery garden associated. These are examined below, together with discussion of the layout and operating procedures. Three study settlements contained wateryards (Markib, Khammas Hajar and Khammas Halab), and other wateryards were encountered within En Nahud District, most notably at Khuwe and Marahig. The three wateryards in study settlements had benefited from CARE's Kordofan Agro-Forestry Extension Project (KAEP) (1985-90), whilst those at Khuwe and Markib had been included in CARE's Interim Water Supply and Management Project (IWP) (1986-88).

Layout:

Some definitions describe wateryards as single fenced enclosures, often containing one or more boreholes and a storage tank (Walsh, 1983; Mohamed *et al.*, 1986). More specifically, Muktar and Bushara (1987) and El Sammani (ed) (1985a) described an 80x60m fenced enclosure containing boreholes, and with a single gate for people and livestock to enter.

McGowan and Burns (1987), however, described greater variety in the form and current efficacy of fencing than other writers. For example, it was noted that at non-IWP sites there were few or no fences, and that those which did exist had deteriorated to such an extent that they were no longer useful. By contrast, at all IWP sites, fences were installed to separate areas supplying human and livestock needs. These fences reportedly comprised steel posts with two to four strands of barbed wire and thorn tree branches in the ground, sometimes wired together. More recent fences tended to be more robust than those constructed earlier. Furthermore, the KAEP supplied barbed wire for nursery fencing (KAEP staff, pers. comm.[1]).

Many of the features described above were observed in the study area. At all three 'wateryard study settlements' the KAEP had provided for four-strand wire and thorn fences around the garden area. The presence, type and robustness of fencing at both Markib and Khuwe wateryards also broadly matched the description of McGowan and Burns (1987) for the IWP sites, and separate fenced water areas for people and animals adjoined each other (and also adjoined the nursery garden at Markib). Each area was gated, although the gates were not always locked when the wateryard was closed. Tanks, pump-houses and out-buildings were not incorporated in these fenced areas, although at Khuwe one pump-house and water tank was separately enclosed and gated.

Wateryards at Khammas Hajar, Khammas Halab and Marahig, not included in the IWP, displayed the lack, and poor condition of fencing attributed to them by McGowan and Burns (1987), rather than the effective single enclosure that is commonly described. At Khammas Hajar, Khammas Halab, and the site of the former (pre-1987) wateryard at Markib, there was evidence that a large perimeter fence had once existed. The scant remains variously included: large gates; iron or wooden perimeter posts; and vegetational differences. The fences at Khammas Hajar and Khammas Halab were originally supplied by the government water authority, and made of wood. They had been destroyed by people who took the wood for 'their own uses' (although at Khammas Halab it was initially reported that it had been completely destroyed by ants!). However, at Khammas Halab, the tap-stand sub-area, which was adjacent to the nursery, had been fenced off (presumably at the time when KAEP installed new taps in 1987) and this fence consisted of barbed wire and thorn. However, it was in poor condition and people were seen to climb through it easily.

Boreholes:

Boreholes are drilled and cased wells (McGowan and Burns, 1987), and normally tap underground water supplies, noted to be up to 30,000-40,000 years old (Walsh, 1983; Hulme, 1986). The number of boreholes per wateryard has been variously documented as: two to five (Walsh, 1983); two or more (McGowan and Burns, 1987); one or more (El Sammani (ed), 1985a; Mohamed *et al.*, 1986; Muktar and Bushara, 1987); and one (Hulme, 1986), with some villages having more than three boreholes (Muktar and Bushara, 1987). In field study, the number of boreholes per wateryard varied from four at Khuwe, three at Markib, and two at Marahig, to one at each of Khammas Hajar and Khammas Halab.

Basic data on borehole depth, diameter and yields were not obtained in the field, but much data have been documented, some of which have been tabulated below for comparative purposes (Figure 4.1). From this sample, it can be seen that there is considerable variance in yield. The most extreme well-yields, however, were reported in an interview at the NWC-El Obeid (not included in the Figure) as 4,546lph on the Basement Complex, and 9,092-31,822lph on the Nubian and Umm Ruwaba Series.

Figure 4.1 Borehole Depths, Diameters and Yields from Various Sources.

Source and Area	Depth (m)	Diameter (cm)	Yield (lph)
McGowan and Burns (1987) En Nahud and Bara	18-91	10-15	5,455 typical
Hulme (1986) White Nile Province	20-400	10-40	3-7,000 from the Nubian aquifers (2-300 from shallow aquifers)
Mohamed et al. (1986) various areas	-	-	>2,273
Walsh (1983) Nuba Mountains	15-366	10-40	4,546 average
Mukdar and Bushara (1987) Sudan	50-600	15	-
El Sammani (ed) (1985a) Kordofan Region	-	15-25	4-10,000
Borehole Log Khammas No. 44	113	-	4,564

Tests for successful boreholes were described in two sources. In Mohamed, Abu Sin and El Tayeb (1986), the test involved continuous pumping of water for 24 hours. If the pumped water exceeded 2,273lph the cost of installing a wateryard system was justified. According to McGowan and Burns (1987), yields greater than 1,000-2,000 lph at a depth of less than 150m were required. An example of an abandoned test borehole was found in Khuwe, where a group of villagers reported that a borehole (trial), sunk to the north of the settlement, had been sealed off although it had produced good-tasting water. The rural council staff explained that it had failed to meet the yield requirements.

Pump-house, Engine and Pump:

A pump-house, containing an engine and pump, is present at each (potentially) operative borehole. The pump-house itself is made of pre-fabricated galvanised steel, and can be readily dismantled for borehole-redevelopment or renovation of the pump (El Sammani (ed), 1985a; Muktar and Bushara, 1987). Once again, McGowan and Burns (1987) described their common state of deterioration, including holes in the roof where the pump's arm punched through. Drainage out of the pump room was noted to be very 'rudimentary' and associated with risks of pollution where the pump foundations were cracked (El Sammani (ed), 1985a).

In the study area, all the above characteristics were observed, but conditions varied markedly. At Markib, Khammas Hajar and Khammas Halab, all pump-houses appeared basically intact although some were not accessible for close inspection. At Marahig, by contrast, the pump-houses were barely in place, and machinery was exposed (Plate 7). The buildings had reportedly been torn apart by winds in 1986 but, because the wateryard 'belonged' to the government and not to the villagers, the community did not consider maintenance their responsibility.

Water is raised by a diesel engine which drives a piston pump mounted in the borehole (Mohamed *et al.*, 1986; McGowan and Burns, 1987; Muktar and Bushara, 1987). In El Sammani (ed) (1985a), engine types recorded were LISTER and TORPIDO, and pumps, EDECO, SCHOELLER and BLECKMAN. McGowan and Burns (1987) noted that, for a project area spanning En Nahud and Bara Districts, the standard NWC engines were LISTER or an Indian equivalent, and pumps, EDECO. Furthermore, Muktar and Bushara

Plate 7: A pump house at Marahig damaged by strong winds in 1986 remains unrepaired.

(1987) report these to be the most common types in Sudan (see Poole, 1987). However, lack of standardisation of equipment has been noted as a major obstacle to efficient operation of wateryards (Bland, 1981; World Water, Jul 1981; Mohamed *et al.*, 1982).

McGowan and Burns (1987) described the typical condition of the engines and pumps. Engines were dirty, covered with fuel and lubricants, and smoky, indicating that maintenance was required. Meanwhile, pumps normally had worn bearings and leaked at the discharge point. Break-downs were also common. Typically one out of two or more boreholes would be in use; the rest would be inoperative due to shortages of fuel, repairs or spares. Other sources also mentioned that boreholes are prone to malfunction for similar reasons (eg Hoagland, 1982; Mohamed *et al.*, 1982; Trilsbach, 1983b; Walsh, 1983; Muktar and Bushara, 1987). Muktar and Bushara (1987) concluded that two or more boreholes are therefore needed at each wateryard to ensure a continuous water supply and allow for mechanical break-downs.

Hulme (1985, - citing Idris, 1960) noted that in the early years of construction, boreholes were located in pairs to minimise disruptions resulting from malfunction, but that this was less common in the 1970s. However, below-capacity operation can be unconnected with malfunction[2].

Observations in the study area confirmed the variations described by McGowan and Burns (1987). For example, at Khammas Halab the engine was very smoky, and at Marahig it appeared that seals on the pumping units were leaking very badly. At Markib, one borehole had not been operational for seven years. Shorter-term break-downs were also widely recorded (below).

Water Storage Tanks:

Many studies have noted that wateryards normally have one water storage tank (El Sammani (ed), 1985a; Mohamed *et al.*, 1986; McGowan and Burns, 1987; Muktar and Bushara, 1987) which is made of steel (Walsh, 1983; Mohamed *et al.*, 1986; McGowan and Burns, 1987), and commonly described as elevated (Hulme, 1983; Walsh, 1983; El Sammani (ed), 1985a; Mohamed *et al.*, 1986; Muktar and Bushara, 1987), at a height of about 3m (El Sammani (ed), 1985a; Muktar and Bushara, 1987). McGowan and Burns

(1987) refined the description by noting that tanks were usually on steel towers at a height of 1.8-3.7m, but that they were sometimes lower and set on concrete piers. Often they were at such a low elevation that water pressure in the taps and troughs was inadequate. Furthermore, they noted that tanks were usually rusty, leaky, and fragile. The IWP included only their painting and welding, but it was noted that future projects needed to include tank-rehabilitation or replacement, since the NWC placed a lifetime of ten years on their tanks and many at non-project sites were often more than twenty years old (McGowan and Burns, 1987). Furthermore, it has been noted that at some wateryards there is no tank at all (Nash, pers. comm.[3]).

In the field, all tanks were made of metal, but the number and elevation varied between sites. There was one tank at each of the NWC wateryards at Markib, Khammas Hajar, Khammas Halab and Marahig, but two at Khuwe (which also had more boreholes). The tanks at Khammas Hajar (Plate 8), Khammas Halab and Marahig were elevated to approximately 4-5m, whereas the tank at Markib was low, supported on concrete piers. (This was the same tank that had been in the 'old' wateryard, prior to the creation of the new one by CARE in 1987). At Khuwe, one of the two tanks was elevated and one at low-level. No detailed investigation was made of the structural condition of tanks, although leaks were observed at pipe-joints at Markib and Khammas Hajar.

Documented capacities varied from a 'usual capacity' of 54,552l - defined as one day of storage - (McGowan and Burns, 1987), to 25,000-40,000l (El Sammani (ed), 1985a) and 25,000-45,000l (Muktar and Bushara, 1987), down to 15,000-30,000l (Hulme, 1986). In the field, reported capacities were lower than those noted above, but also varied, from 20/50 barrels (4,000/10,000l) at Khammas Hajar (which was, therefore, inconclusive), to 13,115l at Khammas Halab.

Distribution Network:

Many reports describe how water is distributed from the storage tank to distribution points by gravity (Walsh, 1983; Muktar and Bushara, 1987) through a c.75mm gravity main (El Sammani (ed), 1985a; McGowan and Burns, 1987; Muktar and Bushara, 1987). Furthermore, McGowan and Burns (1987) noted that the water passes through covered and usually locked meters before reaching the distribution points, as explained by the clerk

Plate 8: A raised water tank at Khammas Hajar wateryard.

Plate 9: Caros commonly filled within the wateryard area by fixing a hose to taps at tapstands, as seen at Khammas Hajar.

at Khuwe wateryard. These water distribution points are generally noted to be tap-stands and troughs, located within the wateryard enclosure (Walsh, 1983; El Sammani (ed), 1985a; Mohamed *et al.*, 1986; McGowan and Burns, 1987; Muktar and Bushara, 1987). All references described the separate designation of tap-stands and troughs for the use of people and animals respectively. McGowan and Burns (1987), however, noted that in reality distribution points were often jointly used by animals and people, and that sometimes there were only troughs. Water vendors, who collect water from these and other water points and sell it off-site, were also mentioned in reports (eg Mohamed *et al.*, 1986), but they are considered later in this Chapter as distinct secondary sources.

In examining further the main components of the distribution network, it is helpful to look at certain features (tap-stands, troughs and hours of operation) in more detail.

Tap-stands are the first of two water outlets to receive supply (El Sammani (ed), 1985a; Muktar and Bushara, 1987). They have been described in some detail by McGowan and Burns (1987) as:

> *"a concrete slab on which water containers are placed for filling. Water distribution pipes and taps are mounted over the bench. At IWP sites, there is a concrete lip around the bench with which wastewater is collected and gravity-fed into sump tanks in adjacent gardens. Tap heights have been standardized so that the most common water container, a jerikan, will fit under the tap with about a one-inch clearance, thereby minimizing spillage. There are two standard size benches - one at hip height, for women carrying jerikans, and the other just above ground level, which is convenient for children and for filling goat skins." (p.iii)*

McGowan and Burns (1987) also noted that at small sites there is normally one bench at each of the two heights, whilst at larger sites there is an additional bench for commercial vendors who attach hoses to the brass taps and fill their *hooridges*. It was widely noted that there were six taps per bench (El Sammani (ed), 1985a; McGowan and Burns, 1987; Muktar and Bushara, 1987), but the condition of both taps and tap-stands was only commented upon by McGowan and Burns (1987). They noted that many concrete benches were cracked and falling apart, taps broken or missing, tap heads missing, and pipes leaking.

Field observations showed a number of variations on the descriptions above. At sites examined, there were variously none, two, three, or four filling benches (see Figure 4.2). Only at Khuwe were there any at hip height - all the others were just above the ground -

Figure 4.2 Provision and Quality of Benches and Taps at Wateryards.

Location	Number of Benches	Number of Designed Outlets			
		Bench 1	Bench 2	Bench 3	Bench 4
Khuwe	4	6	6	6	6
Markib	3	4	4	6	
Khammas Hajar	2	4	4		
Khammas Halab	2	4	4		
Marahig	0				

Location	No. of Taps Examined	No. Not Working	No. Leaking	No. Working Efficiently
Markib	14	5 36%	2 14%	7 50%
Khammas Hajar	8	6 75%	1 12.5%	1 12.5%
Khammas Halab	4*	4 100%	0 0%	0 0%

* Four more taps existed but could not be examined. At least some of these were working.

although women, men and children collected water at the wateryards. No vendors with *hooridges* were discovered: all vendors operated with *caros*, and at Khammas Hajar and Khammas Halab, where there were only two benches, they were seen filling the barrel on their *caros* by attaching hoses to taps (Plate 9). Although it was reported that water vendors collecting water at Markib usually filled their barrels by carrying jerricans from the tap-stands, this could not be verified by observation since, at the time of study, flooding in the animal watering section of the wateryard had resulted in some temporary re-directions of water, and created an opportunity for vendors to fill the barrel on their *caros* directly outside the wateryard[4]. The number of tap outlets per bench also varied between four and six[5] (Figure 4.2).

Although no benches appeared to be cracked, many taps were damaged and unusable (Plate 10; Figure 4.2). In all these cases, some taps or tap heads were missing, however, further comment is needed. At Khammas Hajar one tap classified in Figure 4.2 as 'not working' was in fact fitted with a hose, and the supply annexed by the clerk for his household (although it could not have been used in the normal way because the tap head was missing)[6]. At Marahig, the taps had been vandalised before the Very Dry Year, and the tap-stands had subsequently been removed with the intention of preventing any visiting 'government official', presumably from NWC, demanding that they be mended.

Troughs (animal watering points) are not discussed in detail in any of the relevant reports. There were said to be two to six (McGowan and Burns, 1987) and two to three standard animal troughs per wateryard (El Sammani (ed), 1985a; Muktar and Bushara, 1987), each with about 1,200l capacity (c.6.5 barrels equivalent) (El Sammani (ed), 1985a). Open-pools, created by channelling waste-water from tap-stands, were noted by McGowan and Burns (1987) as additional distribution points at which animals could drink. This practice was, however, to be discouraged in future projects.

In wateryards within the study area, the number of troughs varied between six at Khuwe (two upturned), to four at Markib (one pulled out), three at Khammas Hajar (two upturned), and two at Khammas Halab. These were positioned with large taps at one end. No deliberately created pools of waste-water were seen, but at Markib, animals were

Plate 10: At Khammas Hajar wateryard several tapstands were damaged and the area surrounding the tapstands was very muddy.

Plate 11: People and animals collecting water together from a trough at Marahig wateryard.

allowed to drink free of charge from a pool of water in the animal yard, which formed as a result of a break-down of the water system in 1988.

The qualifications concerning the availability and separate usage of tap-stands and troughs noted by McGowan and Burns (1987) were validated in the field. At Marahig wateryard there were no tap-stands and both donkeys and people drank and collected water from the same troughs simultaneously (Plate 11). Meanwhile, at Khammas Hajar, before the construction of a nursery garden by KAEP in 1988, there had reportedly been only troughs. At the time of field study, although both tap-stands and troughs existed, the distinction in usage for people and animals was not rigidly maintained: cattle were seen drinking from pools of water which collected in the base of the filling benches before draining away, whilst people were filling jerricans from the taps. Apparently the troughs were only filled in *shita* and *seif*. At Khammas Halab, practice was harder to ascertain. Some residents reported collecting water in *seif* from troughs where animals were watering, rather than waiting in line at the tap-stand, whilst others refuted the possibility of this. In one interview it was mentioned that troughs were not for people (salt was put in the water for animals), but occasionally, when there were no animals and many people, water was put in troughs and people collected from them. Another interviewee remarked that people sometimes took water from the tap at a trough in *seif*, although this practice had declined since CARE's improvements.

Descriptions of the conditions around tap-stands and animal troughs reflect those recorded in the study area. Drainage was documented as a problem in the distribution areas (Plates 10 and 12): the yards are not paved and become muddy especially around the water-points (El Sammani (ed), 1985a; McGowan and Burns, 1987; Muktar and Bushara, 1987). Damaged valves and broken taps, which have been noted to exist, frequently exacerbate drainage problems. Some troughs in the study area were in poor condition, and would have contributed to problems of muddiness around them if they were used. Detailed examination was not always possible, but certainly one of the two at Khammas Hajar contained small holes. Around these and other troughs at Khammas Halab and Markib (where one was pulled out of the flooded yard) there were pools of water and mud, and taps associated with the troughs were also observed to be dripping.

Plate 12: The area surrounding troughs at a wateryard is commonly waterlogged, as seen at Marahig.

Hours of operation varied considerably. Figure 4.3 shows different hours of pumping/engine operation documented. These may give some indication of the hours of opening, although it should be noted that hours of pump operation may be less than the hours of opening. For example, in Markib it was noted that the pump sometimes operated for only one hour in *kharif* (compared with normal operation of three to four hours in that season).

The information presented in Figure 4.3 shows considerable variation in hours of operation. 'Typical' hours per day were recorded in the first two instances; El Sammani (ed) (1985a), however, explicitly indicated a seasonal dimension to operation and observed that many wateryards operated for 24hrs per day[7] in times of drought, especially in the northern area. Surface and sub-surface water supplies dried up rapidly after *kharif*, and this resulted in dependence upon wateryards as 'permanent sources of water supply' (El Sammani (ed), 1985a). Muktar and Bushara (1987) also noted that seasonal fluctuations in demand, and the availability of alternative sources in *kharif*, affect operation, and Hulme (1986) reported the cessation of pumping at El Muqeirinat wateryard (White Nile Province) from June-October in the wet year of 1978 (and commonly in July and August) because of the availability of water in alternative 'traditional' sources. In comparing the above 'operating hours' with opening hours reported for the study area, it was interesting to note that 'official' opening hours are from 6.00am-6.00pm. However, this is broken down into two periods: 8.00-10.00am and 4.00-6.00pm (a total of 6 hours per day) (S A H Saddig, pers. comm.,). In village interviews, it was discovered that, in broad terms, wateryards were open between '6am and 6pm', but additional detail was also obtained (Figure 4.4). Seasonal variations of the order described by El Sammani (ed) (1985a) were reported at Markib and, to a lesser extent, Khuwe. At Khammas Hajar, by contrast, it was reported that hours of opening were greater in *kharif* (eight hours) than *shita* or *seif* (six hours). However, at all three study sites, in each of the three seasons, the hours of opening exceeded official guidelines, and the report of opening for 24 hours/day, made in El Sammani (ed) (1985a) and McGowan and Burns (1987), was validated at both Khuwe and Markib.

Figure 4.3: Hours of Operation of Boreholes from Various Sources.

Source and Area	Hours of Operation
McGowan and Burns (1987) En Nahud and Bara	Engine operates 4-24 hours/day - typically 10 hours/day
Walsh (1983) Nuba Mountains	Pump operates 10 hours/day
El Sammani (ed) (1985a) Kordofan Region	Borehole working: 5 hours/day - kharif 10 hours/day - shita 20 hours/day - seif 24 hours/day - drought

Figure 4.4 Variations in Opening Hours at Wateryards.

	Khuwe	Markib	Kh. Hajar	Kh. Halab
Kharif	'am' - 12.00 15.30 - 18.00	06.30 - 09.30 10.00 - 12.00 16.00 - 18.00	06.00 - 12.00 16.00 - 18.00	06.00 - 18.00
Shita		06.00 - 18.00	11.00 - 15.00 16.00 - 18.00	06.00 - 18.00
Seif	24 hours	24 hours	11.00 - 15.00 16.00 - 18.00	06.00 - 18.00

Management and Usership:

Wateryards are government-constructed sources, and Mohamed *et al.* (1986) actually described them as "government managed water sources" (p.13). However, the extent of government control varies markedly. It was reported in interviews with NWC personnel that less than 25 percent of working wateryards in North Kordofan Province and En Nahud District were truly government controlled (ie where the authorities set the water charges; collect all the revenue; supply fuel, oil, and spares; and are responsible for full inspection and guarding). Wateryards in this category tend to be located relatively close to NWC centres.

By contrast, the majority (ie more than 75 percent) were administered by village water committees (VWCs). In some cases, a pre-existing committee took on the role of water management, in others, a new committee was established for this purpose[9]. VWCs set charges and give a specified amount of the revenue to the government in return for assistance in the form of: spare parts, as available; skilled labour to operate the facility (clerks, guards and operators - government employees); and heavy maintenance. The remaining funds are used for the purchase of fuel, oil, and spares which are unavailable at local maintenance centres at the time required. Furthermore, it was reported that other development work, such as the establishment and maintenance of dispensaries, was financed using money generated from the sale of water (S A H Saddig, pers. comm.).

No formal agreement exists between VWCs and the NWC. The former have arisen as a self-help response to the inability of the NWC to satisfactorily look after the wateryards: they are not part of NWC policy. The government was seeking to increase the proportion of wateryards over which it has complete control to fifty percent. The only conflict that was envisaged as a result of the dissolution of VWCs was with the committee personnel themselves. Indeed, it was said that complaints of mismanagement of funds etc by VWCs had been made to the NWC (S A H Saddig; A A Idris[10], pers. comms.).

None of the wateryards at Markib, Khammas Hajar, Khammas Halab, Khuwe or Marahig were completely under NWC control. Separate wateryard committees had been established in the three study settlements (all of which had been involved in one or more of CARE's projects: IWP and KAEP). Of the money collected, 1.5pt of the charge for each jerrican of water sold reportedly went to the government in the manner described above[11]. At Markib, it was reported that when oil etc was bought and the price was high, the price charged per barrel and for animal watering was increased, but the price for a *girba* or jerrican-volume (direct domestic consumption) was maintained at a steady rate.

As government-constructed sources, wateryards are essentially communal facilities. At study settlements, they were used by: people within the settlement; inhabitants of surrounding villages; animal traders; nomads; and transhumants. However, some conflicts were reported between users. At Markib, interviewees reported inter-user conflicts, but it was said that these had been reduced by the segregation of people and animals in the new wateryard, installed by CARE (although, this was only one year old). The most violent example involved a feud between the Abu Zeid and Fawadil at Wad el Badri wateryard (nicknamed '*Mashakil*' - 'Problems'), reported in Abu Shura. Furthermore, there is some indication that similar disputes have occurred elsewhere in Central Sudan. An incident at El Muqeirinat wateryard (White Nile Province) in 1979 arose when visiting nomads tried to extract water at a time of extreme shortage. The resident community believed that they had priority of use and tried to enforce this by restricting access. In the ensuing violence, three people died and many were injured (Trilsbach, 1987).

The development of large numbers of wateryards in rural Sudan has had enormous effects upon supply provision, by (at least potentially) providing high yields of good quality water at a relatively cheap financial cost to the consumer (where geology permits). In the study area and elsewhere, this has led to: the abandonment of *tebeldi* stores and hand-dug wells etc; reduction in the importance of the watermelon crop as a source of water supply; and provided foci for sedentarisation, development and population growth (see Chapter 3). However, there are numerous problems associated with their development.

Wateryards have been associated with increasing animal and human populations (through natural increase, and temporary and permanent immigration), and have become centres of environmental degradation (Ibrahim, 1978; Bland, 1981; Beech, 1985; Mohamed and Abu Sin, 1985; Cater, 1986; Blackett-Ord and Nash, 1990). An example of this situation was found in Khuwe, where the population increased from c.200 before the drilling of the first borehole in 1938, to c.1,350 in 1964 when there were three boreholes, and to c.5,000 in

1981 after the construction of a fourth borehole at the wateryard. A circle of degradation around the town has resulted from the provision of water supply without satisfactory control of land use and natural resources in the vicinity (El Sammani, 1981). Furthermore, the water provision potentials of wateryard technology have created a dependency among user-populations. The high costs of maintenance of those wateryards which already exist are not able to be met by the NWC with available funds; furthermore, various cost-recovery studies indicate the importance of higher charges to cover the high costs of operation and maintenance (Abdalla, 1985; F Linnemann, pers. comm.[12]), and the willingness of people to pay more than the government charge for the essential service to continue (Mohamed *et al.*, 1982).

Open-Wells:

Existing Definitions:

Open-well features have been described in a range of literary sources, and various vernacular terms have been associated with them: *idd*, *tamad*, *thawani*, *gamman*, *gimam*, *jammam*, *bir*, *sania*, *melish*, and *mashish*. Some descriptions are wholly general. For example, Beech (1985) and CARE (1987) referred to 'open-wells' and 'open, hand-dug wells' respectively, as distinct from wateryards. Some descriptions were partially refined by some secondary distinction, variously based upon lining or situation (eg Walsh, 1983; Mohamed *et al.*, 1986; McGowan and Burns, 1987). Elsewhere, well-features were categorised into two classes according to depth or permanence (eg Hulme, 1986; Muktar and Bushara, 1987), and a number of arabic terms associated with each group. Finally, a few authors provided definitions of specific arabic terms but, where comparison was possible, these were sometimes found to be contradictory (for example, the definitions of *tamad* and *idd* by Trilsbach, 1983b and SCF, 1988)[13].

It can, therefore, be appreciated that it is very difficult to identify similar and dissimilar features from the documentary record because of the variety of ways in which descriptions have been structured, and the fact that they are insufficiently comprehensive to permit any sound re-classification. However, certain characteristics were found to be commonly co-related. Firstly, there was a general association between: permanent structure; a lining of brick, stone, cement or wood; a situation near or along a *wadi* or in a natural depression;

semi-permanent supply; and a depth of a few metres, up to more than 100m. There was little comment upon the associated requirements for digging, however these seem to be limited after initial construction: Muktar and Bushara (1987) noted that such wells were dug to a few metres below the water table, and Trilsbach (1983b), that digging was only required at the base[14]. (Semi-permanent well structures (*mashish*) were also constructed in *wadi* beds by sinking barrels). Hulme (1986) noted that these more permanent, deeper wells often tap more extensive aquifers in the Nubian Series. This is supported by their existence some distance from surface hydrological features. Vernacular terms associated with this type of well in the literature include *bir* and *sania*, and these will subsequently be referred to as the 'permanent/deep' well type.

Secondly, there was an association between: temporary structure; lack of lining[15]; a *wadi* bed situation; the need for re-digging each year after the wet-season; temporary supply; and a depth of only a few metres. Such wells tap shallow, often perched aquifers, and the duration of supply seemingly relates to the depth of sand and gravel in the *wadi*-bed (the aquifer) and annual recharge from *wadi* flow and rainfall. Terms associated with this type of well include: *tamad*, *idd*, *thawani*, *gimam*, *gamman*, *jammam*, and *melish*, and these will subsequently be referred to as the 'temporary/shallow' well type.

Additional documentary information concerning the methods of water raising, provision for animal watering and well ownership was sparse. However, some brief comments can usefully be made about these, and problems associated with such sources. Water was raised by people from wells by means of a bucket or a leather or rubber container on a rope (Walsh, 1983; Beech, 1985; McGowan and Burns, 1987), and sometimes from deep-wells with the aid of either animal traction, or a windlass system involving use of a winch or pulley (see McGowan and Burns, 1987; Muktar and Bushara, 1987). It was, however, noted that:

> *"While pulleys or winches are occasionally used to facilitate water lifting, more commonly, tree trunks against which ropes can be pulled are mounted over the well opening. The wood is usually deeply grooved from rope wear." (McGowan and Burns, 1987: p.32)*

Water quality is variable (Beech, 1985; De Waal, 1987). There were reports that animal watering ponds, constructed from clay, were situated close to temporary/shallow wells

(Walsh, 1983; Muktar and Bushara, 1987), with pollution of shallow aquifers an attendant problem. Contamination also derived from the containers used to raise the water (Walsh, 1983; McGowan and Burns, 1987). Furthermore, since most wells were flush with the ground and uncovered and unfenced, there was a high risk of water-pollution from surface material being kicked or blown into the well, whilst the shafts posed a direct hazard to people and animals because they were 'invisible' (McGowan and Burns, 1987). Additional problems of declining water levels and infilling of wells with blown sand during drought conditions were also recorded (Trilsbach, 1983a; De Waal, 1987; Muktar and Bushara, 1987).

Ownership was rarely mentioned: communal (Muktar and Bushara, 1987) and community or private (Mohamed *et al.*, 1986) ownership were recorded (seemingly with reference to permanent/deep wells), whilst it was noted that a few wells were constructed by the NWC or its predecessors and rural councils (Muktar and Bushara, 1987). The scope of usership was generally unclear, however De Waal (1987) reported that in Darfur:

> *"Many villages barred their wells to the animals of migrating pastoralists during the drought." (p.64).*

An escalation in disputes ensued, similar to those which arose where access to wateryards was restricted.

The role of open-wells in rural water supply is very important. They have been described as the most widely used 'improved'[16] source, constituting the water supply base of most settlements throughout rural Sudan (Mohamed *et al.*, 1986). Even in the borehole zone, villagers have reverted to old, abandoned open-wells as the operation and maintenance problems associated with wateryards have become increasingly disruptive (Walsh, 1983; Mohamed *et al.*, 1986). They reportedly provide a 'secure and handy alternative' (Mohamed *et al.*, 1986), even if with the risk of water-borne disease (De Waal, 1987).

In the field, three vernacular terms were used with reference to open-well features: *idd*, *bir* and *tamad*. The term *idd* was used to refer to Abu Dulduc, Bur Islam, Wakeel and Udeid - general water-centre or well-field areas, embracing shafts (both deeper and/or shallower) and the water above and around them. This supports definitions by Jefferson (1952) and El Sammani (ed) (1985a). By contrast, the terms *bir* and *tamad* were used of shafts, and broadly conform to the 'permanent/deep' and 'temporary/shallow' types described above. These terms were generally site-specific: for example, wells at En Nahud and Wakeel were referred to as *birs*, and those at Udeid and Umm Aweesha, as *tamads*. However, both terms were used of wells at Bur Islam and these will, therefore, be considered separately.

Birs: (Permanent/Deep Type):

Observations of wells of this type were made at Wakeel and En Nahud, and information was collected from interviews where reference was made to them, and to wells at Abu Rasein, Abu Dulduc and Behher. (Other wells, apparently of this type, which were mentioned include: Kabra, Wad el Hamid, Idd en Nile, Abu Reyehwa and Fogi).

Many wells examined were lined to some extent with sticks (Plate 13) or cement. It was not possible to confirm their depths because they were either submerged or contained water. However, reported well depths were recorded. The wells at Abu Dulduc were consistently reported to be 25 'men' deep[17 18] (estimated as 46m), and at the main well-field at En Nahud, depths of 14-17 'men' (estimated between 25-31m) were reported. The latter were supported by reports of groundwater depths near En Nahud and El Odaiya towns ranging from 9 to 49m CARE (1987), and Hulme's (1985) statement that some of the deepest hand-dug wells were to be found at En Nahud. At Wakeel, however, the only indication of well depth was an estimation of over 9m of unfilled shaft at a cement-lined well on the periphery of the well-field[19]. Shafts examined at En Nahud and Wakeel were about one metre wide.

Birs were noted to occur in groups. At both Wakeel and En Nahud, the well-fields were associated with a body of surface water - locally termed *rahad* and *fula* respectively. At Wakeel, in August and October some of the well-shafts could be seen near the edge of the water (Plate 14); some of those which were submerged were demarcated with wood and thorn. This site was notably more verdant than the area surrounding it, with many trees around the open water. At En Nahud, however, two well-fields were situated next to tree-lined *fulas* (Plate 15).

The well-fields at both En Nahud and Wakeel reportedly provided a perennial water supply: interviewees could not recall the wells at Wakeel (constructed c.1982) or En Nahud ever

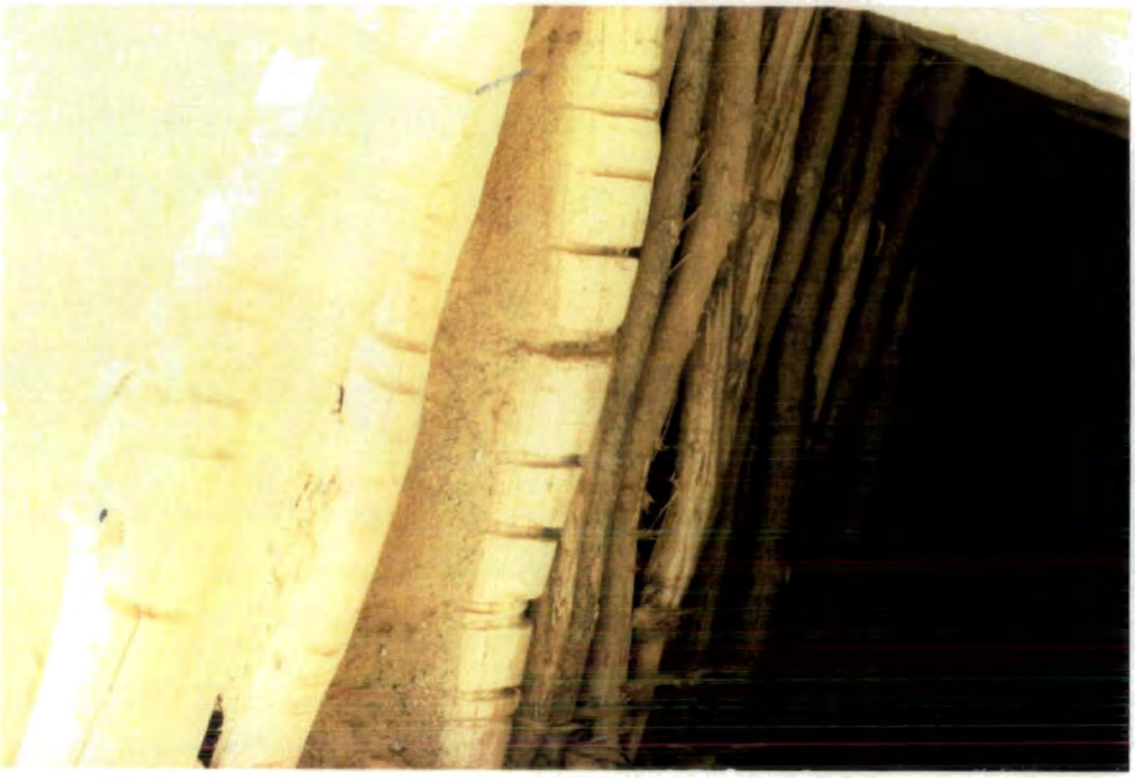

Plate 13: Stick-lined well at Wakeel shows evidence of scoring by ropes used to raise water.

Plate 14: Stick-lined well at the water's edge at Wakeel in August 1988.

Plate 15: A well at En Nahud town located next to a tree-lined fula. A windlass system is installed and there are cement basins and chutes to aid distribution.

Plate 16: A tamad being dug-out at Umm Aweesha.

failing totally in this capacity. However, many commented that the availability of water in both places depended upon the *kharif*. Water was noted to have been difficult to obtain in En Nahud in the Very Dry Year and people had had to visit several wells (in some cases ten) before being able to fill a jerrican. It was also reported that there had been relatively little rainfall since 1984, and that in 1987 there had not been much rainfall or much water in the wells in the *seif* which followed. Nevertheless, the fact that there was some water available suggests that the wells tap water supplies which exceed annual extraction demands, though not the large regional aquifers tapped by wateryards such as at Abu Kheretish, east of En Nahud.

However, not all wells at these sites provided a perennial supply. At Wakeel it was reported that twelve wells had water in them in all seasons of the year; fifteen contained water in both *kharif* and *shita*, and ten had water only in *kharif*. In addition to this, there were other wells which had failed or collapsed, reportedly numbering about twenty. At En Nahud, it was asserted that wells nearest to the *fula* had water in for longer, presumably due to more direct seepage from these pools.

Wells were found to be owned by individuals, and villages. Ownership resulted from digging a well or purchasing it. Specific wells at En Nahud were said to be owned by people from the town (although non-residents may also have owned wells there), and some people owned up to four wells there. The wells at Wakeel were owned by both residents and non-residents (individuals and villages). Non-resident owners included people living near the *jebels* to the south, and in the village of Umm Barouda. Wells at Behher and Wad el Huleiw were also owned by non-residents, for example by Umm Qarn village, and an individual from En Nahud, respectively.

Wells were not only used by owners and their close family, but terms of wider usership (period-restrictions; method of sale; charges etc) varied. At Wakeel, En Nahud, Abu Rasein, and Abu Dulduc, water was sold commercially on an *ad hoc* basis (although in Wakeel no financial charge was made for domestic supply, and at Abu Dulduc and En Nahud some favours were shown). Additionally, well-renting at Abu Dulduc was reported (see Chapter 5). The wells at Wakeel provided: the sole supply for residents all year-round; a supply during the dry-seasons for those living in nearby villages; and a *dammering* centre (see Chapter 7). Similarly, wells at En Nahud appear to have been used after the *fula* was exhausted by: families living in villages around the town (some of whom made a 24-hour round-trip to collect water); seasonal immigrant families (*dammerers*); and town-residents when piped supplies failed. (Presumably those residents who were not on the main water supply network also used this source after the *fula* was dry).

Water was raised in different ways in different well-fields. At En Nahud, many wells had windlasses installed (Plate 15), and labourers, hired by the owners, raised water for domestic, animal and commercial usage in return for half the total earnings derived. Some men found regular employment at the same well each year, whilst others worked for different people. Several wells had: shelters to protect labourers from the sun; cement water-chutes leading to large basins, into which the water was poured from the *dalu*, and from which purchasers scooped water; and smaller basins (*ragabees*), at a lower level, from which animals could drink[20]. At Wakeel, by contrast, no windlasses were observed; water was seen being raised manually by the collector in an open-topped jerrican, tied to a rope which was pulled over a highly grooved branch. Among the residents of Wakeel, women were the main water collectors and they raised water either alone or more often with the help of other women. Collectors from Umm Barouda and Umm Qarn, however, were mainly men and one reported using a camel[21] to raise water from a very deep well at Wakeel. Animal traction was also apparently used to raise water at Abu Dulduc wells, where shafts were said to be too deep to enable even a man to raise water regularly from them. Although men were certainly employed to raise water at Behher and Wakeel, this seemed to be for animal watering only.

Wells also presented some hazard. It was said that a person had died in an unmarked, submerged well at Wakeel. Furthermore, although some wells at En Nahud and Wakeel had raised rims, many others were flush with the ground and would have presented some significant hazard, as well as being more liable to pollution from surface debris. Additionally, the water at Abu Dulduc was said to be salty or bitter and to 'cause diarrhoea'.

Tamads: (Temporary/Shallow Type):

In the field, information concerning *tamads* was collected by observation at Umm Aweesha, and by interviews conducted in Umm Barouda, concerning Udeid. Wells which were reportedly dug at Abu Raziq also appear to fit the emergent description and are considered here.

Tamads were both observed and reported to be shallow (estimates ranged from one to two 'men' - about 2-4m deep), unlined, and hand-dug (Plate 16). Each year they are dug out or re-dug, and progressively deepened throughout the period of use as water levels fall. This accords well with descriptions of *tamads* at Ajery village in North Kordofan (Ahfad University, undated). However, it was reported that stone was encountered at a depth of about two 'men' at the Udeid site. When this happened there was no water in any well, and other water sources were used (indicating the shallowness of the aquifer).

As with *birs*, *tamads* were observed to occur in groups, and to be situated where sub-surface water was (potentially) available. Evidence suggests that they tap shallow, perched aquifers, reliant upon annual recharge. At Udeid, the well-site was reportedly covered with water in *kharif*, and in *shita* water availability in response to digging was dependent upon the rainfall of the preceding *kharif*. One interviewee actually mentioned a *wadi* running from Jebel Afarit in the north to Udeid[22]. Similarly, at Abu Raziq shallow-wells were dug in the bed of a *rahad* after the surface water supply had been exhausted, and this *rahad*-site appeared to be situated in the course of an old *wadi* system. Furthermore, when Umm Aweesha *tamads* were inspected in October there was no surface water at the site, however, it was notably more verdant than the surrounding area, with many trees and bushes, suggesting a favourable surface-hydrology.

Water from *tamads* was used directly after *rahad* supplies became exhausted. *Tamads* at Abu Raziq were reportedly used for three months, and those at Udeid, for one to two months in late *shita* (possibly into early *seif*). This seasonal usage was supported by observation at Umm Aweesha in October: only one *tamad* was being dug, and others showed no sign of recent excavation.

Ownership and usership of the wells at Udeid were discussed in some detail with one man in Umm Barouda. He reported that one payment of LS1 was made to the *sheikh* of Udeid for the privilege of being 'given a well', that is, the right to dig one's own *tamad* there, and permission to dig was extended to people from outside Udeid village. However, anyone could use any shaft to obtain water regardless of ownership. No permission was needed. The respondent stated that, when 'Arabs' used his well, supplies were exhausted and he had to dig deeper in order to obtain water for his own uses. No questions were asked concerning the presence of additional features associated with these specific wells, however, at Umm Aweesha, *tamad* shafts were not edged or fenced (therefore, presumably posing a hazard for people and animals and liable to pollution), and there were no *hodds* or winding devices.

Bur Islam: Tamads or Birs?:

Reports concerning the wells at Bur Islam were confusing in many respects: individual well depths quoted ranged from three to thirty 'men' deep (estimated about 5-55m) (eg Plate 17); some respondents stated that there were only three wells, although many shafts were visible; and water was variously said to be available: only in *darat;* in *shita* until November; until March; and even that it could be found in *seif* in some measure - although others refuted such claims. If these discrepancies were real, they may be explained in different ways. For example, the absence of deep-wells may be due to the limited potential of the aquifer in terms of its extent and recharge, and/or the time and effort requirements in maintaining them, making them unpopular since the construction of Marahig wateryard (3½ hours away by donkey), which offered a relatively abundant supply for minimal effort and financial abstraction-costs (and provided a source of supply for sale by water-lorries). Indeed, Mohamed *et al.* (1986) noted that in borehole zones open-wells were commonly abandoned, and only revived when maintenance problems at the wateryards become apparent (see too De Waal, 1987).

Information gleaned in interview did not help clarification. For example, it was variously noted that: the wells were mainly dug in an earlier generation and that digging had ceased because there was 'no water left'; in *shita* there was not enough water - if you dug and waited 4-5 hours only 1-1.5jc could be collected from a *bir*; before Marahig wateryard was built, people cared for and dug their wells, but since then they have neglected them; and that there was water in the wells in *seif*, but not much. It may be, therefore, that more deep

Plate 17: A cement-lined 'well' or 'pool' at Bur Islam illustrates a variant on sub-surface water features.

Plate 18: The well-field at Bur Islam is submerged by a rahad in August 1988.

wells formerly existed but that they have become infilled or partially collapsed, or that many shallow pits were dug to meet a limited seasonal water requirement. There were 25-30 wells at Bur Islam, and in August these were covered by a *rahad* (Plate 18), and the site was notably more verdant than the surrounding area, possibly explained by the presence of an old *wadi* running through Abu Zerga to Bur Islam. Some shafts were lined to some extent with sticks and a very few with cement, however, others appeared unlined.

Ownership was acquired by inheritance and by the 'adoption' of deserted wells, and it was said that more than two families or 3-6 individuals owned one well[23]. Indeed, it was noted that no wells had been dug at Bur Islam for fifteen years or more. Usership was more limited than reported elsewhere. Some well-owners reportedly sold water in *shita*: methods of sale included time shares (see Chapter 5), and *ad hoc* sale of water for domestic usage. Others jealously guarded their supplies, without permitting others to buy or collect water from their wells.

No devices or surface structures were associated with these wells. People dug in the shafts to collect water after the surface water was gone. One interviewee said that people had to bring their own rope and *dalu* when they went to purchase water. It was reported that the site was too dangerous for animals to water there, or for people to wash clothes near the wells. Certainly there were many earthworks, and the wells were very closely spaced and many had subsided. Only around the one deep cement well was there any guard erected - a wooden fence.

Handpumps:

Handpump technology has been relatively recently introduced into North Kordofan (Plate 19). The work of UNICEF and SCF in this respect has already been outlined in Chapter 1 with examination of the benefits in terms of water quality (through having a capped shaft) and reliability. Furthermore, environmental impacts of handpumps are less than those associated with wateryards. One handpump is installed to serve about 200 people and so concentrations of people and animals are not encouraged. Handpumps were not encountered in the study villages, but reference to them is merited as they will be considered later in this thesis (Chapter 8).

Plate 19: A UNICEF handpump near Er Rahad is simple to use. Wastewater is collected and channelled outside a small enclosure.

PRIMARY SURFACE WATER SOURCES

Mohamed *et al.* (1986) noted that away from the Nile, most surface water supply sources are highly seasonal, of limited capacity, and unevenly distributed, reflecting differences in: geology/bedrock; soil permeability; depth of clay soils; rainfall regime; catchment area; and drainage network. In general, their number, size and capacity increase southward with clay and loamy soils and increased rainfall, and concentration is in:

> *"areas of heavier rainfall south of Lat. 14 N on clay soils and higher grounds that have a network of drainage system, fossil drainage and depressions in the north of Mazroub lake." (Mohamed et al., 1986: p.57)*

Channelled and ponded primary surface water supplies are now discussed and, as in earlier sections, some consideration is given to conflicting terminology.

Channelled Water Supplies:

Wadis and *khors* are defined as intermittent streams which drain water from higher ground, and are in flood only after infrequent rain storms (Walsh, 1983; Mohamed *et al.*, 1986; SCF, 1988). Most carry water only for a few hours after rain events, which occur infrequently (Mohamed *et al.*, 1986; SCF, 1988). There is no explicit distinction made in the literature between the two terms and they are used interchangeably. In central Sudan, well-developed, dendritic *wadi* patterns have been noted to exist on pediments where the channels are commonly wide, with flat beds covered with loose sand. On the *qoz*, by contrast, few watercourses exist because infiltration capacities are high and runoff is minimal (Trilsbach, 1983b). A notable exception is the Idd Umm Qantur (crossing the *qoz* between Es Shiqeiq and Es Sheikh el Hassin, in White Nile Province). Walsh (1983) also noted that a network of *wadis* was well developed on the Basement Complex but poorly developed on the permeable Umm Ruwaba sediments, in the Nuba Mountains. Comments concerning the origins of various drainage systems and directions of flow have evoked: past and present relief (Walsh, 1983); structural controls (Walsh, 1983); and past pluvials (Shakesby, 1986).

SCF (1988) reported that, in the Umm Ruwaba District of North Kordofan, *wadis* (with the exception of the Khor Abu Habl):

> *"... do not have direct significance for the water supply although wells are dug in the dry river beds following the rainy season." (p.18)*

It was further noted that the irregularity and limited period of flow makes them impossible to dam for irrigation. They have, however, been more favourably described by Mohamed *et al.* (1986), who noted that they provide a water source, mainly for animal use, in the wet-season, and make a major contribution to the solution of water problems in rural areas by: acting as feeders for mechanically constructed *hafirs* (see below); being able to be dammed to produce reservoirs as an alternative to *hafir* construction, and to increase recharge to sub-surface wells (see also Trilsbach and Wood, 1986).

In the field, several *wadis* were described and/or observed (Plate 20). For example, there was clear evidence of one running southward from Jebel Afarit. Near the *jebel* itself, the channel was deeply incised. Further south its course was marked by a string of *rahads* including Rahad Ferakit, Umm Sunta, Udeid (and Abu Raziq), which may have been part of an ancient drainage network. Interviewees in Umm Barouda said that water had flowed from the *jebel* to fill the *tamads* at Udeid[24]. Additionally, in Abu Shura it was reported that water was collected from a nearby *wadi* after heavy rains: the water lasted about one day (presumably in pools). Also, in various villages there were reports of animals watering in '*el wadi/el khalla*', outside settlements (presumably from temporary pools). Furthermore, unlined 'wells' were observed being dug in *darat* in Khor Baggara near El Obeid (Plate 21) (a deep, wide *khor*, which had been in flood that August), and at Umm Aweesha well-site.

Surface Ponds:

Terminology:

In some documents, a number of arabic terms have been associated with a prescribed category[25] of surface pond, and none or only a few considered individually (Mohamed *et al*, 1986; Hulme, 1986). Where arabic terms have been specifically defined, however, descriptions have variously included some note of: areal extent; depth; situation; supply duration; and type of intervention (none, man, machine) etc. These definitions are often indistinct and/or incompatible.

Mohamed *et al.* (1986) briefly mentioned some regionalism of terminology:

Plate 20: A khor near Khuwe village. This flooded in 1984 causing much structural damage to the village.

Plate 21: Shallow, temporary well dug in the bed of Khor Baggara, near El Obeid.

> *"... natural pools, [are] known by different names as Turda, Fula in Western Sudan and hafirs elsewhere, besides ponds..." (p.8)*

This regionalism does not, however, provide a satisfactory explanation for the discrepancies identified, since inter-documentary comparison shows that at least some terms are not exclusively regional. For example, the term *rahad* is used in Kordofan, White Nile Province, and more widely in Sudan for a type of natural source (eg Trilsbach, 1983b; Morton, 1986; Muktar and Bushara, 1987). Additionally, the characteristics associated with different terms are not consistent. For example, even within Kordofan Region the term *rahad* is used of both 'small' and 'large' surface features (El Sammani (ed), 1985a; Morton, 1986; SCF, 1988). Furthermore, the term *hafir* (derived from the arabic 'to dig') has been variously defined, within and between documents, to include both: large and small features; the modification of natural features and the construction of new ones; machine and hand intervention; and a supply-duration ranging from two weeks after the end of the wet-season, to perennial supply (see Walsh, 1983; Hulme, 1986; Mohamed *et al.*, 1986; McGowan and Burns, 1987). Perhaps 'use of language' has more explanatory power. A term may, for example, be used both specifically of a surface pond with particular characteristics, and also more generally to embrace a range of open-pond features. The latter usage, therefore, represents a simplification, which may be made either by an author or by the study population.

Clearly a wide variety of sources may be defined by various combinations of: areal extent; depth; situation; supply-duration; and type of intervention (none, man, machine) etc. Therefore, for the purposes of this study, discussion will focus upon two types of surface ponds: the small, natural or hand-modified surface stores with short potential supply-duration; and the large, government-owned, mechanically-excavated stores with (potentially) long-term supply-duration. Terminology used in the study area is adopted in discussion.

Small, Natural/Hand-Modified Surface Stores:

These sources commonly have a short supply-duration; are predominantly unmodified; and are used by animals and people together. They are consequently liable to a range of dynamic problems including: evaporation, some seepage, and pollution, as well as variable supply (due to rainfall localisation) (Plates 22 and 23) and reduction in capacity (due to

Plate 22: Khuwe fula the day before heavy rain in August 1988.

Plate 23: Khuwe fula, one day after Plate 22 was photographed.

siltation). These problems are similar to those considered in the following section for mechanically-excavated surface stores.

Potential and implemented improvements have been documented. Muktar and Bushara (1987) noted that large perennial surface water sources could be improved by deepening, fencing and pumping water for domestic and other purposes. The merits of similar basic improvement were also described by Morton (1986) for seasonal pools (*rahads*) holding water for no more than three weeks after the last rains. The case of Abu Tama *rahad* was cited, where deepening and banking had been carried out to increase its capacity[26]. Use of the water was free and supervised by the VWC, whose members gave their time free to prevent animals fouling the water. Such improvements were endorsed by Morton (1986) in his recommendation for tool donations to assist in this maintenance work. It was noted that these *rahads*:

> *"... appear to be genuine communal resources." (p.78)*

In the study area, interviewees used the terms *rahad*, *rahud* and, very rarely *fula* (at Khuwe and En Nahud)[27]. *Rahad* referred to larger pools, which sometimes lasted into *shita*, and *rahud* was occasionally used of smaller rainwater pools in fields which lasted for up to three days[28]. It was found that most surface pools were unimproved, and accessed directly by both people and animals. However, some evidence was found of improvements similar to those described above, including: deepening; banking; supervised use; and also some fencing to prevent animal entry. In these ways some 'guardianship' of source was exercised by the local village. For example, the author observed the supervision of water collection, digging and banking, and the watering of animals outside a fenced *rahad* enclosure at Gangei in October 1988 (Plate 24). The fence was satisfactory and the management method seemed to work very smoothly.

Interviews revealed some variation in patterns of source-management, where it occurred. Interviewees in Hariri reported that the *sheikh* of a village appointed a man to be responsible for 'its' *rahad*[29]. His role was to stay at the *rahad* all day and to measure out, and order people (apparently both men and women) to dig an area 1x1m next to the waterline. 'Arabs' sometimes caused problems by refusing to dig as instructed, and fighting occasionally ensued. At nearby Mustafa, it was reported that different people, chosen by

Plate 24: Rahad Gangei is fenced and those who collect water must dig an area close to the water's edge to increase its capacity.

the *sheikh*, took turns at staying by the fenced *rahad* there each day, and instructed collectors (including 'Arabs') to dig an area 1x1m: women were, however, exempt from such digging.

Besides individual users digging at the time of water collection, there was reportedly some system whereby every village had a *rahad* to dig in *shita* and *seif* (although further details were not forthcoming). Accordingly, a team of men from Hariri dug at Gangei *rahad* in these seasons upon request. They only dug at this *rahad*, although they obtained water from other *rahads* besides Gangei in *kharif*.

Although the purposes and advantages of fencing and digging were understood amongst users, few *rahads* were reported to be managed in this way. The only example recorded, besides one *rahad* at Mustafa and that at Gangei, was Wad el Akhmer *rahad* (used by residents from Hariri and Mustafa). However, it was stated in Hariri that the presence or absence of fencing did not affect the decision to use a *rahad*: people went to the 'nearest' one. By contrast, none of the *rahads* used by residents of Umm Barouda were fenced or dug. This may be explained by a lesser perception of the need to improve sources in this manner, because of the greater number of *rahads* which existed within a short distance of the village. Indeed, in Umm Barouda (and Umm Qarn) there was some evidence that *rahads* were selected for use on the basis of the absence of animal pollution rather than minimising of distance. In wateryard settlements on the Nubian Series, residents rarely collected water from *rahads*: these were essentially used for animal watering and, therefore, fencing was not a major concern.

In many ways, *rahads* did provide an important communal water source: people from many villages, and 'Arabs' used their supply. However, there was some indication of territorial claims upon water as the rainy-season waned.

Large, Mechanically-Excavated Surface Stores:

These are constructed by the government to provide a long-lasting supply for people and/or animals (see Robertson, 1950; Trilsbach, 1983b; El Sammani (ed), 1985a; Muktar and Bushara, 1987)[30]. The term *hafirs* will be used in this thesis with reference to this source type only. Ninety percent of the NWC-El Obeid Surface Water Department's work reportedly concerned the construction of dykes, dams and large mechanically-constructed *hafirs*.

Hafirs are generally constructed in impervious clay, in areas underlain by Basement Complex where groundwater is difficult to find (El Sammani (ed) 1985a; Mustafa, 1982). However, they have been introduced on an 'experimental basis' in sandy soils (Muktar and Bushara, 1987). Shepherd *et al.* (1987) noted that in such areas:

> *"... no cheap and workable technology has yet been discovered." (p.184)*

Various lining techniques have been used, including: asphalt; clay; mud-lining; stone masonry; and various plastic linings or PVC membranes (Mustafa, 1982; Anon, 1985; Muktar and Bushara, 1987; UNDP, undated; NWC staff, pers. comm.[31]). Problems associated with these linings have included: inability to secure the specialised labour and equipment for asphalting; termite attack; sun-induced cracking; and leakage from joins in various light-weight plastic-linings. Future experiments are expected to test the suitability of 'duty rubber' and types of polythene-sheeting (high density, and cement-coated - UNDP) (Muktar and Bushara, 1987; UNDP, undated). The UNDP-proposed material has: a life of twenty years in the sun; can be welded in the field; and would be used with common-salt to guard against termite attack.

The existence of such an array of experimental endeavours, however, seems somewhat inconsistent with the NWC account of the success of lined *hafirs* in Kordofan Region. These have reportedly been constructed with a layer of 'insect powder', covered with a layer of black plastic, a layer of mud and finally, a layer of white plastic. There were said to be no problems with termites, or cracking in the sun, and some were said to be twenty years old (although animal hooves were mentioned as presenting a problem). However, some *hafirs* noted on lists provided by P Tucker[32] were reported to be 'not working', but further information was unavailable.

Hafirs are constructed in the shape of an inverted frustum of a rectangular pyramid, with slopes rarely steeper than 1:5, to allow machinery to leave the excavation (El Sammani (ed), 1985a; Muktar and Bushara, 1987). Recorded depths ranged from 3-9m and depended upon the thickness of the impermeable soil cover. *Hafirs* are filled with runoff, but may be classified according to the nature of the catchment. Jefferson (1952) provided the most detailed categorisation: *jebel* (close or remote); *wadi/khor* (modern - direct or extension - or ancient); *gardud*; swamp; *idd*; reverse flow; *raqaba*; and *feid*. Elsewhere, a simpler three-way classification was noted: *jebel*; *khor* and self-catchment (Robertson, 1950; Trilsbach, 1983b; El Sammani (ed), 1985a; Bland, 1981). Experiments are also planned for improving water harvesting by various treatments of catchments[33] (UNDP, undated).

Recorded capacities ranged from 3,000m^3 to 500,000m^3 (Figure 4.5)[34], and size can be designed according to socio-economic/ecological goals, with reference to the size of catchment and feeder (Robertson, 1950; Mohamed *et al.*, 1986), (although UNDP (undated) referred to sizing the catchment and the storage system for human water consumption, providing for ten litres per capita per day, and using a computer model system and rainfall data to model runoff). Robertson (1950) described how constructed capacity was decided according to the type of usage (defined as domestic or cattle) and user population size. When used for the domestic requirements of sedentary people, the required capacity was calculated upon the basis of a 'typical family' (five people, two goats, one donkey)[35] for a period of 300 days (which, together with seasonal rainfall, was deemed to furnish an all-year-round supply). Estimated consumption per family was 140 lpd. Therefore, for 100 families (one unit) for the 300 days, estimated consumption totalled 4,200m^3. To permit this consumption, the constructed capacity had to be 7,000m^3, to allow for evaporation losses. When the *hafir* was for animal watering, the water supply was to last as long as the grazing. Therefore, there had to be assessment of the grazing area, and its carrying capacity. Jefferson (1952) noted that single, smaller *hafirs* of less than 10,000m^3 capacity were often constructed for heavy usage during harvest only.

Twin *hafirs* (one larger, one smaller) have often been built for large capacities, to facilitate rectification, and reduce losses due to evaporation (by allowing water to be pumped to the smaller *hafirs* as the water level falls, thereby reducing its surface area) (El Sammani (ed), 1985a; Muktar and Bushara, 1987). Indeed, Jefferson (1952) noted that *hafirs* built for permanent settlement:

> *"... must be dug as twins so that one twin can be emptied and cleaned, or single hafirs must be doubled when maintenance time comes round." (p.235)*

Figure 4.5: Hafir Capacities from Various Sources.

Source	Range (m^3)	Area
El Sammani (ed) (1985a)	5,000 - 500,000 5,000 - 250,000	Kordofan Kordofan
Anon (1985)	5,000 - 40,000	Kordofan
McGowan and Burns (1987)	5,000 - 50,000	En Nahud/Bara
SCF (1988)	8,000 - 60,000	Umm Ruwaba
Bland (1981)	3,000 - 85,000	-
Mohamed et al. (1986)	5,000 - 25,000 5,000 - 100,000	Central Sudan Central Sudan
Muktar and Bushara (1987)	5,000 - 25,000	Sudan
Hulme (1986)	5,000 - 10,000	White Nile Province

Maintenance is normally required after 7-15 years depending upon the siltiness of the water (see below). Many *hafirs* incorporate a settling tank at the intake to reduce the sediment which enters it (El Sammani (ed), 1985a; Muktar and Bushara, 1987).

In the standard design of *hafirs*, it is intended that water should be abstracted from a masonry well, connected to the *hafirs* by a gravity-fed pipe. A few *hafirs* have water purification systems at the point of distribution. At several sites, concrete or metal troughs are provided for animal watering, and there is a perimeter fencing with access through a single gate (El Sammani (ed), 1985a; Muktar and Bushara, 1987). At newer *hafirs*, fences are constructed from thorn and/or barbed wire. Water is free of charge, and management is reportedly undertaken by one guard, with a supervisor visiting once a month (E S M Tahameed, pers. comm.[36]). However, commonly, fences are dilapidated and animals enter the water freely, and many abstraction wells are blocked or in poor repair, necessitating direct abstraction (El Sammani (ed), 1985a; Muktar and Bushara, 1987; Shepherd *et al.*, 1987).

Problems associated with all *hafir* water supplies (and those of other open surface water bodies) include: siltation; evaporation; seepage; pollution (associated with water borne diseases); turbidity; increasing saltiness through evaporation; the provision of a haven for malarial mosquitoes into the dry-season; and their limited ability to last through the dry-season (eg due to increased user population and unpredictable rainfall conditions)[37]. The poor condition of maintenance noted above further results in increased: bank erosion; water turbidity; and pollution hazards (see El Sammani (ed), 1985a; Mohamed *et al.*, 1986; Muktar and Bushara, 1987; McGowan and Burns, 1987; Shepherd *et al.*, 1987). In Kordofan, it was reported that UNICEF had stopped *hafir* construction because of guinea-worm, which was being spread increasingly northwards by nomadic people collecting water directly from *hafirs* with infected goatskins (UNICEF staff, pers. comm.[38]).

Siltation is a particular problem at all *hafirs* and dams[39]. Lack of 'rectification' has resulted in present storage capacity being only 50-60 percent of the installed capacity (El Sammani (ed), 1985a; Muktar and Bushara, 1987) and many *hafirs* are reaching the end of their 'useful life[40]. Furthermore, *hafirs* in North Kordofan are suffering problems of sand encroachment, which is blocking inlets and burying sources. A programme of rectification, including desilting, repair of inlet/outlet, and strengthening of embankments is essential. Such a programme was signed between NWC and UNICEF in 1978 to apply to 150 *hafirs* in South Kordofan (El Sammani (ed), 1985a).

Evaporation and seepage have already been discussed to some extent. Estimates of the volume of water lost annually vary between 30-40 percent (El Sammani (ed), 1985a; Muktar and Bushara, 1987), whilst other authors estimated evaporation losses alone at 40-50 percent (SCF, 1988; Hulme, 1985 - citing Lebon, 1956). By contrast, seepage has been noted to be relatively insignificant when *hafirs* are constructed in deep, heavy clay (Robertson, 1950). There have been several experimental techniques which have been documented, aimed at reducing evaporation from *hafirs*. These included: a roof supported on pillars (Doxiades Associates, undated); hollowed, ceramic flattened spheres (UNDP, undated); and a reinforced cement coated foam raft (UNDP, undated).

Hafir development was most popular in the 'Conservation Phase: 1942-56' (Chapter 1), and has been associated with various goals: opening up new agricultural land; allowing permanent settlements to become established where cultivators were previously forced to *dammer* because of lack of water in the dry-season; provision of animal watering points in grazing areas away from cultivation; and inducing cultivators to relocate from poor, overcultivated land near traditional sources (ie population redistribution) (Robertson, 1950). Geographically, they predominate in the south of Kordofan Region where their development is aided by clay soils, higher intensity rainfall, availability of high land (Nuba Mountains), and the presence of *wadis* (El Sammani, undated). However, the siting of *hafirs* in areas of over 600mm annual rainfall has been relaxed in recent years (see Hulme, 1985), and several are located in drier areas such as in Sodiri District (see Abu Kumbal, Abdalla, Abu Diek, Ubaid Ala and Abdalla, 1985; Anon, 1985).

The importance of *hafirs* in the rural water supply system has been evaluated in various ways. Despite the very real problems of poor water quality and siltation etc, there are still many benefits - they provide supplies which last throughout the dry-season or part of it; are available to animals and people generally; are excavated mostly on the Basement Complex in Kordofan, where groundwater is difficult to find (El Sammani (ed), 1985a; Mohamed *et* *al.*, 1986); and their capacity can be controlled to enable protection of a fragile environment (Mohamed *et al.*, 1986). It has been estimated that 15-20 percent of the entire population of Kordofan Region depends upon *hafirs* water for three months after the rainy season (El Sammani (ed), 1985a).

SECONDARY SURFACE WATER STORES

Cisterns:

Cisterns have not been widely discussed in the literature of water supply in the Sudan. The main, clearly discernible, references to them were made by Morton (1986); SUDANAID (1986a); McGowan and Burns (1987); and CARE (1987). It is possible that some of the features termed 'small *hafirs*' may also be classified as cisterns; in Abu Shura, the terms *hafirs* and *kazan* were both used with reference to the type of feature described here. However, information concerning 'small *hafirs*' is itself very limited, and the following discussion will focus upon the named documents and field evidence, using the terms *kazan* and cistern synonymously.

In reports, cisterns were described as stores which are usually hand-dug, and lined with: concrete blocks and mortar (McGowan and Burns, 1987); concrete (CARE, 1987); reinforced concrete; or cement and rough stone (Morton, 1986). They can also have a slow sand filtration system (McGowan and Burns, 1987). Field study affirmed this basic description, although no evidence of slow sand filters was found. However, the reports contained only one detailed account of cistern form. This is compared with, and supplemented by, field observations.

The cisterns described by Morton (1986) and observed by the author were predominantly below ground-level with a raised edge less than a metre above the ground. In the report, plan areas were described as varying from 2.5x2.5m to 6x6m, and depths from 2.5m to 4m, with 'claimed capacities' of 50-300 barrels[41]. Cisterns examined by the author were approximately square in plan, and had dimensions and reported capacities (with one exception) within the documented range (eg capacities of 40, 150 and 175 barrels).

All cisterns examined were covered with metal sheets or flattened barrels, weighted down by rocks (Plate 25), which reduced evaporation and prevented sand from being blown into them. At one *kazan* at Umm Bum, the owner had been forced to sell part of the metal covering in order to obtain money, and a 'thatch' had been constructed to replace it (Plate 26). As a result, its water supply was reportedly no longer considered by the villagers as fit for human consumption (although presumably it was better quality than that of the *rahads* which were utilised in *kharif*).

Some cisterns examined in the field had fences around them. In Abu Shura, the fencing comprised wooden uprights with a single wooden branch between them, and enclosed a relatively large area around the cistern itself. In contrast, the fences which had been built at two of the *kazans* at Umm Bum were more dense and robust, made of wood and thorn tree uprights, with a bar across the entrance. These were smaller enclosures. Animals watered outside the fences from *tashits*. Furthermore, at Khammas Halab, a *kazan* was actually built within a family's *hosh*. Other *kazans* such as those at Markib, Marahig and one at Umm Bum were not fenced at all.

Two types of function, associated with different locations, have been attributed to cisterns: as a main source where other types can not be developed; and as a back-up, in case of failure of other sources. Referring, presumably, to the first type of location, McGowan and Burns (1987) stated simply that cisterns were used:

> *"... in areas where water is not available locally, or available only on a seasonal basis." (p.33)*

CARE (1987) noted more comprehensively that:

> *"Private cisterns... are especially important in areas where wateryards, open wells, and hafirs are not geologically or environmentally feasible. These areas exist to the west of En Nahud town and to the north of Gubeish. Such facilities also serve as back-up reserves for the times when other systems break down or dry up... In some areas, those having sandy soils and underlain by the basement complex, this system is the major source of water during the dry season." (p.20)*

Field study confirmed the above statements. Firstly, cisterns were found in settlements remote from wateryards etc, where sandy soils were underlain by Basement Complex and alternative supplies were available only seasonally (eg cisterns at Treya, Umm Bum, Umm Zummam, Abu Rakhei, Sherati and Gangei and Hariri). Secondly, they were observed in

Plate 25: The cistern at Abu Shura with a metal cover weighted with stones and in a fenced enclosure.

Plate 26: Part of the metal covering at the cistern at Umm Bum was sold and a thatch one constructed in its place. As a consequence the water was considered unfit for human consumption.

wateryard settlements, where they were constructed to provide a safeguard against breakdown (eg those at Markib, Khammas Halab and Marahig).

Three types of 'ownership or use' arrangements were identified in the reports: public storage for public use (McGowan and Burns, 1987); private domestic storage at homes (McGowan and Burns, 1987); and storage by water vendors for both private use and commercial sale (Morton, 1986; McGowan and Burns, 1987; CARE, 1987) at a high price (CARE, 1987). CARE (1987) noted that in most villages in Kordofan, merchants and money-lenders had constructed such cisterns. Furthermore, cisterns examined by Morton (1986) were owned by merchants resident in, and ethnically part of, the villages in which they were located.

No cases of public ownership of cisterns were discovered in the field, but both types of private ownership and use arrangements were found. The ownership and intended usership varied between the two types of location. In wateryard settlements, cisterns were constructed for the private use of the owner's family (and often their many animals - a capital investment). Although they were all used in some measure by other people when the local wateryard broke-down, their primary role was not commercial. By contrast, in settlements remote from perennial sources, cisterns were generally commercial ventures (although the owner in Abu Shura had not yet been able to fill the *kazan* properly); only in Hariri was there reported to be a small, non-commercial private *kazan*. Cistern-owners included: a local merchant at Markib who owned many animals and a lorry; a migrant labourer working in the Gulf, leaving his family in Abu Shura; and a *caro* owner in Khammas Halab.

The establishment of communal or community-owned cisterns[42] was recommended by Morton (1986), and in the CARE report (1987) for villages where the construction of wateryards and open-wells was not feasible. However, CARE's attempt to build a public cistern[43] owned by a co-operative in a rural area, at Al Hareg[44], was unsuccessful and suffered two main problems (H S Gebrelassie, pers.comm.[45]). Firstly, water had to be trucked-in by either government or merchant lorries. Therefore, even if the co-operative were adequately organised and money was collected, lack of fuel, and spares and breakdown etc meant that there could be no guarantee that a lorry would be available when required. Secondly, the people were already using a private cistern and relied upon the relatively rich cistern owners for loans, and so would not set up against them. The idea of cistern development had been prompted by the unsuccessful construction of open wells. Time and money had been expended in digging and blasting (NWC 1983-88). However, the idea of cistern development was rejected in the talking stage. Therefore, any plans for such developments merit careful socio-economic as well as logistical investigations. (For a description of the pre-construction investigation required see SUDANAID, 1986a: p.55).

According to the reports, cisterns are filled with water from a distant source, transported to them by lorries (Morton, 1986; McGowan and Burns, 1987; CARE, 1987), and donkeys (McGowan and Burns, 1987). Some merchants (water vendors) owned lorries themselves, others had to purchase water from lorries (Morton, 1986; McGowan and Burns, 1987; CARE, 1987).

In the study area, cisterns were filled with water which was variously: transported by lorries and *caros*; scooped by hand from the surrounding area after heavy rain; and pumped along a channel, from a nearby *rahad*. The mode of filling was seen to vary with cistern-location and the season. In *kharif*, cisterns in locations both with and without a local wateryard were filled from contemporary rainfall. Commonly this was quickly collected after showers from the surrounding area. However, in Khammas Halab, water was channelled off a tin roof into the *kazan* which was situated within the owner's *hosh* (Plates 27 and 28). Also, one of the three *kazans* at Umm Bum had, in past years, been filled with water from a nearby *rahad*: a channel had been dug from the *rahad* to the cistern and a pump had been borrowed from a neighbouring village to assist in the transference of water. By contrast, in *shita* and *seif*, cisterns located in wateryard settlements were filled with water from the wateryards, transported by *caros* belonging to the *kazan* owners. Cisterns in areas more remote from wateryards received water transported by lorries - in no case was it reported that the *kazan* owner owned such vehicles.

Morton (1986) noted that cisterns had been constructed at various times, the earliest recorded in that study being in 1966. In the current study area, where construction dates were discussed, it was found that only Iyal Bakheit cistern was developed before the Very

Plate 27: Water collected from the metal roof of a permanent dwelling in Khammas Halab is channelled into a covered cistern within the compound.

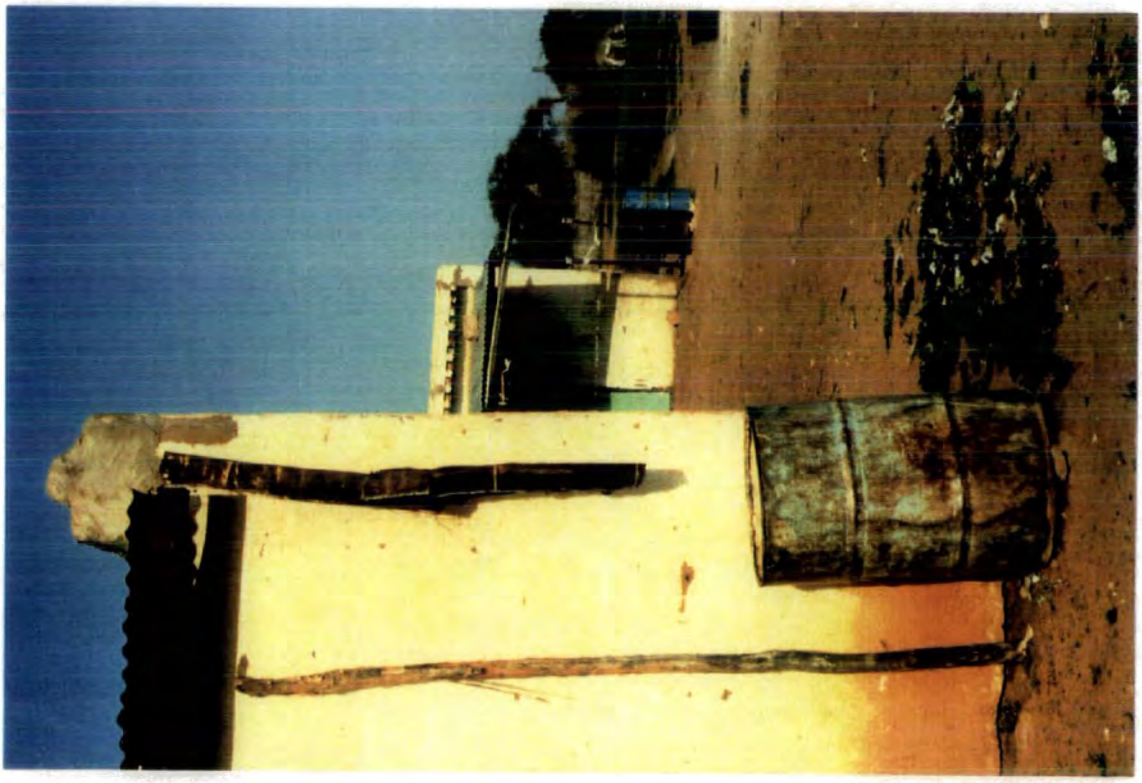

Plate 28: A sabaloka at the suq at Khammas Halab allows collection of rainwater from one of the relatively few metal roofs: a smaller-scale cistern.

Dry Year. Others were constructed in or after that year: Markib (1984); Khammas Halab (1985); Treya (1985); Abu Shura (1986/87); and Abu Rakhei (1987).

Problems associated with cisterns include: the cost of construction; the availability and price of water to fill them (especially in *seif* and *shita* when delivered by lorry); the related problem of cement cracking when cisterns are not filled for either reason (mentioned in one interview[46]); and the high price charged by vendors to consumers (see Chapter 5). In Morton (1986) a quotation of LS5,000 was reported for materials and labour for the construction of a large cistern. In field-study, however, the amount of cement, its cost, and the price of the metal covering, was unclear. In Mustafa, it was estimated that a cistern 4x4x4/5m would require 90 sacks of cement, at LS90-100 each from En Nahud, or LS80 each from El Obeid (ie a total cement cost of LS8,100/9,000 or LS7,200 respectively). However, some confusion occurs in these figures because the total cost, including a zinc cover, was quoted as "up to LS6,000". In a second interview, a total figure of LS13,000 was reported, and the price of a sack of cement was said to vary markedly when purchased from a merchant as opposed to En Nahud Council. Furthermore, in El Obeid, it was reported that the official price of a sack of cement was LS40 and the blackmarket price LS120. All such estimates may be expected to be distorted by the effects of inflation, but the important conclusion is that, in general terms, they are expensive to build and only individuals with substantial financial resources can afford them.

Despite the problems, the number of cisterns in the rural areas is likely to increase. Their importance as an interim source was very evident, especially when: wateryards broke-down; people stayed at home to work on the land (in *hashab*); containers were sent to a distant source to be filled and were returned late; the preferred source of water was a lorry and this did not arrive (cistern water was either used until a lorry came or for the family whilst the collector travelled to a source more than one days journey by carriage animal); people *dammered* to watermelons and no alternative accessible additional supplies existed; or people returned from *dammering* before *rahads* were full.

In concluding this section, it is of some value to note that during the Land and Water Use Survey of Kordofan undertaken in the 1960s, which focussed on the *qoz* lands of the north-central area, the 'catchment tank', was developed. It had a variable capacity of

5,000-200,0001 (25-1000 barrels capacity), and was to store rainwater on the spot. Prototypes were tested at a site at El Obeid and at two or three villages in the district (including Abu Kereis). In 1982, two of those constructed at the El Obeid site were still collecting water, and in 1985 the tanks at El Obeid and Abu Kereis village were still largely intact (Stern, 1985). Stern (1985) quoted El Sammani as writing:

> *"The project covered almost the core of that part severely affected by [the drought] at present in Kordofan. The project's findings were killed because of professional jealousies at the time. Its recommended plan of action still provides sound solutions in many respects." (p.13).*

There was no mention of the materials used, or the way in which water was harvested, but the most obvious differences from the cisterns described above were the larger maximum capacity and the source of water stored. Since these tests were made, lorry transportation has increased, and now enables water supplies to be taken to and stored in areas remote from the primary supply in the dry-seasons.

Evaporation-losses and water pollution at *rahads* could be reduced if the water which collected in them were transferred into a covered cistern. In Abu Raziq, it was said that water lasted about three months in the *rahad*, but that it could last nine months if the government built storage facilities. (The only example of this occurring in the field was at one cistern in Umm Bum).

Tebeldis:

The role of *tebeldis* in the rural water supply system generally receives cursory attention in the literature. This appears to be because of the trees' relatively limited storage potential, geographical zoning, and the fact that they are reported to be becoming less numerous, and outmoded as water stores. From documented information and fieldwork, the following comments can be made.

They generally grow in sandy soil in the semi-arid zone of Sudan between Latitudes 11° and 14° North, especially in Western Kordofan - Dar Hamar (Blunt, 1923; Muktar and Bushara, 1987)[47]. El Sammani (undated) noted more specifically that they occur mainly in the north-central parts of Dar Hamar, which embraces the author's field study area. However, Khogali and El Sammani (1986) noted that:

"... parts of the [En Nahud / Dar Hamar] district have few or no Tebeldi trees." (p.168)

Tebeldis have reputedly been used to store water since the Nineteenth Century (Blunt, 1923; Parr, 1924; El Sammani, undated). Blunt (1923) noted that about one third of the *tebeldis* in use at that time were hollowed in or during the Turkiya, when the Hamar were more nomadic. Parr (1924), however, stated that only since the 1880s were they used for water storage, and that:

> *"So long as the Hamar were nomadic it is probable that they did not take even an academic interest in the tebeldi ... as the Messeria do still [in 1920s]." (p.119)*

Information collected by Ahmed (1988), and examined in Chapter 3, provided a more comprehensive view. The Hamar were still nomadic at that time, but had recognised the commercial value of gum arabic. Consequently, they encouraged workers from other parts of the region to the area to tap and market it, and villages of sedentary cultivators sprang up. This was made possible by the hollowing of *tebeldis* and cultivation of watermelons.

Although Blunt (1923) asserted that *tebeldis* were naturally hollow, the weight of evidence supports manual hollowing (eg Newbold, 1924b; Parr, 1924; World Water, Non 1979; Mohamed *et al.*, 1986; Muktar and Bushara, 1987; El Sammani, undated). For example, Parr (1924) noted that:

> *"... in Western Kordofan the inhabitants were unanimous that tebeldis had to be hollowed by themselves, and that it took about three weeks satisfactorily to hollow a normal tree. This proves that the core is soft, but I think disproves the idea that it becomes hollow naturally." (p.118)*

Newbold (1924b) similarly described man's work as finishing off what nature had begun: extracting the soft core and paring the inside walls. The central part of the tree trunk (3-5m diameter) is removed manually; an artificial pond created around the base to collect rainwater, using clays; and the hollowed trunk is filled annually from an opening near the top, which is then closed to reduce evaporation and surface contamination (Muktar and Bushara, 1987)[48].

Broadly the same practice was described in the study area, but some reported and observed differences from, and additions to, documented information can usefully be noted. In Khammas Hajar it was reported that when trees were initially hollowed, one metre of trunk was left unhollowed at the base of the cylinder, and this was then lined with grass to prevent seepage. Annual preparatory work was also mentioned here: in July men dig round the tree and (reportedly) remove branches. The water stored in *tebeldis* was most commonly reported to be rainwater taken from the basal pool (Plate 29), as noted in Muktar and Bushara (1987); it was said to take three to four hours to fill a 200jc-capacity *tebeldi* from this pool by *dalu*. In Mustafa, however, water was reportedly derived from both basal pools and *rahads*. Furthermore, good trees had even been filled with lorry-delivered water in the dry-seasons of the Very Dry Year, when there were watermelons, and families remained in their village. In Khammas Hajar, *tebeldis* were reportedly filled at the beginning of *kharif* when rains filled the basal pool. In Hariri, however, it was noted that the trees were repeatedly filled when new rains fell, and there was scope for topping-up. The recorded storage capacities are listed in Figure 4.6[49].

Blunt (1923) mentioned the destruction of *tebeldis* during the Mahdiya when western tribes successively overran Dar Hamar and pierced the trunks. In the study area, some *tebeldis* were reported to be 'bad' and/or have holes in them. The cause of holes was not discussed in field interview. In Mustafa and Hariri, it was said that holes were bunged and a reduced volume stored in the tree and used for watering animals only. This implies that the quality of the water stored is diminished. Some people believed that *tebeldis* (without holes) purify the water stored within them. Indeed, Hall and Ismail (1981) noted that the water remains "sweet and drinkable" (p.134). However, Baxter (1981) reported that water stored in *tebeldis* "may be polluted by bird and bat droppings" (p.5) and in three interviews conducted in Markib the water from *tebeldi* stores was variously said to be dirty and to have insects in it (as observed in the field). In this settlement there was a wateryard providing a readily accessible local perennial and popular water supply, and there had been some extension work carried out with women as part of the CARE IWP.

In published sources there are some comments about the ownership of *tebeldis*. Penn (1927) stated that:

> *"1. Original rights in tebeldis were obtained by first seizure and claim to a definite area, including the trees. The boundaries of the claim were marked out and a second arrival had to mark trees outside this area.*
>
> *2. The original founder of each claim in course of time started a village within its boundaries. As others came to settle with him he would grant them a certain number of tebeldis to hollow." (p.73)*

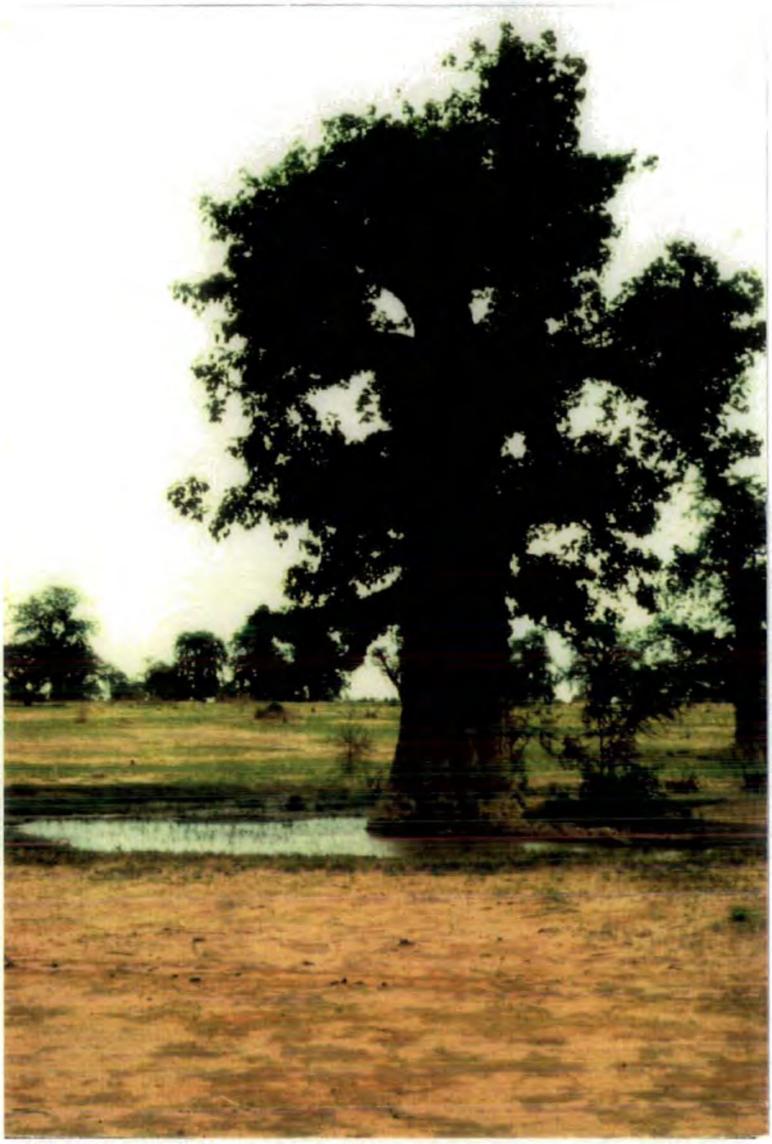

Plate 29: Water from basal pools provides the most common supply stored in tebeldis.

Figure 4.6 Comparative Capacities of Tebeldis.

Source	Comment	Litres	Barrels	Jerricans
World Water (1979)	average tree may store...	5,455	30	
Grabham (1934) cited by Hulme (1985)	in some cases holds... more commonly holds...	9,000 1-2,000	50 6-11	
Blunt (1923)	estimated input...	1,114	6	
Interview: Kh. Hajar	case: tree holds...	3,600	20	200
Interview: Hariri	case: tree holds...	1,800	10	100
Interview: Hariri	case: tree holds...	900	5	50
Interview: Mustafa	case: tree holds...	1,800 - 2,700	10-15	
Interview: Umm Samra	case: tree holds...	1,800 - 2,700	10-15	
Interview: Umm Samra	case: tree holds...	1,080	6	60

Blunt (1923) noted the role of *tebeldis* in boundary disputes at various scales, and this seems in keeping with Penn's statement. However, although concurring with the *sheikh's* role in allotting *tebeldis* to be hollowed, Pumphrey (1933) seemed to describe ownership of *tebeldis* transcending village domains by stating that:

> *"...it is of no significance that it [a tebeldi] may be within the seraiya [cultivated area] of another village." (p.79)*

Consequently, he stated that the ownership of *tebeldis* need not be considered in delimiting a boundary (Pumphrey, 1933). This conflict may possibly be explained by reference to the process of village reproduction: the establishment of *arits* around parent villages, which later assume the status of independent villages (Pumphrey, 1933).

All *tebeldis* were said to remain in the possession of the *sheikh*[50] until they were hollowed, after which they became the property of the hollower and his descendants, and could not be reclaimed by the *sheikh* (Pumphrey, 1933; Penn, 1927). However, Penn (1927) added that:

> *"6. Should a member transfer to another village he gives up all claim to the tebeldis which he previously owned. He cannot sell or dispose of them, except to one of his family, and they fall into the hands of the sheikh. He can sell the water contained in his tebeldi." (p.73)*

Pumphrey (1933) also noted that absence from the village for an extended period (usually four or more years) extinguished rights of ownership. Additionally, it was stated by Penn (1927) that when all possible *tebeldis* within the village boundary had been hollowed and new people continued to come into the village, the *sheikh* called a village council and "by common agreement", made provision:

> *"... out of the hollowed and owned tebeldis for these newcomers. Once given away, the tebeldi becomes the property of the donee." (p.73)*

In the study settlements, ownership was clearly defined. *Tebeldis* had been allocated by the *sheikh* and people inherited ownership from their grandfathers. It was, however, widely observed that "one cannot find a *tebeldi* now to own" and that "every *tebeldi* belongs to someone", and in most settlements not all residents owned *tebeldis*.

No documentary information was discovered concerning the availability of water stored in them for non-owners. In the study area, the entitlement of people to use water from *tebeldis* which they did not own varied greatly. In some settlements all villagers were (reportedly) allowed to share *tebeldi* supplies freely (although in Abu Shura, for example, where there were two *tebeldis*, those interviewees who did not own one did not report using this supply). In others, owners: shared the use of *tebeldis* with the families of certain close relatives only; kept the supply exclusively for their own use; or permitted non-owners to use the water only when in extreme need, when it was given free of charge. There were also some reports of owners selling water either by jerrican or, in one case, by the tree-full.

The type of use made of this source by owners and non-owners can be related to: the availability and cost of alternative water supplies; the number of trees in good condition and filled; and season of use etc. For example, in wateryard settlements ownership and use of *tebeldis* were not highly prized. Very few owners actually filled or used these stores at all because of the availability of a perennial supply of financially cheap, good quality water at the local wateryards, for less time and effort costs (Chapter 5). Even when these wateryards broke-down alternative sources were often preferred. Some families, however, kept some water in their *tebeldis* for emergency use. Elsewhere, all those who owned *tebeldis* used them for water storage (in one of the ways noted below), and those without supplies (due to lack of ownership or user-rights or supply exhaustion etc) sometimes purchased *tebeldi* water in the dry-seasons/*rusharsh* when cheaper alternatives were inaccessible.

Supplies of water from *tebeldi* stores have been documented as being rationed during 'the summer' (ie *seif*) for drinking, and often supplemented by watermelons during harvest-time (Muktar and Bushara, 1987). El Sammani (undated), however, noted that *tebeldi* supplies were traditionally augmented by the watermelon crop, grown over wide areas to supply some of the animals' water requirements. This practice of rationing was reported in the field - although where access to water was difficult, water obtained from any source was rationed in some measure. Furthermore, when watermelons were available they were used by animals and people to supplement *tebeldi* and other sources of water.

Different families reported using the limited volume of water stored in *tebeldis* at different times of the year. Six distinct strategies of usage, related to different times, could be identified.

(i) Use of own supplies in *kharif* as a local alternative to more distant, less accessible *rahad* supplies. The two families of the *sheikh* of Hariri used water stored in a *tebeldi* near their *hoshes* in this way. When this water supply finished the families *dammered* to perennial wells. If the watermelon crop was good, the supply stored in the *tebeldi* could be supplemented, and last into *shita*. This type of use was not encountered elsewhere.

(ii) Use of own supplies in *kharif* as a financially-free alternative to more local wateryard supplies. Only one of the interviewee families living in a wateryard settlement used *tebeldis* as part of the normal water supply strategy, and this was in *kharif*.

(iii) Use of owned or shared supplies after accessible and free surface and sub-surface water sources are exhausted. Normally this occurred before *dammering*, or the purchase of water at a high financial or time-effort cost. In some cases, use began in late *kharif/darat*, sometimes extending into *shita*; in others, it began in *shita* itself, and even extended into *seif* sometimes; in still others, it occurred in *seif* itself.

(iv) Use of owned, shared or purchased supplies from *tebeldis* at the end of *seif/rusharsh*, after returning from *dammering* locations to prepare and plant the land for the next crop. Sometimes families saved water deliberately for this, having *dammered* after local surface and sub-surface supplies had been exhausted. Other families purchased or used relatives' supplies at this time.

(v) Use of owned, shared or purchased supplies as a temporary alternative to wateryard supplies when these are interrupted by mechanical break-down. This strategy was discovered in Umm Samra, although alternative sources, such as Abu Dulduc wells, were generally more popular. Of those interviewee families living in wateryard settlements, only two out of 45 (all of whom experienced some period(s) of break-down of the local wateryard) used *tebeldis* in the event of wateryard break-down in the year 1987/88. The rest mainly purchased from *caros* or collected from neighbouring wateryards (about thirty minutes distant by donkey).

(vi) Use of purchased supplies to supplement watermelon supplies at a *dammering* location. On one occasion, it was discovered that a family purchased water from *tebeldis* over an extended period of time in *shita* whilst *dammering* at Abu Khazm. The family *dammered* to watermelons after shared *tebeldi* supplies in their home-settlement ran out, since they had no watermelons or money to sustain residence. At Abu Khazm, they purchased water from commercially-operated *tebeldis* to supplement watermelon supplies because it was cheaper than the only other alternative supplementary source - cisterns. Most other families which *dammered* either went to water-centres (permanent/deep wells or wateryards) where water was cheap and local, or to watermelon areas, collecting supplementary supplies from a wateryard or permanent/deep wells.

The importance of *tebeldis* for water supply in past times has been clearly described. Blunt (1923) noted that *tebeldis* formed the chief water supply for the inhabitants of western Kordofan. He stated that:

> *"It is no exaggeration to say that the siting of 90% of the Hamar villages in western Kordofan must have originally been determined by the location of the Tebeldi." (p.116)*

Indeed, in the past whole villages were reputed to have been completely dependent upon the water supply provided by *tebeldis*. Umm Chawo in Shallota *omodia* was noted to be of this number: in June 1921, the village was said to be deserted because of the lateness of *kharif* and empty *tebeldis* (Blunt, 1923). Pumphrey (1933) furthermore noted the prerequisite of water and cultivable land for a village to exist in Dar Hamar, and reported the co-incidence of *tebeldi* water supplies and cultivable land. El Sammani (undated), however, noted that:

> *"Initially this source was not adequate in meeting the population needs for the whole of the dry period. The source was augmented by the watermelon crop ... Many of the villages practised migrations during the dry season to centres of abundant supply." (p.60)*

Nowadays, the potential of *tebeldis* in the rural water supply system is considered limited. Mohamed *et al.* (1986) stated that this was due to increasing population and the decreasing number of *tebeldis* (attributed here to over-use and desertification: see Chapter 3 for alternative explanations); the great labour requirement for storage; the likelihood of water contamination; the insufficiency of the volume of stored water ("barely enough to support the extended family" (!)); disputes concerning tree ownership; and the preference for new sources of water such as boreholes and hafirs. The overall conclusion reached by Mohamed *et al.* (1986) was that they now provide no practical solution to domestic water supply problems.

The inability of *tebeldi* stores to satisfy local communities' dry-season water requirements - or even those of individual families - was certainly apparent in the study area: families used other sources in addition to *tebeldis* in the dry-seasons. There was ample testimony to the difficulties and dangers associated with cleaning, filling and abstracting water from the trees. Most especially these problems were described in wateryard settlements where *tebeldis* had been widely neglected after the installation of a local wateryard. Before the local wateryards were opened, *tebeldis* had been an important water source, because of the need for water. This same need prompts their usage in other settlements currently lacking a perennial supply. It is suggested here that they should not be ignored as water sources, but rather recognised for the important role which they have been shown to fulfil in such settlements. For example, all interviewees in Umm Barouda and twelve out of the fourteen in Umm Samra had used *tebeldis*' supplies at some time in the year 1987/88.

Watermelons:

The use of watermelons as a water source has been associated with the rural population of western Sudan (Mohamed *et al.*, 1986), central Kordofan and Darfur (Muktar and Bushara, 1987) and, in a study of Umm Ruwaba District, with areas of severe water shortages within that district (SCF, 1988).

Various uses of watermelons have been noted. Firstly, they provide a valuable means of storing water (Hamdouk *et al.*, 1985; Hulme, 1985; SUDANAID, 1986a); even before the drought (1984), watermelons were stored in many outlying villages as:

> *"... an invaluable 'on-site' water source for farmers in the dry season." (SUDANAID, 1986a: p.9)*

Secondly, they provide a source of water and food (pulp) for people, and a source of animal fodder (husks) with a high water content (eg Tothill, 1948; SUDANAID, 1986a). Thirdly they provide a source of income: seeds are sold as an oilseed cash crop and many are exported to other Middle Eastern countries (Tothill, 1948; SUDANAID, 1986a); watermelons themselves are also sold for fruit near major settlements (Tothill, 1948; M

Musa, pers. comm.[50 51]). Additionally, the seeds are cooked and salted as an appetiser and, in times of famine, ground into flour (Tothill, 1948).

In the study area in 1987/88 watermelons were cultivated by almost every family interviewed, and used for both animal and human consumption and, to some extent, as a cash crop (through the sale of areas of watermelon to *dammerers*, and the sale of seed). The way in which the crop was used, however, was noted to vary between settlements. In settlements on the Basement Complex (including Wakeel - with perennial wells), water and pulp were used by people for: eating; drinking; and in cooking (for making *aseeda*, *kisra*, *mulhaa*, and sometimes coffee). Seeds were eaten, sometimes sold and, in one case, were mixed with *mayker*, ground, and used by the family in the manner described by Tothill (1948) for famine conditions. Meanwhile, animals ate the husks and/or "the insides". In settlements with local wateryards it was generally noted that watermelons were used by both animals and people, for eating and drinking. The seeds were also used (sold if many, or eaten). Watermelons were, however, rarely used in cooking. In both locations the water supplied by watermelons was apparently supplemented for people by other sources of water, either collected locally or from a distant source. These additional supplies included *tebeldis*, but also cisterns and wateryards.

The season(s) in which watermelons are used are variously documented. Some sources noted that they are used at harvest time, when they provide harvesters with their sole water supply (SUDANAID, 1986a; Mohamed *et al.*, 1986), or that they are used to supplement water stored in *tebeldis* (El Sammani, 1982; Muktar and Bushara, 1987). Other sources noted that watermelons are used for several months or part of the dry-season, after other sources have dried up (Tothill, 1948; Mohamed *et al.*, 1986; SCF, 1988), by animals (Tothill, 1948) and people (Mohamed *et al.*, 1986; SUDANAID, 1986a). The role of watermelons in extending the period of annual residency in areas of severe water shortage was clearly noted in SCF (1988), where it was reported that the majority of villagers had to leave their homes for 'the summer' (ie *seif*) after the supply of watermelons was exhausted. Mohamed *et al.* (1986) also commented that their provision of both food and water makes them a preferred option when natural sources dry out during the end of the wet-season.

In the field, the success or failure of a family's watermelon crop reportedly impacted upon: family location; water collection from other sources; and water-hardship. The impact was greatest upon the residents of villages lacking perennial water sources. This was unsurprising given the greater range of uses made of watermelons, and the lack of alternative local supplies.

On the Basement Complex, in settlements lacking local perennial water supplies, when the watermelon crop belonging to a family or its close relatives was good, interviewees reportedly used this source throughout *darat* and often into *shita*, and sometimes even into *seif* (supplemented by limited volumes from other sources). When this crop was located on *qoz*, some distance from their village, families relocated (*dammered*) to this site. When this crop was poor or failed, *dammering* was the most common response, with preferred destinations generally those with watermelons rather than a conventional water source, because watermelons provided animals (and people) with a source of water and food which made them fat (cf Mohamed *et al.*, 1986). Those who did not *dammer* to watermelons included female-headed households (because women could not collect watermelons[52]).

By contrast, in villages with local perennial water supplies, no families *dammered* when watermelon crops were poor or failed. There was also generally limited effect upon the volume of water used by families, especially in Markib and Wakeel. In Khammas Hajar and Khammas Halab however, half the interviewees reported that failure of the crop increased problems for their families; these were essentially related to animal watering and the need to take water to the farmland. (Only one case of water-economisation was noted and this involved the only family in Markib which reported cooking with watermelon supplies).

Mohamed *et al.* (1986) stated that a special type of watermelon was cultivated and stored for drinking in the 'critical months of water shortage'. Muktar and Bushara (1987) also discussed the type of watermelon, describing it as small, with a high water content, and able to be stored for a long time. This description accords with that supplied by WSARP (El Obeid) for local[53], as opposed to imported, varieties. They are smaller and rounder, less sweet, but more adapted to harsh environmental conditions. The white local varieties were said to be grown mainly for water production and seed and used by animals and man. In

1988, the watermelon crop had failed in all study villages, therefore, observation was restricted to markets outside the study area and one garden in Marahig.

The planting practice described in SUDANAID (1986a) and Coughenour *et al.* (1985) was intercropping. However, El Sammani (undated) noted that watermelons were grown over wide areas. This seemingly accords with a note by Pumphrey (1933) that only watermelons can be grown on the *qoz*-proper[54] (see too Tothill, 1948). Interviewees from various authorities in El Obeid and En Nahud (WSARP, CARE, and the Ministry of Agriculture) described intercropping, although it was reported that some watermelons were planted with field crops for family usage during harvest, and others planted in separate areas for market sale (M Musa, pers. comm.). In village interviews, two types of planting practice were also described: annual planting with a field crop; and biannual planting over large areas in the *qoz* (for family use and possibly sale to *dammerers*). There was no awareness of the latter practice among interviewees in WSARP, CARE, or the Ministry of Agriculture[55]. Accounts of each will be made below.

Much information concerning annual intercropping was provided in an interview with O A Osman[56]. It was noted that watermelons are normally planted at the end of the rainy-season to utilise the late rains. They are grown among the rows of other (field) crops at a time when these are approaching maturity and there are still rains expected (this was also noted by M Musa, pers. comm.). Although this time is not optimal for the watermelons, it is chosen to avoid competition with field crops' needs (eg weeding) in the early stages of the rainy-season. Watermelons are more hardy than field crops. Once they have germinated, and the shoots emerge at the surface, the roots go down more than two metres. In this way they can make use of the moisture at lower levels of the soil. Two to three reasonable showers will produce foliage and seed development and there will be a reasonable yield (unlike field crops). Such a crop acts as a buffer in case of field crop failure, but farmers concentrate on field crops and do not look for maximum yields from watermelons. This is reflected in the priority of planting. In the study area, however, there was some mention of watermelons being planted in the same hole as *aesh* to provide a water supply at harvest. This accords with the findings of Trilsbach (1986), who noted that this was because they grew horizontally rather than vertically.

The two-yearly planting of watermelons described in the study area involved burning the grass from the previous year when it was long, dead and flattened by the rain, together the new emergent grass. In this way a large area could be planted. The area could not be replanted in consecutive years because there would be no old grass to burn, and it would require an impossible amount of time and effort to clear a large area by hand for this purpose. This description accords well with the *harig* method of cultivation described by Tothill (1948) and Jefferson (1949) (although the former noted that it requires rich clay plains, and the latter, that the northern limit was defined by the 450mm isohyet). Evidence suggests that individual families planted in this manner every two years, rather than each year in different locations.

The importance of watermelons in the rural water supply system has been documented both as 'diminishing' and 'increasing'. The demise was attributed to drought conditions, and farmers choosing to cultivate other types of watermelons that earn more money (Muktar and Bushara, 1987). Several imported varieties of watermelons, such as Sugar Baby, Congo, and Black Diamond, were mentioned in interview with the O A Osman. These are table melons which are red, bigger and sweeter. Although less well adapted to harsh climatic conditions, in tests conducted by the WSARP (El Obeid) centre these varieties yield better returns than traditional varieties under conditions of good rainfall when planted at the beginning of the rainy-season (although their seeds are less in demand because they are black/brown). However, Hamdouk *et al.* (1985) and Hulme (1985) mentioned the importance of watermelons as a reserve of water in times of drought, and SUDANAID (1986a) noted that, in outlying villages, a common response to the loss of donkeys due to the drought has been an increased reliance upon watermelons as a "crucial water source" (p.56). Furthermore, the report noted their ecological and economic prioritisation by farmers, credited by relatively small reductions in areas of watermelon cultivation in relation to the other major crops. Certainly in study settlements lacking local perennial water supply the contribution of watermelons to the annual water supply was very important for both people and animals.

Mobile Sources: Caros and Lorries:

All sources discussed hitherto have had fixed locations. However, it is important to consider sources which have some degree of mobility, notably *caros*, which tend to have a restricted range of movement, and water lorries which can travel relatively long distances, sometimes covering large parts of a rural council area. *Caros* are privately owned horse-drawn carts, on which one or occasionally two barrels are tied. In the study settlements they were manned by men or youths, either from the owner-family, or hired labour. The barrels, together with perhaps two jerricans, were filled with water from wateryards and deliveries made all year round within wateryard settlements and their local environs. Therefore, whilst they formed part of the water distribution system of wateryards, *caros* are discussed separately here because they effectively provided a water-point at-*hosh*. Furthermore, they were not dependent upon the availability of water at local wateryards; when these broke-down, they could obtain water from alternative sources in neighbouring settlements.

Water lorries include both purpose designed tankers, which are directed by the government (RC and MADP) and merchant lorries, filled with barrels. RC lorries were operated as a service rather than as a commercial venture, with charges rarely covering more than immediate costs. This caused some problems for funding repairs. Those lorries concerned specifically with the water supply 'development project' (MADP), however, apparently had some provision for repair work included in the price charged to consumers (Chapter 1). Merchant lorries were privately owned and manned by hired staff. They were commercial enterprises and therefore the price charged per unit of water was higher. They also had more flexible uses, for example, merchant lorries visiting Abu Shura brought water, and took away crops to market. Both types of lorry collected water from wateryards, and delivered in *shita* and *seif* to villages which had water supply problems. Maintenance was performed in *kharif*, when surface water was available to these villagers.

The patterns and costs of delivery by *caros* and lorries are discussed in greater detail in Chapters 5 and 6.

PROBLEMS AFFECTING WATER AVAILABILITY

In this chapter, a wide range of water sources have been considered in terms of their: site and situation; structure; ownership and usership relations; and role in the rural water supply system. There has been some mention also of more dynamic controls upon actual availability of water at a source, such as rainfall variability affecting aquifer recharge, and user-preference for newer sources. These and other broad dynamic influences will be explored further in this section.

Physical Problems:

Annual Rainfall Variability:

Kharif rainfall in semi-arid Sudan is characterised by relatively few high intensity rainfalls and extreme localisation of precipitation events (Chapter 3). This is associated with a variable pattern of supply at surface water stores and channels (natural and artificial), with some remaining dry for all or part of their period of potential supply. In the study area, it was commonly reported that the range of *rahads* used by residents of a village contained water at different times throughout the *kharif* of 1988. In 1987, however, there were several examples of the *khors*, *rahads*, and the basal pools of *tebeldis* receiving no rainfall input.

Aquifer recharge is also affected by the characteristics of annual rainfall. Those wells tapping perched aquifers are especially susceptible (see Chapter 3). However, the wells at En Nahud and Wakeel, which provide perennial supply, suffered reduced supply in the Very Dry Year, and in years of poor rainfall following it. At En Nahud, 1987 was again highlighted as a year of poor *kharif* rainfall, and consequently of difficulty in obtaining water at the wells in *seif*.

The success of watermelon crops and field crops are also affected by the local distribution of rainfall (O A Osman, pers. comm.). The former were said to produce reasonable yields in even poor environmental conditions, whereas the latter suffer greatly from lack of or late rainfall. Therefore, the watermelon harvest acts as a buffer, and watermelons are sold when field crop yields are poor. This has repercussions for the available water supply *in situ*. In

1987, many watermelons appeared in El Obeid market. M Musa (pers. comm.) suggested that this could have been either because the watermelon crop had been very good that year, or because other crops had produced poor yields. If the latter were true, this would have been particularly worrying as it would have indicated both a food shortage, and a water shortage from watermelon-sources.

Pests:

In the study area, pests were noted to destroy or reduce the yield of watermelon crops. Interviewees in all study settlements reported the failure of the September/October 1988 crop. Furthermore, respondents in Hariri, Mustafa and Umm Barouda also reported the failure of the 1987 crop. This was almost universally attributed to a beetle known locally as '*Umm Bagga*', and to a lesser extent to another known as '*Humeiri*' (as well as to locusts, and '*Umm Hashera*'). O A Osman (pers.comm.) reported that bugs and beetles cause serious problems for watermelon crops. Bugs were said to suck the juice from the stem, branches and fruit, and beetles, to make shot holes in the foliage, which stop the flow of nutrients so that the foliage dries and the fruits shed prematurely. Plants which survive usually only produce very small fruit, and the beetle can attack at any stage in the plants' development.

Failure of the watermelon crop, (whether due to rainfall deficiency or pest attack), or its spatial redistribution through increased marketing in response to field-crop failure, may be assumed to have implications for water stress and family finances (with loss of revenue from sale of the seed and fruit *in situ*, and/or additional expenditure due to increased purchased-water requirements), as well as for the following cultivation cycle (because of depletion of the seed-stock etc).

Climatic Conditions:

Although there is some debate about the permanency of recent climatic changes, there is no doubt that the last two decades have been substantially drier than the previous two (Chapter 3). Some dead *tebeldis* were seen near Udeid and Umm Qarn in the north of the study area, where these trees were commonly used as a water source. *Tebeldis* were also said to have once existed around Wakeel, although none remain. One explanation postulated invokes long-term climatic change (Blunt, 1923), although this pre-dates the current period of change and was based on qualitative rather than quantitative methods of analysis.

Socio-Economic Problems:

A number of non-physical variables, associated with the state of the economy and social traditions or conventions (at various scales) also affect water supply availability at water points. These include: mechanical break-down; fuel shortage; limited resources; source preference; ownership; and demand, each with a variety of causes.

Mechanical Break-down:

Mechanical failure is a widely reported problem which hinders development in Sudan generally, and especially in rural areas (Abdalla, 1986; Al-Awad *et al.*, 1985). The break-down of lorries and wateryard machinery (pumps and engines) are especially pertinent to problems of water availability, and may result from: lack of routine maintenance; inappropriate repair; over-use; the old age of equipment; and poor road conditions. The problems are further aggravated by the shortage of money, spare parts and lack of technical expertise to enact repairs.

Wateryards are particularly vulnerable to mechanical break-down, resulting in the reduction or elimination of supply for some period. Communities dependent upon wateryards with only one borehole are especially vulnerable, and it was for this reason that Muktar and Bushara (1987) recommended that all wateryards should have two or more boreholes. Baxter (1981) noted that:

> *"... pumps often break down and may not function for months if spare parts and benzene [fuel] cannot be found." (p.4)*

In study settlements, it was reported that all wateryards had broken-down for some period(s) in 1987/88. This was supported by information collected from NWC maintenance centres at El Obeid and En Nahud (see Figure 4.7). The duration of break-down varied. For example, NWC records showed that at Marahig wateryard break-downs (full or partial) lasted for up to 25 days (in 1987). Wateryard rehabilitation has been tackled in programmes by several aid agencies including CARE (eg IWP: 1986-88) and SCF. Meanwhile, limited

Figure 4.7: Number of Wateryard Break-Downs in Study Settlements.

Location	1984	1985	1986	1987	1988
Markib	15	9	8	5	3
Khammas Hajar	10	6	7	7	7
Khammas Halab	19	8	4	2	4

Source: NWC Records (El Obeid)

repairs have been co-ordinated by individual wateryard management committees, using finances loaned by merchants or collected by VWCs. For example, at Markib IWP activity included the cleaning of two boreholes; overhaul of mechanical units; the installation of a new pump and engine; and the rehabilitation of the wateryard (McGowan and Burns, 1987). Furthermore, it was reported that sums of money had been borrowed by the water committee from the rich individuals in the village to finance necessary repair work.

Once money has been raised there are problems of obtaining spares and the technical skills to repair broken machinery. These should not be understated. The whole of North Kordofan is serviced by seven maintenance centres, located at En Nahud, Gubeish, El Obeid, Bara, Sodiri, Umm Ruwaba, and Wad Ashana (near Umm Ruwaba; since 1986) (S A H Saddig, pers. comm.). It was stated that spares could be obtained free of charge from maintenance centres when they were available there. If they were not in store, they could be sent for from the regional centre at El Obeid, however, villagers often preferred to purchase from the market (legal) rather than waiting.

Fuel and lubricants, essential for wateryard operation also are financially draining. McGowan and Burns (1987) reported that NWC reimbursement to communities purchasing fuel and oil out of VWC funds amounted to only 17-25 percent of the cost of fuel and 4 percent of the cost of oil purchased on the black-market. However, S A H Saddig (pers. comm.) reported that the fuel and lubricants required per borehole per week cost about LS325, purchased on the black-market, and that revenue collected may amount to more than LS2,100 in that time[57].

Deliveries of water by lorry are also affected by mechanical break-down. The impact which this has upon water availability to dependent communities partly relates to the time of year when the break-down occurs (no deliveries are made in *kharif*, whilst *seif* is the season of peak demand), and the number and location of lorries. In November 1988, of the six lorries deployed by Khuwe RC, two were in El Obeid at the Maintenance Centre (NWC), and one was broken-down and standing in the rural council compound. One of these had only recently been made operational after an earlier break-down. The repair work had been financed by a loan from two village councils which received the water, and repayment was being made in the form of a free delivery service until the loan had been repaid.

Fuel and oil supplies are also required for vehicles and for wateryard engines. Supply shortages and the expense of purchasing such commodities can also, therefore, limit the operation of these sources of water supply. Various provision arrangements were reported in the field area between the rural councils (which direct government lorries) and recipients of supply. Generally it seemed that villages had to buy the fuel, although at Khuwe RC it was said that there were efforts being made to obtain government supplies. Meanwhile, two prices were quoted for sale of water from MADP lorries, according to whether fuel was purchased for the delivery by the Project or the recipients.

Competing Demands for Limited Resources:

At a smaller scale, competing demands upon limited family resources (of time, energy or money) can also result in irregular maintenance of sources and/or filling of secondary water sources. In some cases of protracted neglect the source itself may be at risk of decay. An interviewee at Umm Samra commented that the family had not filled their *tebeldi* in 1987 because at the time when water was available in the basal pool her daughter had been very ill and could not be left. In this case the family's labour resources were insufficient to perform both tasks, and child-care was prioritised. The *tebeldi* was filled the following year as normal. In Umm Bum, where there were three cisterns, one owner had sold half of the zinc cover because he required money, and replaced it with a 'thatch'. This reportedly had the effect of reducing the water quality to the extent that the villagers deemed it fit only for animal usage.

Preference for Newer Source Types:

Preference for a 'newer' source may result in a decision not to maintain or fill 'traditional' sources. This neglect may result in the unavailability of water at the source and its eventual destruction. In the literature, there has been some recognition of traditional sources becoming outmoded by newer ones, most especially wateryards (Mohamed *et al.*, 1986) and several examples were found in the study area.

The wells at Bur Islam had been neglected over a period of time in favour of supplies from the wateryard in Marahig. *Tebeldi* stores were also commonly found to have been wilfully neglected in study settlements with wateryards, which provided a plentiful, cheap, clean (and sometimes nearer) water supply, contrasting favourably with the high effort and time-input, and risk involved in maintaining, filling and abstracting from *tebeldis*. Some *tebeldis* were reported to be partially filled at the time of interview, although it was stated in some cases that the water had in fact been stored in the trees for two years. This water supply was (generally) not part of the normal annual water supply, but was held in reserve for times when the local wateryard broke-down. However, even at these times they were often not used, because alternative wateryards were nearby (in all cases only about thirty donkey-minutes distant), and *caros* transported water from these wateryards to the study settlements (although at a higher price than normal). Sometimes water stored in private cisterns was also used temporarily by some villagers. Therefore, many families which owned *tebeldis* did not even use them as a reserve. It was also stated that many *tebeldis* had become 'bad' and could no longer be used for storing water because they had holes. Some had been ruined because people had scraped too hard within the tree to obtain material for rope making, suggesting further failure to protect the store.

Government-administered sources also suffer from competing demands within the NWC upon limited resources (of money, skilled labour, equipment etc). Programmes of *hafir* rectification and wateryard rehabilitation have been noted to be long overdue. These are major maintenance operations to treat progressive deterioration. There has been some discussion about the development of more appropriate cost-recovery systems, which would provide for the necessary upkeep of such sources (Abdalla, 1985; McGowan and Burns, 1987; Linnemann, pers. comm.).

Indifference/Lack of Initiative and Perception of Responsibility:

Failure to maintain or increase the capacity of available 'community' water points (open-pools of various sizes) and protect the water quality can result from community indifference or lack of initiative. This chapter has revealed advantages gained by effective management, involving: fencing a source to protect it from pollution caused by animals entering the water; supervised digging and banking associated with water collection; and dry-seasons work parties. These activities require relatively small labour inputs, the burden of which can be spread among the local community and water point users.

Similarly, failure to care for the fabric of a wateryard was associated with the perception that the source belonged to the government (the technical owners) rather than the community (the users and effective owners). At Marahig wateryard, the pump-houses had been badly damaged by strong winds in 1986, but had not been repaired (even though this required limited financial and/or labour expenditure), because it was perceived as the government's responsibility.

Ownership:

Water supplies at communal and government-administered sources are made available to all families at the same 'price'. However, at privately owned sources - including most cisterns, wells, and *tebeldis* - the supply is managed by the owner. He may reserve all water for his own use and possibly that of close relatives. Alternatively water may be made available to all people, commonly for a fee (although at Wakeel, water from the perennial wells for domestic uses was free of financial charge). Sometimes the open sale of water is suspended, until the waning supply is replenished. At secondary sources (most notably cisterns) this suspension of sale may be short-term, until the next lorry delivery of water is made. However, at wells which tap perched aquifers, the supply is not replenished until the next wet-season. The remaining supply may, therefore, be kept for the owners family's use, or extraction-rights rented by the month to another family. This occurred at Bur Islam.

The Relationship Between Supply and Demand:

The availability of water at a source is affected by the characteristics of physical supply, resulting from ancient or recent rainfall *in situ* (primary sources) or transposed (secondary sources), and demand for it from people and/or animals. Secondary sources (including *caros*, lorries, cisterns, and *tebeldis*) have relatively small capacities, and are associated with high levels of demand. Consequently, the availability of water at them is restricted, and its financial cost high. In Abu Shura, it was reported that the availability of water for sale at the cistern in the year 1987/88 had been very limited, because little water had been able to be purchased from lorries to store in it (due to cost and infrequency of delivery). Furthermore, it was reported that the cement was cracking because it had not been kept full of water since it had been built (although this was not verified by observation), and no money was available to repair the damage.

CONCLUSIONS

Different types of sources have been identified: primary sub-surface sources, and primary and secondary surface stores. Primary sources derived their supply *in situ* by tapping aquifers or draining catchments, and included wateryards, wells, and various surface pools respectively. Secondary sources, which included *caros*, lorries, cisterns, *tebeldis*, and watermelons, derived their supplies from primary sources.

Potential water availability at each type of water point was determined by the source and catchment characteristics of: site (eg aquifer potential; vegetational regeneration; catchment size); and the water point itself (eg pump capacities and dimensions). However, there were other dynamic influences which defined actual availability. These controls were physical or socio-economic in origin and either reduced or eliminated the supply storage potentials at these sources. Physical controls included: annual rainfall variability; rainfall localisation; and pest attacks. Socio-economic controls included: mechanical break-down; fuel shortage; limited resources; source preference; preserves of ownership; and demand.

The multiple problems associated with ensuring an available supply at mechanised water points (wateryards and lorries) have been well documented, and were supported by field evidence. They included: break-down; fuel shortages; and lack of technical skills. Wateryards have additionally become centres of environmental problems, because of the concentrations of people and livestock which they have attracted. Because of these problems, UNICEF has increasingly placed emphasis upon handpumps with limited capacities. They are easily maintainable and repairable; their installation is accompanied by training of male and female technicians within each settlement; and several spares-stores in each rural council - many more than NWC stores. Previously, the spares had been stored together with wateryard spares, but this arrangement had been notably unsatisfactory. At the time of study, a major problem was in providing the necessary tools to the trained personnel.

Digging and banking increases or maintains *rahad* capacity and prolongs the potential availability of water at surface pools, whilst fencing protects the source from animal pollution and associated erosion. In Hariri it was said that these improvements resulted from people agreeing together and caring for their *rahad*. An analogy was made with a hut:

"If you own a hut and you do not care for it, it will fall on you."

In view of the problems of general water availability, and of erosion and siltation associated with these source types, it is easy to highlight the priorities which need to be given to promote maintenance and improvement of existing stores, including adequate provision of tools.

FOOTNOTES

1 El Obeid office.

2 Hulme (1986) noted that at Muqeirinat wateryard, pumping commonly ceased in July and August. This was an operators' decision as water was available in other local sources.

3 Independent water consultant.

4 At that time, a hose, connected to a large tap within the flooded 'animal watering section' of the complex, had been fed through the fence to provide water for a trough which had temporarily been moved outside the yard. Vendors filled their *caros* directly by using this hose.

5 It was interesting to see the old tapstand at Markib which had been removed from the wateryard. This was made of metal rather than concrete and had been left, redundant, beside the water tank. Containers used to be placed on a shelf which was a much greater distance below the taps than at the current type of benches, and there was no lip around the bench edge to collect any of the waste-water.

6 A second tapstand at Khammas Halab was inaccessible to the author.

7 This overuse, together with lack of maintenance due to shortages of spares and mismanagement, was blamed for fifty percent of the yards not working at that time (1985). The importance of recording the maximum hours rather than calculating averages (which are more often noted in the literature) is clearly demonstrated.

8 NWC, El Obeid.

9 CARE preferred the establishment of VWCs with specific responsibility for water rather than allowing an existing committee to take on new responsibilities.

10 Deputy Director for Water, NWC, El Obeid.

11 McGowan and Burns (1987) noted an official NWC rate of 1pt/jc compared to the 1½pt reported at Markib.

12 Preussag, Khartoum.

13 Both Muktar and Bushara (1987) and Hulme (1986) grouped *idd* and *tamad* together as local terms for the same category of well (described as 'shallow' and 'temporary' dug-wells respectively).

14 Walsh (1983) reported linings occurring only at the top of the shaft.

15 Muktar and Bushara reported that 'temporary dug wells' were lined with millet stalk hoops and filled with timber to prevent collapse, however, this category referred to wells situated along *wadis*. Furthermore, Hulme (1986) noted that 'shallow hand dug wells' were occasionally lined with wood, bark or straw, but this category included wells ranging from 2-20m deep, in and along *wadi* courses.

16 That is, constructed, modified, deepened or widened by human or mechanical effort.

17 A 'man' is assumed to be six feet (1.83 metres).

18 The great depth of these wells was widely emphasised in reports.

19 Digging at Wakeel was apparently only required at the base of these wells as the water levels fell. Beech (1985) also provided some additional records of well-depths for four selected areas of North Kordofan.

20 It was reported that animals drink water from a *tashit*, taken from a *ragabee*. In one interview, it was said that camels and cows could drink straight from the main basin as they would not make the water bad, but that sheep and donkeys had to drink separately.

21 Donkeys were also observed undertaking this task.

22 Borne out by observation of a line of *rahads* stretching south from the *jebel*.

23 Shepherd (1984) noted that in the Butana:

"Wells owned by individuals and divided amongst the owner's sons when he dies. The older wells therefore tend to be owned by many people. The right to use a well is shared according to ownership. An individual may have rights in more than one well. Over time, as rights are inherited and shares cut, any individual is able to use less and less water. This creates pressure to dig new wells and to seek out alternative water supplies." (p.73)

24 See note [22].

25 The Sudan Survey Department maps mention several relevant terms: *rahad* (lake); *fula* (rainpool); *hafirs* (rainpond); and pool. These are not discussed in the text as the definitions lack clarification.

26 It was noted that twenty men could be mobilised for the work, although it was not clear whether these came just from Abu Tama or from other villages as well.

[27] From observation of various surface water stores, the only distinguishing feature was their greater depth. However, distinctive terminology may not be significant. Indeed, the surface pond at Khuwe was referred to by El Sammani (1981) as a *rahad.*

[28] Generally, brief supplies were discussed only as rainwater on the land.

[29] The man was said to be chosen at a village meeting called by the *sheikh*, and people from the *rahad* village helped him with his farmland by planting, collecting gum and helping with the harvest. However, a man could refuse if he had other work to do.

[30] Trilsbach (1983a) noted that:

"In most of central Sudan they [hafirs] supply both humans and animals, but [in an area of White Nile Province] they are built predominantly for human consumption."

[31] El Obeid office.

[32] Research student, University of Oxford.

[33] This involved investigation of less expensive, alternative treatments of catchment areas, including the use of 0.25mm polythene-plastic and, on sandy soils, mixing cement with topsoil, and subsequent compression and waxing of the area, and, on *hamaraya* soils, direct application of wax.

[34] NWC records show capacities ranging from 1,000m^3 to 500,000m^3.

[35] Estimated daily water rations were as follows: man - 20lpd, goats and sheep - 10lpd, donkey - 20lpd, cattle - 30lpd. These are very high. The maximum daily water requirement for a healthy normal life is estimated by WHO as 18lpd, but the average per capita water consumption in Sudan is about 7lpd. Abu Kumbal *et al.* (1985) estimated that an average family possessing: one head of cattle; two sheep; three goats; one donkey; and one camel, required a total of 291lpd (182lpd for humans and 109lpd for animals), reportedly based on information derived from Mohamed *et al.* (1982).

[36] NWC, El Obeid.

[37] The design life of hafirs was estimated at twenty years by El Sammani (ed) (1985a).

[38] El Obeid office.

[39] Many *hafirs* do have a settling basin at the intake to control the amount of sediment entering them.

[40] see note [3].

41 It should be noted that capacities calculated from these dimensions could vary from 62 to 360 barrels, to more than 600, if they were filled 0.5 metres below the brim.

42 Administered by water consumer co-operatives (CARE, 1987),or VWCs (Morton, 1986). According to H S Gebrelassie (CARE, El Obeid), co-operatives do not have a good reputation.

43 Although cisterns were not included in the IWP, where no other source was feasible, and a request was made, assistance was sometimes given towards the development of a public, co-operative-run cistern on an experimental basis.

44 About twenty kilometres north west of Umm Kreidim.

45 CARE, El Obeid.

46 According to Gould (1984), it was noted that in Botswana, where underground tanks were made from chicken wire and plaster (with capacities between 10,000 and 20,000l) there was:

"... a serious danger of cracking if they are allowed to dry out completely." (p.15)

47 Newbold (1924a) disputed this description, noting that, in the "Kordofan Zone", *tebeldis* were found as far north as 15° 15', and elsewhere in Africa were found at Latitude 18°, although their main belt was between 5° and 15° North.

48 It has been suggested that some trees are, by the configuration of their upper branches, self filling. This type of *tebeldi* has been referred to as "*Um/El Lagai/Lagat*" (Blunt 1923; Newbold, 1924b). Hall and Ismail (1981) seemingly described this when they noted that during the rainy season the hollowed bole sometimes filled with rainwater.

49 Muktar and Bushara (1987) suggested that a tree could store 100,000l annually, but this would require a complete refilling 50-100 times a year!

50 CARE, El Obeid.

51 Hamdouk, Bashir and Abudiek (1985) noted that En Nahud District produced about forty percent of total watermelon seed in the region

52 The reasons for this were not clear, but seemingly related to the amount of time commitments required.

53 No names of local varieties were known.

54 Penn (1933) defined *qoz* narrowly as land unfit for cultivation owing to its unproductiveness (rather than to include all light, sandy soil, as is commonly defined). However, he noted that watermelons will grow on *qoz*.

55 An agricultural extension worker at the Ministry of Agriculture had seen this in En Nahud District but could offer no specific information.

56 WSARP, El Obeid.

57 The prices per litre of fuel and oil on the black-market, quoted by S A H Saddig, were 4-7 times lower than those quoted in McGowan and Burns (1987), but requirements per borehole were higher.

CHAPTER 5: WATER ACCESSIBILITY: AT-SOURCE LIMITATIONS

INTRODUCTION

The previous chapter has described the availability of water in the study area. However, in semi-arid Sudan, the availability of water at a water point is only one aspect of its value as a source for domestic and other uses. To assess the value of a given water source, it is necessary to examine a number of 'costs' which restrict access to it.

In the course of routine water collection (abstraction plus transportation), the absolute cost of water to a household variously comprises: the time and energy, or money expended in transporting water from a source; and time, energy, and financial costs incurred at the source itself. Transportation costs are examined in the next chapter, but here the 'at-source' costs are discussed. These can be examined under the three cost components mentioned. 'Time' and 'effort' costs are associated with: digging at a source to increase immediate availability of water; waiting for water to collect physically, or be made available; queueing; and extracting the water. 'Financial' costs include the price charged for water by volume, or by purchasing the rights to use a source on a monthly or seasonal basis (time-share rentals). Other 'at-source' time, effort and financial costs less routinely incurred include those generated by: creating; enhancing; renovating; or filling a secondary source. These are also considered.

The Interaction of Various Cost-Factors:

Time, effort and financial costs combine in many different ways at different water points (Figure 5.1), according to factors such as: the depth of the water supply; the capacity or yield of the source; the supply-demand balance; the style of management (comprehensiveness and competency) affecting the organisation of users; price of water; 'opening hours'; operational efficiency; and whether the labour is hired. These in turn often vary seasonally. Some idea of the range of combinations existing in the study area can be demonstrated with examples, although the components are examined in more detail later in this chapter. (Please refer to Figures 6.1 to 6.3 for the relative location of sources in the study area).

Figure 5.1: At-Source Abstraction Costs (For Non-Owners).

Source	Shita			Seif			Kharif		
	Queueing Time	Effort Cost	Finance Cost	Queueing Time	Effort Cost	Finance Cost	Queueing Time	Effort Cost	Finance Cost
Wateryard	L	L	L	H	L	L	L	L	L
Tamad	L	H	L - H						
Bir	L - H	H	L - H	L - H	H	L - H	L*	H*	L*
Cistern	L	M	H	L	M	H			
Tebeldi	H	H	H		H	H			
Caro	L	L	H	L	L	H	L	L	H
Lorry	L	L	H	L	L	H			
Open							L	M	L

L - Low/No Cost
M - Moderate Cost
H - High Cost
* - only the wells at Wakeel considered

In the study area, the at-source costs of obtaining water were found to be relatively place-independent at wateryards. Here, time costs were the most varied component of overall cost. These varied seasonally (according to supply-demand) but, at a more detailed level, variations could be identified according to: time of day; the method of queueing; the user's social niche; and the patterns of break-down and/or shortages of fuel/lubricant supplies. Effort and financial costs, however, were usually low and relatively uniform throughout the year: supply was obtained at taps and water charges were defined by VWCs or the NWC according to the volume purchased, or the number and types of animals watered[1]. Sometimes prices were increased when there was need to raise extra revenue for repairs, however, in Markib for example, it was reported that the price of water per *girba* and jerrican (for domestic supply) was maintained and the increase was borne by those watering animals and filling barrels. Corruption also affected prices in certain locations, and it was reported by NWC officials in El Obeid that they had received complaints about this from villagers.

The cost of obtaining water at other types of source in the study area was more varied. This can be seen by comparing the costs involved in abstracting water at Wakeel and Bur Islam 'wells', both located on the Basement Complex. Well water at Wakeel was reportedly available throughout the year (although the supply in any given well may be more restricted) and queueing negligible. There was no charge for abstracting for domestic supply, but those wishing to water animals had the option of paying for 'ready' water or digging in drier wells until a supply was obtained. The principal cost for domestic abstraction, was, therefore, one of effort, associated with raising water from shafts. At Bur Islam, by contrast, the physical availability of water was much more restricted. Interviewees reported digging in a well and waiting for twelve hours to collect a mere two to four jerricans of water, or 4-5 hours to collect 1-1.5 jerricans. Besides these effort and time costs, those who did not own wells at the well-field experienced 'financial' costs (reportedly up to LS4 per jerrican, or a monthly payment of LS10-15 for a twelve hour shift every three and a half days).

TIME COSTS

In this section, attention is focussed on the time costs associated with queueing, and waiting for water to collect physically (at various wells), or be made available at a source (mainly wateryards). Time costs are also involved in constructing, filling and preparing a source for regular abstraction, and raising water at-source. These will be considered primarily as effort and/or financial costs.

Perception of Time Costs:

Before examining data relating to queueing, and waiting for water to collect physically or be made available at-source (the limitations of supply), it is useful to make some comments concerning the discreteness and perception of these costs. These varied, according to the source utilised, with: the formality with which collectors were organised; how visible the water was at the source; and more personal factors of recall.

One problem concerned the ability of respondents to distinguish between normal queueing time costs and time costs associated with abnormality of supply provision at wateryards. The collector does not see the water being raised: mechanical pumps, enclosed in sheds, raise the water from boreholes; it is then directed to storage tanks and no water is seen until it is extracted from taps. Queues are normally organised when demand (temporarily) exceeds yield (especially in *seif* when the number of users increases), and people must wait to obtain water. So long as at least one pump is operating for part of each day, however, a collector may be unaware of a mechanical break-down or shortage of fuel, which leads to increased queue-time because the rate of water supply is reduced.

A second problem concerned the distinction between (demand-generated) queueing-time and the time spent waiting for water to collect physically. At the wells at En Nahud, people stood informally around the ***hodds*** into which hired men poured the water directly it was raised. Here the separation of queueing and waiting times was sometimes indistinct because many people stood around the ***hodds*** and took water at the same time rather than waiting in line. This contrasted with Bur Islam where it was noted to be dangerous to stand except in a queue formation because of the many earth-works; here the two time components were distinct.

Additional factors affecting perception of the various time costs included: the degree of involvement of the respondent in abstracting water; the variety of different organisational arrangements which actually existed at each wateryard at various times; various response-simplifications; lack of concern with subdividing total time cost; and concepts of time and time-frameworks.

Queueing Time Costs:

In this section, an attempt is made to quantify time spent queueing at each of the main water source types in *seif* and *shita*. (Data for *kharif* was not analysed because 1988 was especially wet and many surface stores, such as *rahads*, were widely available to supplement the normal range of sources). The sample sizes were too small to apply rigorous statistical analysis, but the ranges quoted identify extremes. The day was separated into sub-periods of morning, lunchtime and afternoon, which were divisions adopted by interviewees. Where an interviewee identified a source as being purely for their private use, such as a personal *tebeldi* or *kazan*, the record was excluded from the analysis, as were cases where mobile sources were commissioned, such as supplies by *caro*.

Chapter 4 has identified the variety of source types which are available to the inhabitants of the study villages. Clearly, if a particular source type is associated with long queueing time costs (for example), and exists predominantly in one or other of the geological zones, there is going to be a distinctive spatial pattern in queueing time costs. For inhabitants on the Nubian Series, the main water source in both *seif* and *shita* was a wateryard, but a wide variety of sources were utilised on the Basement Complex.

Basement Complex:

One of the main characteristics of water supply on the Basement Complex was the general lack of wateryards. A great range of sources were, therefore, used by repondents on this geology in the course of a year.

The majority of interviewees in Umm Samra used the wateryard at Marahig in the dry-seasons, but few of them provided specific information on queueing times and even when these were given there were significant inconsistencies between responses. Therefore, it was difficult to identify the ranges of normal queueing times, as demonstrated below.

In *shita*, a maximum queueing time of nine hours was recorded, but there was sufficient circumstantial evidence to dismiss this as unrepresentative[2]. The next highest maximum was of three and a half hours, but more respondents commented that normally there was no queue.

Interview responses indicated that queueing patterns were slightly different in *seif*. The highest recorded queueing time (twelve hours) was again provided by the respondent mentioned above. Other queueing times were of up to two hours. A further nine respondents who failed to quantify their queueing times also indicated that queues did in fact exist, although some respondents reported no queueing sometimes.

Queueing times at wells varied considerably. At Udeid, Bur Islam and Wakeel, some respondents used wells which they, or a close relative, owned or which they rented. Furthermore, usership of the *tamads* at Udeid was free and relatively uncontrolled to those willing to dig. Use of the wells at Abu Rasein and En Nahud, meanwhile, was controlled to a much greater degree and access was more organised[3].

Results indicated that no queueing occurred in *shita* at the wells at Udeid and Wakeel. However, at Bur Islam it appeared that an element of queueing occurred at the cement-lined well from which water was purchased. No specific figures were mentioned, but this queueing was not thought to be considerable. Elsewhere, at Abu Rasein and En Nahud, maximum queueing times of half an hour and two hours were recorded respectively.

In *seif*, the variation in queueing time between different well sources was greater. At Bur Islam and Udeid, there was no viable water for abstraction. At Wakeel, queueing was not common, although some interviewees, reported waiting for a well to refill after animals had been watered from it, or use of an alternative shaft, (or the need to dig and wait for water to collect). Arguably one of the more interesting observations was that queueing at Abu Rasein was the norm; one and a half hours was the minimum time recorded. It was also generally noted that there was often great clamouring for water at the wells at En Nahud[4], and a maximum of four hours queueing was recorded. However, some interviewees reported no queue, or sometimes no queue.

It is possible to speculate that 'no queue' occurred in the early months of *seif* and that queues formed as *seif* progressed and water became more scarce. Other possible explanations of varied reports of queueing may include: the time of day at which collection occurred; problems of defining queueing (people rarely queue in a literal sense by standing in a line); and social order (unaccompanied women often get preferential treatment enabling them, in effect, to queue-jump - indeed, women without husbands reported 'no queue'). These are discussed later.

At Treya *kazan*, no queue was reported in *shita* or *seif*. At Gangei and Sherati *kazans*, in both *shita* and *seif*, reported queueing times ranged from no queue to one hour. The longest queues were reported at Abu Khazm, which was only used by respondents in *seif*. It is possible to speculate that there could have been greater pressure on Abu Khazm *kazan*, due to people coming from Mustafa (and presumably other places), choosing to *dammer* nearby, close to watermelons, and the absence of alternative sources of water other than commercial *tebeldis* (where queues were reported to last as long as five hours). The *kazan* at Treya may have experienced reduced pressure at this time for the obverse reasons: many people moved away from the area to *dammer* elsewhere[5].

Nubian Series:

The dominant source of water on the Nubian Series is wateryards and this section focusses exclusively on them.

No queue at all was reported by over three quarters of interviewees for the wateryards of Markib, Khammas Hajar and Khammas Halab in *shita*. Indeed, ninety percent either recorded no queues at all or no queue as the lower end of a range of queueing times. The maximum queueing time recorded was four hours at Khammas Hajar and Khammas Halab and two hours in Markib. Interviewees in Abu Shura, however, identified a different trend with only half observing a normal absence of queueing at Wad el Badri wateryard in *shita*.

An analysis of queueing times in *seif* was more complicated. Queues of up to six hours were experienced at all four wateryards, but those at Wad el Badri appear to have been more consistent. A number of complications arose in trying to interpret the reasons behind this though. Comments concerning Wad el Badri came exclusively from interviewees at Abu Shura. These were the only interviewees on the Nubian Series who did not have a wateryard in their village. It was possible that queueing times reported were not those incurred by individual collectors, but by a group, because it was noted that people travelled together to collect water and waited for their companions to abstract water and load it. It is also possible to speculate that quoted queueing times could have been exaggerated due to a mistaken belief that inflated figures would assist in their attempts to secure a wateryard of their own. It is equally pertinent to note though that the local name for Wad el Badri is "*Mashakil*" which, roughly translated, means "problems". Such problems are believed to relate both to problems of the reliability of water for abstraction, and to social conflicts at the wateryard between various tribal factions.

Influences on Time Costs:

Most of the discussion hitherto has concerned factors which relate to specific water sources. There are, however, some influences which have a broader effect across the study area.

Time of Day:

The time of day at which water was collected seemed an important factor in determining queueing times at wateryards in *seif*. There was no clear association between queueing times and the three periods - morning, lunchtime and afternoon. Few people reported collection at lunchtime and no clear pattern (within or between wateryards) was established for queueing times in the morning and afternoon periods. However, at Markib wateryard, one respondent noted that early in the morning there was no queue, but by 10am queueing sometimes lasted three hours. Similarly, at Khammas Halab it was stated that very early in the morning there was no queue, but that later in the morning queueing often lasted between two and six hours. Therefore precise timing, rather than the 'period' in which collection occurred seemed important in explaining queueing times at wateryards, and perhaps at other sources too. It must also be recognised that where a water source was not local (eg within half an hour's ride by donkey), the number of trips to it per day was normally less than made by those living closer to it. Because fewer trips were made and the time required to reach a source was greater, there was less opportunity to make use of less busy times of the day. These circumstances were more common on the Basement Complex.

Social Order:

Social order is less easily illustrated, but one clear example of its effect on reported queueing times was discovered in Markib. The respondent was a childless, separated woman, recently joined in her *hosh* by her female cousin. She collected one jerrican of water from the wateryard on alternate days, but never had to queue. Her age and status in the village encouraged others to let her go first; she said "Hello and how are you?" and they let her fill her jerrican. In effect, this also demonstrated the advantages of living in the same village as a major water source (since it is doubtful whether 'outsiders' would get such preference, as their personal circumstances would not necessarily be known).

Reduction in Operations:

Reduction in operations was an important influence on time costs. With respect mainly to wateryards (and sources dependent on vehicles, notably cisterns), mechanical break-down or a shortage of fuel and/or spare parts often led to a partial or total source-failure. However, when the failure was partial, there was sometimes a substantial increase in queueing times. As has been noted already, it is possible that there was not a full awareness of the problem, and that perceived queueing times did not take account of such circumstances. In Markib, awareness was shown by some respondents who mentioned that there was no queue except: "when there was no water" and "when there was no fuel and little water". In Khammas Halab, however, under similar circumstances, it was stated that there "was a queue, but not daily - only if there were many people". These cases illustrate the contrasting perceptions of 'normal conditions' and understandings of the causes of queueing.

EFFORT COSTS

Effort costs fall into two distinct categories: occasional effort costs, attributable to requirements for creating, filling, enhancing and renovating sources; and regular effort costs, mainly linked to the daily abstraction of water.

Occasional Effort Costs:

Occasional effort costs are divided into two categories for discussion: source creation, enhancement and renovation; and source filling. Broadly, the first group is less frequently undertaken than the second, although the distinction is blurred at times, for example, digging at the base of a *tamad* may occur every few days whereas the filling of a *tebeldi* may occur only once or twice a year in extreme circumstances. Nevertheless the distinctions are helpful. Inevitably, significant cross-references need to be made with Chapter 4.

Creating, Enhancing and Renovating Sources:

The construction of wateryards, permanent/deep wells, *tebeldi*-stores, *kazans*, lorries and *caros* are all once only creations, but other 'construction' activities occur on an approximately annual basis.

Watermelons were planted annually in many parts of the study area. Two-yearly planting broadly accorded with the *harig* method of cultivation described by Jefferson (1949). Also, watermelons were planted with field crops. Efforts involved variously included the clearing of land, sowing and weeding. Unlined *tamad* shafts, located in areas of water pooling, also required annual re-digging because they were often substantially destroyed by heavy rainfall and flooding in *kharif*.

Other effort costs were associated more with specific, local initiatives to improve existing sources, for example the deepening and progressive enlargement of *rahads* to increase their water storage capacities. These activities at Gangei, Wad el Akhmer and Mustafa *rahads* have been described in Chapter 4. *Rahad* perimeters were fenced and a supervisor appointed to ensure that users (normally men) dug one metre square plots adjacent to the current watermark (Plate 24) as the pool receded. Also, in *seif* and *shita*, the people from Gangei normally approached the *sheikh* of Hariri, requesting manual assistance for the digging and clearing of ground in order to enlarge the *rahad*. Other effort costs were incurred in renovation and maintenance activities such as: replacement of machine components; topping-up of fuel tanks; cleaning boreholes and *tebeldi* trunks; re-shoring well-shafts; and maintaining *kazans* (including the replacement of covers).

Filling Sources:

Whereas boreholes at wateryards, *birs*, *tamads*, *rahads*, *fulas*, watermelons, and *khors* are filled directly from rainfall or groundwater seepage, many sources, notably lorries, *caros*, *kazans*, and most especially *tebeldis*, need to be filled with water manually.

Merchant lorries are normally filled at wateryards. In Khuwe, the process was observed first-hand: a hose was connected to a tap, situated over a trough in the animal watering area, and water fed into each of the barrels (Plate 30). This particular case occurred before 6pm. Apparently, the normal practice was for such lorries to be filled by hose from a different tap to that used by animals, after 6pm; until that time, water was not available there. Occasionally, in order to obtain 'financially'-free water (and thereby generate higher profits), lorries were filled from the *fula* at En Nahud. This was not observed but it is assumed that the barrels were filled by siphoning, which, inevitably, would generate somewhat higher effort costs.

Government lorries based within Khuwe RC reportedly normally filled from the MADP borehole. However, at the time of the field visit in November1988, that borehole had been broken since the previous July, and filling was taking place from a 'raised tank' at the NWC wateryard. These were tankers and, therefore, less effort was incurred in filling them than merchant lorries.

When *caros* were filled at wateryards, the normal procedure reportedly involved the operators in a series of trips with jerricans to collect water from filling benches. This water had to be raised to the barrel, and poured into it. However, short-cuts were commonly observed: in Khammas Halab and Khammas Hajar, the author observed *caros* being filled by hoses attached directly to the taps at tapstands (Plate 9). Also, in Markib,

Plate 30: A merchant lorry filling in the animal-watering area of Khuwe wateryard.

caro-operators were seen taking advantage of a water-leak in the animal section: hoses were fixed to taps in that section and passed through the fence, directly into their barrels. Effort costs in these circumstances were presumed to be minimal.

Tebeldi-stores are associated with a high effort cost in many respects. The height of the small access hole at the top of the trunk is estimated at about four or five metres. A person (normally a man) must climb up to the hole with the aid of a notched stick (or footholds cut in the trunk). Water must then be raised by hand using a *dalu* and poured into the opening (until either the supply is exhausted or the maximum capacity of the tree is reached). It is a tedious process, and the work may take three to four hours to complete. If the supply is used regularly, the process will normally be repeated as often as rain collects in the basal pool. If, on the other hand, the store is kept for emergency use it may be kept untouched for two to three years. In Mustafa, in years when the village's watermelon crops were good, lorry-conveyed water was also stored in *tebeldis* to provide supplementary supplies (Chapter 4).

A variety of diverse effort costs can be associated with *kazans*. They may be filled from local or distant water sources. In Umm Bum, Abu Shura and Hariri, all relatively remote from wateryards, water was scooped manually from the surrounding land following rainfalls. Additionally, in Umm Bum, a pump had been borrowed from Shoggara village to transfer water from a small *rahad*, situated close to one of the three *kazans* via a channel cut in the earth[6]. Both processes required significant time and effort expenditures. Deliveries of water by lorry to *kazans* in Gangei, Sherati, Umm Bum and Treya occurred in *shita* and *seif*[7]. In Umm Bum it was noted that water was transferred from lorries into the *kazans* either directly by hose or via an input chute, with negligible effort costs.

Other *kazans* were discovered close to wateryards, such as at Markib and Khammas Halab. These were filled with water transported from the local wateryard by the owners' *caros* in the dry-seasons (and with rainwater in *kharif* - channelled by chute in Khammas Halab). Because the source was not normally used (but kept as a back-up supply in times of wateryard closure), the supply local, and the means of conveyance owned, this filling could be done at the owners' leisure and effort costs would have been minimal.

Regular Effort Costs:

With respect to regular effort costs, it is possible to classify sources into three effort categories, based on the height or depth at which abstraction takes place (Figure 5.2).

Category 1: Knee/Head Height (Minimal Effort):

At wateryards, abstracting water from filling benches with taps required minimal effort: jerricans or other containers were lifted into and out of low rimmed *hodds* at a height just above the ground (or occasionally at hip height) with taps above. This procedure operated at virtually all the wateryards in the study villages and elsewhere in the study area. One exception was at Marahig where tapstands had been damaged and removed four years prior to the study; users abstracted water from animal troughs (which were also above ground level) by submerging containers and raising them out.

Abstraction from lorries also required minimal effort, although some qualification is needed. Water was usually transferred from the lorries' tanks or barrels via a hose into a water container. If a barrel was used, however, its subsequent manoeuvering or the transference of supply (when required) could demand considerable effort. An additional, often hidden, effort cost existed in the process of requesting water. In the case of Hariri, for example, one person (normally the *sheikh*) had to travel to En Nahud to add the village's name to a delivery schedule. Other practices operated elsewhere (Chapter 6).

Water delivered by *caro* normally required minimal abstraction effort. *Caros* delivered directly to a *hosh* and water was usually transferred by a hose. The main effort was often finding a *caro* operator to make the delivery. As with many abstraction processes, one cost was minimised at the expense of another. This situation provided an excellent example, as minimal effort costs were paid for by higher financial costs.

Category 2: At or Just Below Ground Level (Moderate Effort):

Abstraction direct from primary surface water sources involved standing in or near to the edge of the water; submerging the containers by bending from the waist; and raising them up and out (Plates 24 and 31). At some *rahads*, including Gangei, Wad el Akhmer and one of the three local to Mustafa, additional effort was demanded in digging (normally only of male collectors) in return for use of the supply. This has already been mentioned in terms of

Figure 5.2: Regular Effort Costs At-Source

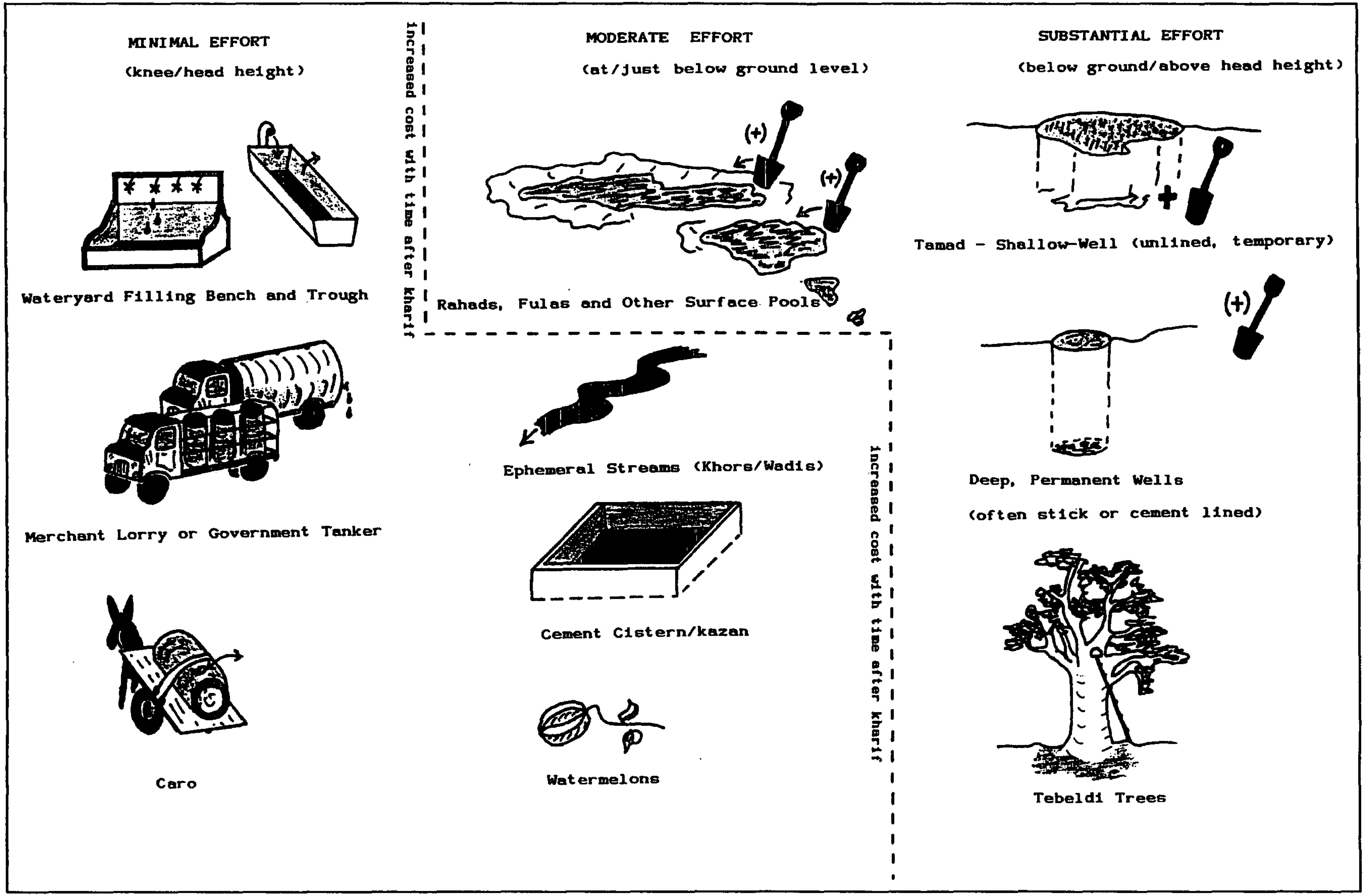

Plate 31: Water is collected from the ground after heavy rainfall.

Plate 32: Water is raised by a man using an 'open-topped' jerrican attached to a rope at Wakeel. The rope is pulled over a highly-grooved branch.

'source enhancement', but since it was a condition of use, may be considered here as an 'abstraction cost' also. Furthermore, at Khuwe, there was evidence of general deepening in the lowest part of the *fula* bed, presumably in order to extract water from just below the surface (although this would also have enhanced source capacity for the future). Abstraction from cisterns also required moderate effort.

Watermelon cultivation forms part of this category also. A measure of the effort required can be demonstrated with reference to the scale of cultivation. On a small scale (family needs), both men and women participated, but on larger plots, such as in more commercially-oriented cultivation, the labour requirements were normally considered too difficult or time consuming for women.

Category 3: Significantly Below or Above Ground (Substantial Effort):

At both *tamads* and *birs*, digging was sometimes or always required in order to obtain water, for example at *tamads* at Udeid and Umm Aweesha (Plate 16), and at *birs* at Wakeel. *Tamads* were dug annually and progressively deepened with increasing time after *kharif* as the watertable fell. The work was demanding physically and beyond the scope of women. *Birs* seemingly varied in the amount of digging they required each year. The well-field at Wakeel provided examples of both: 'cement lined wells', reputedly fully lined and requiring no digging, at which charges were levied for watering animals (it may be that the owner himself regularly dug the well, although this was not stated); and others where water was available free of monetary charge, but the abstractor had to dig at the base of the shaft to obtain the water. In the latter circumstances, the shaft owner was contacted and he usually stood at the top and raised the loosened material by *dalu*, with the aid of camel-traction. Digging was also required at Bur Islam well-field, even in at least one of the cement-lined wells. Interviewees from Umm Samra described how their husbands or fathers dug within the shaft and daughters or other men stood at the top of the shaft to receive the earth which had been dug.

In addition to the preparatory digging, effort was expended in raising water from shafts. The effort required varied according to: the depth of the shaft; the presence or absence of animal traction; and, in the absence of animal power, the age and sex of the abstractor and other helpers. Baxter (1981) noted that:

> *"... pulling the water several metres to the surface is difficult work. Two or more women are needed to bring the water up, and they often suffer from irritated and calloused hands." (p.4)*

The wells at Abu Dulduc were the deepest recorded. Here, camel-traction was employed in *seif* by a woman from Umm Gemeina who regularly collected water. Respondents from Umm Samra, who used these wells when Marahig wateryard broke-down, noted the extreme effort required to raise the water; it was observed that "It needs men to raise the *dalu*; women could not raise the water" and that, even for men, this would be an impossible effort cost for their normal day-to-day collection. Women who went to these wells to collect asked people for water, but this was at a high 'social cost': it was described as 'not good' to ask in this way. At two well-fields visited at En Nahud, however, winding devices had been installed. These were operated by hired labourers who poured water into the basins. Therefore, collectors were involved in minimal effort costs of scooping water from the water basins. Between these two extremes of energy cost associated with abstraction were the wells at Wakeel (Plate 32) and Bur Islam. At both of these sites, women who came to collect generally reported being given assistance by other people in abstracting the water. (By contrast, at Udeid *tamads*, only men were noted as collectors, seemingly because collection by women was precluded by the requirements of digging already noted).

The withdrawal of water from a *tebeldi*-store is a complex process which requires at least two people. One adult climbs the tree and lowers a skin on a rope into the hollowed trunk. The full container must then be raised within the tree, guided through the relatively small access hole, documented and estimated in the field to be about 40cm in diameter (see World Water, Nov 1979). It is then lowered to a second person on the ground who empties it into a jerrican (Plate 33). The process is repeated until the jerricans are filled. In most of the cases described in interviews, a man climbed the tree and a woman received the water at the ground. This was also described by Hall and Ismail (1981). It was reported in one interview that a woman cannot climb a *tebeldi* and, therefore, where there was no man to do the climbing, the source could not be used. In two cases where a respondent's husband was working away from home at the time or had deserted her, water was raised: by a man from one of the other families sharing use of the store; and the respondent's brother who lived in the village, respectively. However, one example was found in which a woman from Umm Barouda climbed a *tebeldi* to collect water. Her husband was abroad and her children

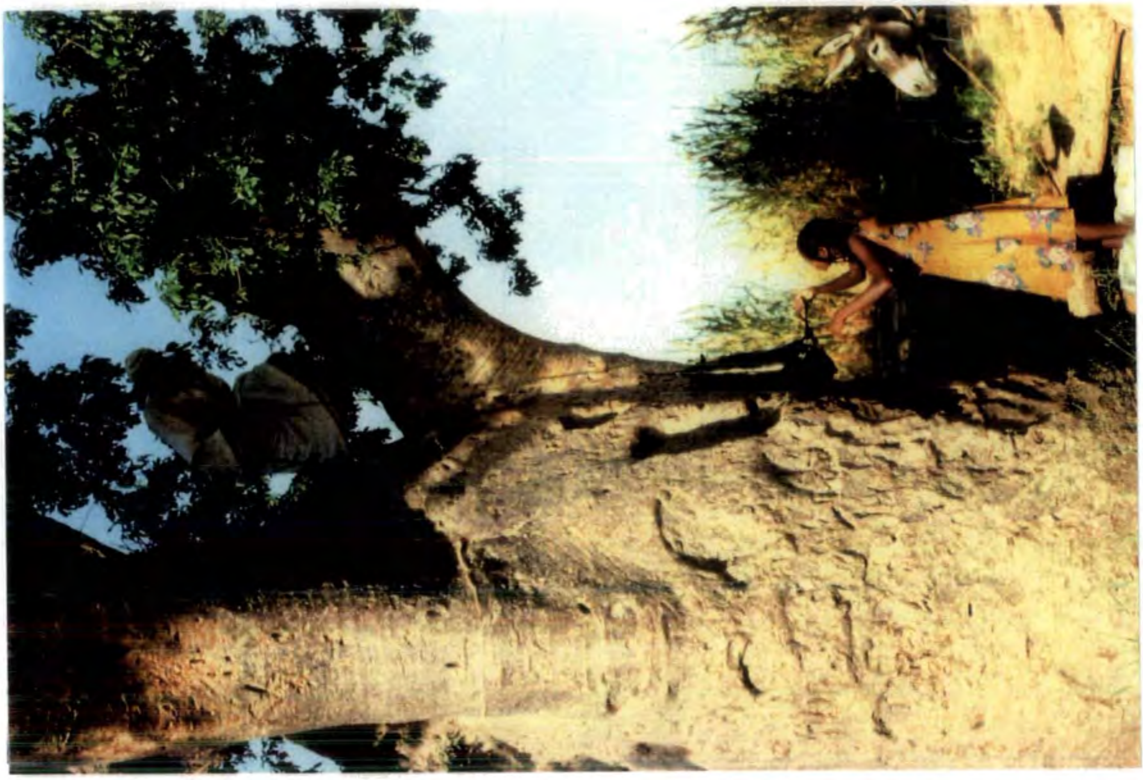

Plate 33: Water is raised by a man from within a tebeldi by girba, and lowered on a rope to a woman who transfers the water into a jerrican.

Plate 34: Water purchased from caros is stored in a barrel within the hosh.

were young. In this case, the woman climbed the tree and a young son received the water on the ground. It was stated that much water was spilt because he was unable to pour well and that it was difficult for her to climb. No alternative, available sources were more accessible: the *tamads* at Udeid, used by other villagers, required too much effort in digging and, furthermore, were too far for her to travel with children to collect water (see Chapter 6).

FINANCE COSTS

Financial costs, unlike time and effort costs, were not incurred at all sources. There were two main types of finance cost: occasional costs, associated with construction, maintenance and filling; and regular payment for abstracted water. At many sources, water was free of charge, most especially at primary open surface water sources, such as *rahads*, *fulas* and *khors*. There were also examples of water being given free from *kazans*, wells, and *tebeldis* to people most in need.

Occasional Finance Costs:

Construction costs can be substantial, however, figures quoted could have been subject to inflation and a range of reporting errors. Nevertheless, they serve to highlight the nature of the cost and the order of its magnitude. The cost of purchasing a lorry, such as those used in the MADP, was reported to be of the order of LS100,000-150,000 without the tank, which was manufactured locally at extra cost. Figures associated with the construction of a *kazan* at Mustafa were inconsistent, but it was noted that costs varied according to: the type of metal cover acquired (with zinc more expensive than beaten barrels) and the source of cement used. A sack of cement reportedly cost about LS80 or LS100 when purchased from the councils at El Obeid and En Nahud respectively, but was substantially more expensive when purchased from merchants, for example three times more expensive when purchased in El Obeid in November 1988. Even less ambitious developments could be financially burdensome. The cost of cement for lining a well at Wakeel was reported to be about LS650-1,150. Additionally, at Umm Samra, the cost of hired labour to dig wells was estimated to be about LS500 per man-depth. Furthermore, the cost of well-repair at En

Nahud required payment of LS50 per day for specialist workers. Lorries also required frequent and often substantial financial expenditure for maintenance and repair. The age of vehicles, and the difficult terrain over which they operated, contributed to higher costs for these activities.

Payments for the rights to construct a source were only mentioned once, in Umm Barouda. This related to the digging of *tamads* at Udeid. Permission from the local *sheikh* was purchased for a notional LS1. This was effectively a courtesy payment since use of the *tamads* already constructed was free.

Regular Finance Costs:

Where a financial cost was involved in abstracting water, differences in price per unit were found to exist between: source types; sources of the same type; and seasons at the same source. Also, many different measures and methods of payment existed, including payment: by container filled (jerrican, *girba*, barrel, *hooridge* etc); by animal type and number of animals watered; for a 'rented' time share; and for a pre-determined volume of stored water.

Method of Payment:

When a barrel (approximately equivalent in capacity to ten jerricans) was filled with water from a wateryard, the basic monetary price of the water was about 50pt. This price, however, does not account for a variety of other hidden costs. The barrel itself was expensive; one respondent in Khammas Hajar reported that a barrel cost LS50. Therefore, certain families were unable to purchase water from *caros*, for example, because they had insufficient storage for a barrel-volume of water (Plate 34).

Examples of 'time share' rental arrangements were reportedly associated with wells at Wakeel, Abu Dulduc and Bur Islam (Figure 5.3). At Wakeel, water could be obtained free of charge for domestic use, however, charges for watering animals could be substantial in the case of large herds (if 'ready water' was required). One respondent from Umm Qarn, however, claimed that by digging in wells where water was not readily available, and drawing that water free of charge, he saved himself an estimated LS3,000-4,000 through the seasons of *shita* and *seif*. An alternative strategy for watering animals cheaply was

Figure 5.3 'Time-Share' Rental Arrangements for Wells.

Location	Frequency of Use	Hours of Use	Price	Prime Motive
Bur Islam	3.5 days	06.00 - 18.00 18.00 - 06.00	LS10-15 per month	Domestic
Wakeel	ad hoc	06.00 - 18.00	Community Rate. Each family contributed.	Animals
Wakeel	ad hoc		LS600 divided between 2 men	Animals
Abu Dulduc	alt. days	all day	LS2000 for darat, shita and self	Animals

demonstrated by the *sheikh* of Umm Qarn and his brother. They rented a private well at Wakeel for LS300 each. This was a separate transaction from that made by the other families in the village, who sent their animals in a group (taken by their sons and daughters) and paid a share of the overall price in proportion to the number and type of animals owned. In neither case was digging involved

The private rental of a well at Abu Dulduc throughout *darat*, *shita* and *seif*, by a family in Umm Gemeina, facilitated regular access to water for both domestic and animal usage. This outlay provided an alternative structure to expenditure: one payment for the period instead of repeated payment according to volume and animals watering each day. Although domestic water was drawn from the well, it was essentially a strategy for animal watering.

On a smaller volume-scale, a system of monthly rentals of a well at Bur Islam offered an alternative payment-scheme to the repeated purchasing of domestic water supply by jerrican volume. (At these wells water was not free for domestic use; prices of up to LS4 per jerrican were quoted). The abstraction process demanded onerous time and effort costs in digging and waiting for water to collect, and the rewards in terms of volume of water were small (sometimes only two to four jerricans in a twelve hour session). The family, however, did not own many animals and this method of payment suited their requirements for regular supplies of water for domestic usage.

The 'bulk' purchase of a discrete volume of water was found to offer a number of advantages to those who could afford it. An example of this can be shown with reference to a family from Umm Samra who rented a *tebeldi* at Abu Rakhei. They paid a fixed rent of LS280 for the entire volume stored within the trunk - estimated at more than 100 jerricans. The supply lasted about forty days. The family of eight consumed about two jerricans each day for domestic use. Additionally, another two jerricans were used every fifteen days for washing clothes and the rest was distributed to the family's goats in measures of about two jerricans. The payment for the stored-water was made in one lump sum and this reportedly precluded many families from adopting this strategy: it was stated that normally, if one had the money, it was better to buy in this manner; if not, water was purchased from lorries. When water was bought from a lorry, although many smaller payments were made, the supply was irregular, and the overall monetary cost more expensive. Another interviewee in the village noted a similar principle on a smaller scale: if you had money you bought water by the barrel from a lorry at, for example, LS20 per barrel in *seif*; if you did not have money, you had to buy by the jerrican from lorries at LS3-4/jc, which is more expensive per unit volume.

Actual Monetary Costs:

The costs of domestic water supply, reported in household interviews, are tabulated in Figure 5.4, which shows the seasonal ranges of monetary costs of water at named sources of the various types[8]. A clear and largely predictable pattern of costings emerged between source types. Wateryards, constructed by the government, and operated by NWC personnel and VWCs, were associated with very modest charges. By contrast, cisterns, *tebeldis* and lorry supplies had very high costs, which could variously be explained by the premium placed on 'local supply' in areas where water was scarce in *seif* and *shita*, and the actual costs of transporting water. Lorry transportation costs were very high (Chapter 6); when these lorries were operated commercially, additional costs derived from profit margins. Cisterns, which received supplies from such lorries, incorporated this cost in the higher prices which they charge per jerrican. Morton (1986), however, noted that profit ('exploitation') made by cistern owners exceeded that by 'lorries'. It would appear that *tebeldi* supplies, derived from rainwater pools, were associated with high costs exclusively because of the high demand for water in areas where water was generally not locally available. The cost of water at wells, however, varied considerably: at Wakeel *birs* and Udeid *tamads*, water was free; at Bur Islam, En Nahud, Abu Rasein and Abu Dulduc it was relatively costly, but prices were noted to vary seasonally.

CONCLUSIONS

This chapter has introduced three types of cost: time, effort and money. The stages at which such costs were incurred at different sources, and variation in their scale, have been examined. Attention has focussed principally upon the costs involved in water-abstraction. These were seen to vary according to a range of factors, most especially sourcetype and season, but also according to: the social status of the collector; specific time of day;

Figure 5.4: Financial Cost of Water (measured in pt per jerrican/barrel).

Source	Shita		Seif		Kharif	
	min	max	min	max	min	max
Wateryards (jc)						
Wad el Badri	10	12.5	12.5	17.5		
Markib	5	5	5	10	5	5
Khammas Hajar	4	5	4	5	4	5
Khammas Halab	5	5	5	5-10	5	5
Marahig	5	10	5	10		
En Nahud			5	5		
Wells (jc)						
Udeid	0	0				
Bur Islam	20	400				
En Nahud	25	100	25	150		
Abu Rasein	100	200	100	300-350		
Wakeel	0	0	0	0	0	0
Abu Dulduc			150	150		
Cisterns (jc)						
Abu Shura	200	200	200	300		
Gangei	200	300	300	300		
Sherati	200	300	300	300		
Treya			300	300		
Abu Khazm	300	300	300	350		
Tebeldi (jc)						
Abu Khazm	250	250				
Umm Samra			200	400		
Umm Dereisa			100	100		
Abu Rakhei			200	200		
Caro (barrel)						
Markib	200	400	200	600	300	400
Khammas Hajar	150	250	150	300	250	250
Khammas Halab	200	400	200	500	200	400
Lorry (barrel)						
Abu Shura	1,000	1,000	2,000	2,000		
Hariri	1,000	3,000	1,000	3,000		
Mustafa			2,500	2,500		
Umm Samra			1,300	3,000		

individual source-management practices; and the physical limitations of supply (eg delivery of water and aquifer capacity) and volume of demand.

It has been shown that aspects of at-source costs can effectively preclude certain potential users from accessing supply. This was perhaps most clearly shown in terms of 'effort' costs and 'financial' costs. The relative burden of each at-source cost component varied according to the resources which a family possessed, and the amount of demand placed on them. An analysis of relative costs requires an understanding of such factors as: perceived family resources (number, age and sex of children and their education standards; number, type and condition of livestock; crops; remittances and other income); commitments (to acquire food, water, shelter, clothes, education, health etc); prevailing market conditions; the deployment of resources with respect to domestic and other requirements (such as looking after crops and animals); and environmental constraints (weather, pests, diseases etc).

Most domestic requirements could, to some degree, be met by the use of a family's internal resources and the presence of naturally-occurring 'financially-freely available' products. However, the way in which these needs were met was influenced by: the quality or satisfaction attainable; and the ability to meet needs in alternative, more desirable ways. Depending on family circumstances, the relative burdens of each of the cost components varied. A family with minimal realisable assets may, of necessity, have expended more time and effort at the expense of financial expenditure. By contrast, a family with greater financial resources may have chosen to reduce time and effort costs by adopting a more convenient method of abstraction, such as buying water from lorries, *kazans* or *caros*.

In overall conclusion, it has been possible to demonstrate the variety and patterns of time, effort and financial costs at-source, which contributed to the making of decisions about the sources and methods of water abstraction. These decisions were, in turn, influenced by specific family circumstances which defined the relative costs. At-source costs, however, were not the only costs involved in water collection: the choice of source was also affected by the other major cost component, transportation costs, which is the subject of the next chapter.

FOOTNOTES

1 Examples from Markib show the ranges of prices charged (pt):

Agent	Kharif 1988	Shita 1987-88 and Seif 1988
one jerican	5	5
hooridge	50	50
goat	-	3
sheep	-	4/5
cow	-	10-15
donkey	5	5
horse	5	5
camel	25	25
lorry barrel	75	50-75

2 The nine hours could be accounted for by combining the collection of water for domestic purposes at night with the watering of animals: the queue time related to the whole process.

3 The wells at En Nahud are considered here because, although they are sited on the Nubian Series, they are used as a source by people living on the Basement Complex.

4 In En Nahud, not all dwellings were linked into the town's tap water supply system. Demand for water from the wells (and wateryards) came from both the town's indigenous population and people *dammering* in the area (Chapter 7). As Province capital, it was able to offer disproportionately high work opportunities and as such was an attractive location for migrants and refugees. With all these pressures and associated demand for water, it is not unreasonable to anticipate queueing in the drier parts of the year, especially towards the end of *seif*.

5 Although this section has passing reference to queueing at *tebeldis*, insufficient data for more detailed comments on *tebeldis* and other sources was available. More comments can be made, however, with respect to other limitations on accessibility to these sources in other sections of this chapter and in Chapter 6.

6 This system, however, had lapsed in 1987 because the *kazan* owner had been forced to sell part of the zinc cover to liquidise his finances/assets. The partial covering of straw replacing the zinc was such that the water within was deemed fit only for animals (although presumably it was as clean as the water obtained from the *rahad* and contained in a better store).

7 These journeys may well have involved the lorry crews in *ad hoc* effort costs because of poor 'road' and vehicle maintenance.

8 Where a respondent, or a close relative of a respondent, owned a source which was used, the information was disregarded because water was obtained without financial charge.

CHAPTER 6: WATER ACCESSIBILITY: TRANSPORTATION LIMITATIONS

INTRODUCTION

The concept of distance as a barrier to movement is well articulated in 'geographical literature' (eg Von Thunen, 1826). Distance to water, and the cost involved in overcoming it, constitutes one of the main obstacles to securing a family's water requirements, and like 'at-source' costs, it has time, effort and financial elements. Access to sufficient domestic water supply at-*hosh* is determined by the ability to overcome both the transportation and 'at-source' costs (Chapter 5).

This chapter examines the wide-ranging factors which influence ability to overcome distance in accessing water supply, and includes investigation of variations in: speed of transportation; the volume which can be carried (carriage-potential) by different modes of transportation (carriage teams/systems) in a given period; and the availability of the various carriage systems to families in the study settlements. The costs of travelling to and from a water source, and transporting water (measured in terms of time, effort and finance costs) are distinguished from: 'at-source' abstraction costs (Chapter 5); and the special case of family relocation to water sources in the dry-season (*dammering*), which is examined in the next chapter. Consideration is also given to the complications of measuring distance.

Measuring Distance:

Measuring distance posed several problems in the field, both theoretical and practical. The need for standardisation, the way in which it was achieved, and the limitations resulting from it are examined here.

Obtaining Standardisation:

It was necessary to standardise the unit of measurement in order to gain an impression of the relative distances from study villages to the various water points used by the residents, and to permit comparisons to be made between villages.

Measurement of linear distance, in kilometres or miles, could have provided a 'reliable' standardisation, free from reporting error. Unfortunately, this was impossible because the milometer on the landrover was broken. A less accurate measure of physical distance could also have been calculated from the journey-time when attempting to drive the landrover at a constant speed. This may have been technically possible if the speedometer were operational, but any measurement involving the landrover was ultimately considered unjustifiable because of: the limited volume of fuel which could be carried and the extreme difficulty in obtaining it outside Khartoum; time constraints; and the often hazardous terrain, remote from garage facilities (see Chapter 2). Furthermore, any such measurement would still have been subject to error since it is probable that water carriage teams would have taken several different routes to any one source, and some routes would have been unnegotiable in a landrover because of terrain.

The solution adopted was to take the reported or estimated time required to complete a journey when travelling by donkey ('donkey-time') as the standard unit of distance measurement. This is employed throughout the remainder of this thesis unless otherwise stated. This measure was selected because donkeys are commonly used to transport water from both local and more distant sources. Furthermore, time-distance is more relevant in an understanding of space as an obstacle to water accessibility than any linear distance measurement, because the differential effects of terrain are incorporated within it and the cost of transportation is experienced by a family in the form of loss of labour for a period of time.

For each study settlement on the Basement Complex, all fixed water sources were mapped from orientation and donkey-time information supplied by the *sheikh* and other interviewees (Figures 6.1 to 6.3). Wakeel, with local perennial wells, provided an exception, with one water source used by all interviewees throughout the year. In wateryard study villages on the Nubian Series, time-distances and orientations were not requested routinely. Therefore, distance measurements were generally solicited from interviewees only, with reference to sources used in circumstances of real or perceived wateryard break-down. On this geology, Abu Shura provided the exception. Since it contained no perennial supply, donkey-time estimations were recorded.

A degree of 'guesstimation' was necessary on the Basement Complex when no donkey-time measurement was available. In many cases this originated from simplified responses such as, "When in En Nahud, we lived in a rented *racouba* near the *idd*". In such cases, a time of

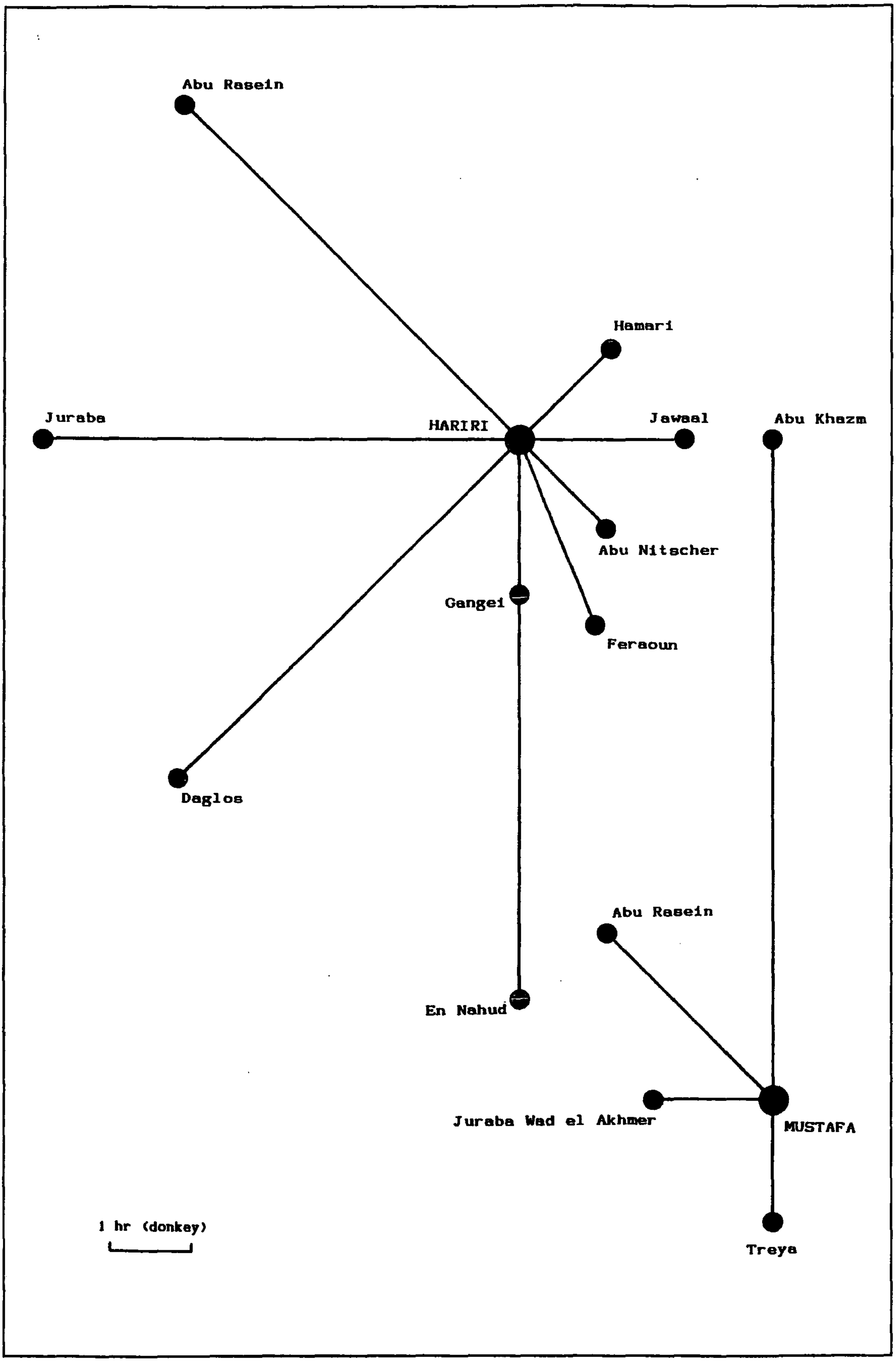

Figure 6.1: Distance and Orientation to Fixed Water Sources (Hariri and Mustafa)

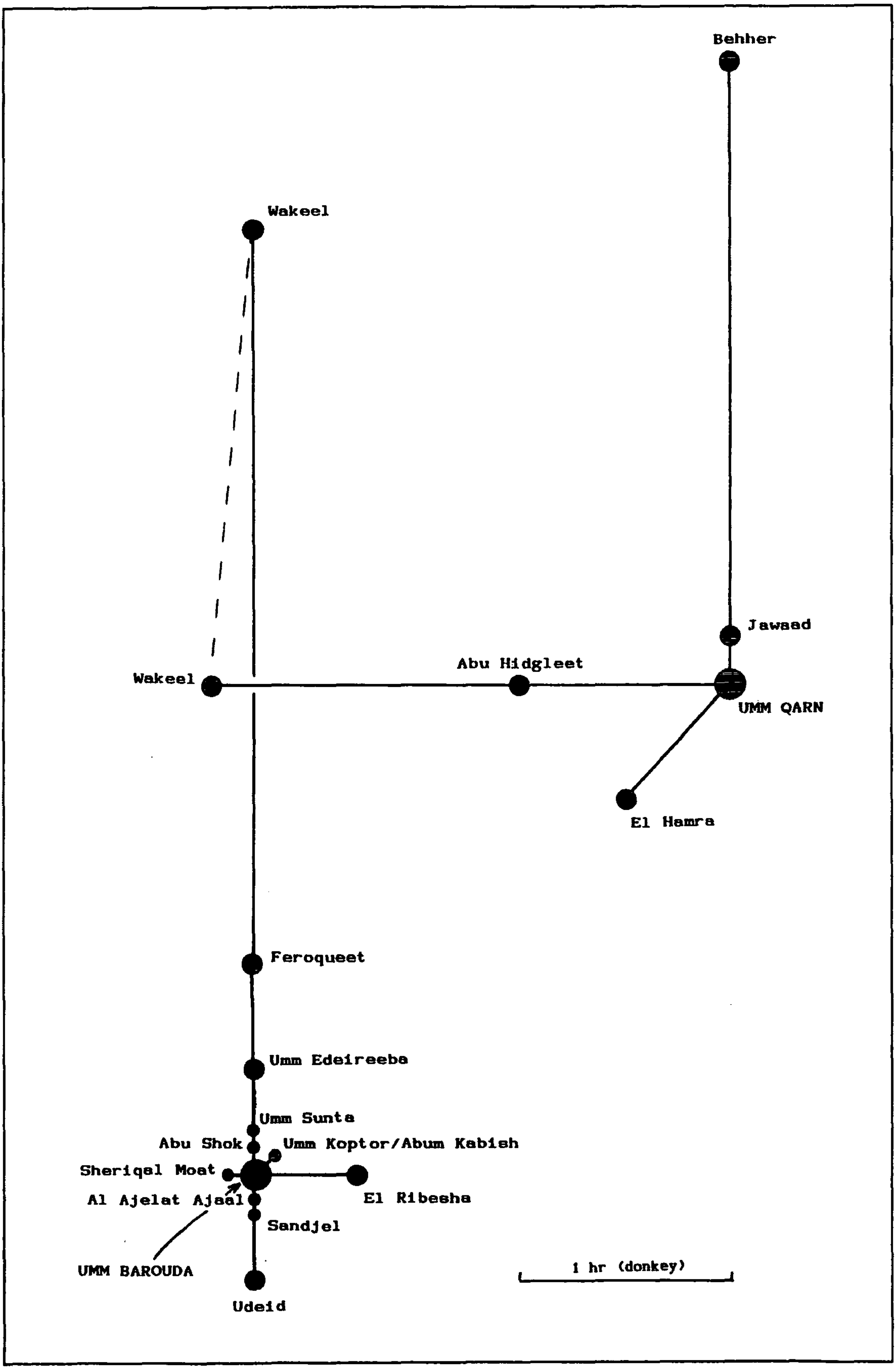

Figure 6.2: Distance and Orientation to Fixed Water Sources (Umm Barouda and Umm Qarn)

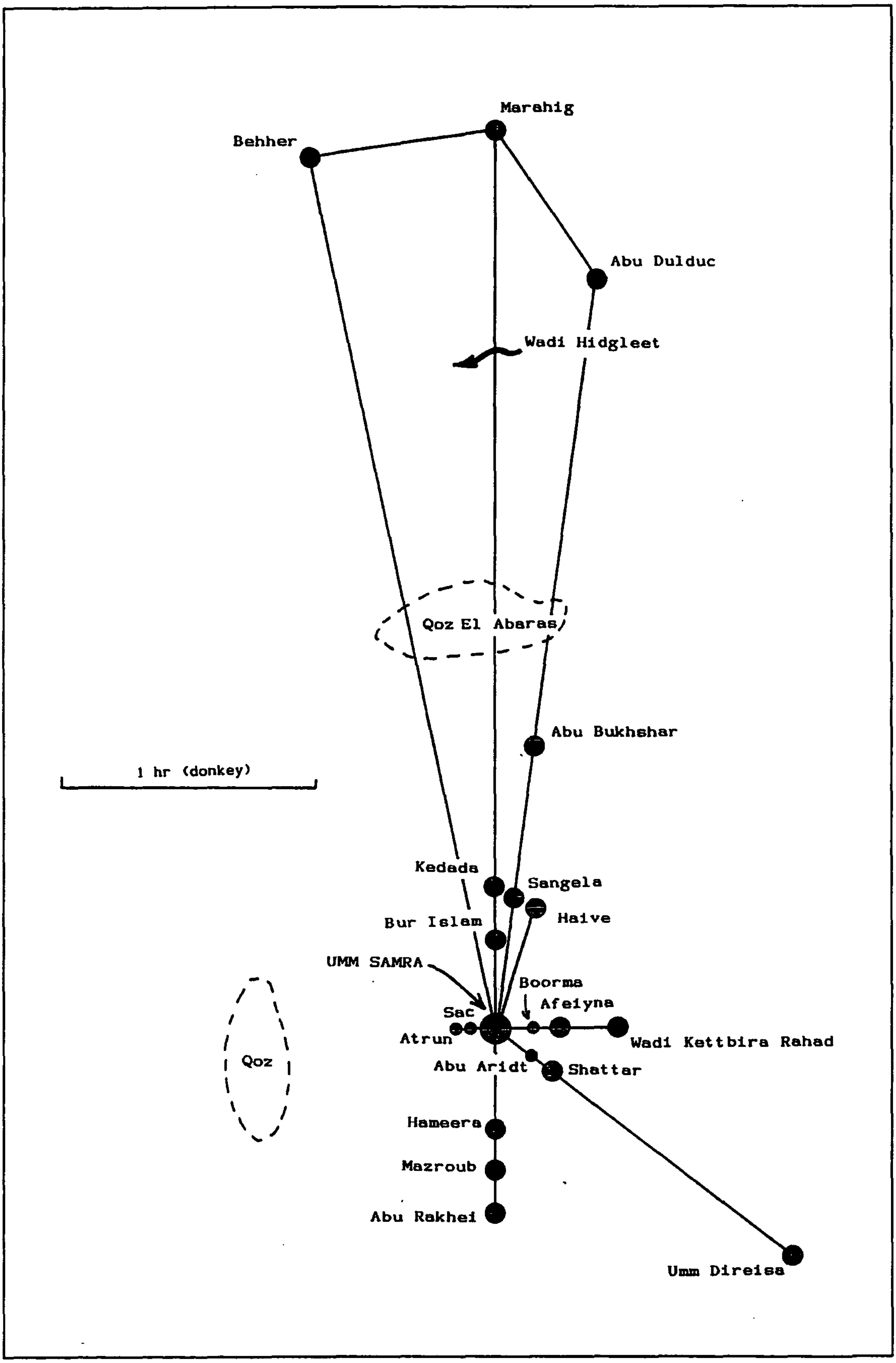

Figure 6.3: Distance and Orientation to Fixed Water Sources (Umm Samra)

either less than or greater than one donkey-hour was estimated on the basis of information available. In the specific case mentioned, a time-distance of less than one hour was confidently assumed. Similarly, *dammering* sites on the perimeters of En Nahud were estimated, on the basis of information available, as being less than one hour from the wells. Elsewhere, distances from the family *hosh* to personal *tebeldis*, frequently described in terms of 'near' or 'far', were all estimated to be within an hour's distance. Distances from watermelon *dammering* sites at Wad Abu Tahrhah, Jebel Afarit and Qoz Al Abaras to water points at Abu Rasein, Wakeel, and Marahig respectively were estimated to be within an hour's journey by donkey.

Errors in Distance Measurement

Donkey-times were either reported or estimated, rather than measured in the field. When distances were estimated, some degree of error was intrinsic; when they were reported, errors may have occurred due to: poor remembrance; intentional hardship-exaggeration; lack of knowledge; or an inability to accurately 'translate' time-distance from one carriage method to donkey-time. Furthermore, additional problems were associated with the fact that: different routes to a source may have been taken by different people; the measurement of distance is an alien concept to some people; and that travel time is only one part of the total time expenditure associated with water collection. In Hariri especially, the dispersed village morphology probably contributed to some confusion in mapping distances as some of the villagers' *hoshes* were an estimated 45 minutes from that of the *sheikh* (which was the reference point for standardised measurements).

Friction of Distance:

Many geographical models incorporate the concept of the friction of distance. These include Christaller's Central Place Theory; Von Thunen's Agricultural Land Use Model and the Gravity Model (Warntz/Ravenstein) and its derivatives. In the former two, explicit assumptions relating to distance-costs included: no physical barrier to movement and equal ease of transportation in all directions; one method of transportation; the cost of transportation being directly proportional to distance; and the rationale of 'economic man'. Also, in the Gravity Model there is no consideration of the attributes of space across which movement occurs, or variations in the type of transportation available or movement undertaken. Clearly, these assumptions do not describe reality. Some accommodation of this fact is seen in the modifications of the basic models: Von Thunen's was adapted by incorporating a route of alternative transportation and a barrier (a navigable river), commanding increased speed and decreased financial cost for travel along it. Similarly, Gravity Model derivatives require the exponent that best fits the particular interaction to be employed, in recognition of the effects of terrain, transportation technology and type of movement, upon the relationship between movement and distance.

These models illustrate the frictional effects of distance, expressed in terms of: profit margin (Von Thunen); propensity to migrate (Ravenstein); or the distance which will be travelled for a level of service or good (Christaller). They do not, however, embrace the multiple objectives of a family, and its personal weighting of at-source and transportation-cost characteristics. Movement between *hosh* and water source is the result of a complex interaction of factors pertaining to: the characteristics of physical space (eg presence of *qoz* obstructing movement); family resources (including cash, fixed capital, and people and carriage animals, with their associated potential for water carriage); family requirements other than for water (for production and reproduction); the facilities, besides water supply, which a location possesses and which a family demands (offering potential for combining water collection and other activities, such as marketing goods or performing wage labour, to reduce total travelling requirements); and the characteristics of the source (abstraction cost). Distance must be traversed in such a way as to ensure that 'enough' water is secured if residential stability is to be possible.

TRANSPORTATION POTENTIAL OF CARRIAGE SYSTEMS

Different types of 'carriage systems', here defined as: people; or people plus a means of carriage (animals, *caros* or lorries), command differing water-transportation potentials. These can be considered in terms of speed of movement and the volume which can be carried on a given trip. In Chapter 4, *caros*, and different types of lorries (government and merchant) were discussed as 'mobile secondary surface water sources'. Because they are mobile, they can also be considered as a form of water transportation. Indeed, the price charged for water from them includes both the financial cost of the water, and a 'service charge', which relates to the time, effort, and money expended in filling and transporting the water as well as any profits and/or a reserve fund for maintenance.

Speed of Carriage:

Time-distance comparisons between different modes of water carriage were not possible for all journeys. Firstly, not all methods of transportation were employed for each journey. For example: families living in settlements with a wateryard or wells never used camels to collect water from them; *caros* only operated inside and within a small radius of wateryard settlements; lorries only delivered outside settlements with a perennial supply; and pedestrian-carriage was restricted to round-trip distances of less than a day on foot. Secondly, distance measurements were generally requested in terms of donkey-time (above). Thirdly, time-distances (speeds) were not recorded for *caros* or lorries, although these were clearly faster than other forms of carriage on respective journeys.

Speed of carriage varied between different transportation modes. It was reported that camels and donkeys travelled at approximately the same speeds and, therefore, there was no advantage in this respect between them. By contrast, some speed differential was revealed between donkeys and pedestrians where comparative journey times were recorded, and it varied with distance travelled. Over short distances, speed differences between animal and pedestrian-transportation were hardly discernible (for example, to six out of the nine *rahads* used by interviewees in Umm Barouda which were less than ten minutes distance by donkey). By contrast, over distances of 30-50 donkey-minutes, donkeys were two or three times quicker than pedestrians (see Figure 6.4).

Some qualification of the relationships described is necessary. References above to pedestrian-transportation relate to travel unhampered by children. However, the effect of young children accompanying a mother as she fetched water from local *rahads* was explained in one interview in Umm Barouda: time costs were three or more times higher for selected local journeys. For example, the journey from Umm Barouda to Sheriq al Moat *rahad* took the interviewee ten minutes travelling on foot without children, but with children accompanying it took half an hour. Consequently, the physical distances across which water collection activities could range was reduced and, consequently, the number of accessible sources was reduced; Udeid (thirty minutes distant by donkey) was too far to

Figure 6.4 Comparative Journey Times by Donkey and on Foot (mins).

From	To	(A) by foot	(B) by donkey	(A) / (B)
Khammas Halab	Khennaga	90	30	3
Khammas Halab	Abu Hantuta	120	50	2.4
Umm Qarn	El Hamra	90	45	2

travel with children[1]. Additional factors which can be expected to have affected the efficiency of various carriage systems include: age; sex; health; and climate, especially heat.

When families lived close to the water sources which they used in any given season, almost no speed advantage was gained by using animal rather than pedestrian-carriage. This related to residents of wateryard and perennial well settlements in every season, and those *dammering* to sites nearby in the dry-seasons. The speed advantages of animal-transportation emerged only for those living or *dammering* in locations more distant from their water sources. The extent of the advantage increased with distance. Additionally, more sources were potentially accessible (in terms of overcoming transportation costs) when animal-, rather than pedestrian-carriage was used, since a greater distance/area could be covered in a given time (and more water carried per journey). Finally, the importance of delegated child-minding was suggested.

Carriage Volume:

As with speed, the volume carried per trip also varied between different modes of transportation, and among different transportation agents of the same type. This data was systematically collected, and is assumed to be more reliable than the time-distance data because the 'number of jerricans (jc) or jerrican-equivalents' is a physical rather than mental measurement, and has tangible relevance for the family unit (ie in defining water available for use at-*hosh*), unlike travel time which is only one of many time costs associated with water collection.

Figure 6.5 shows the array of volumes reportedly carried per trip by each mode of transportation, and the norms (where appropriate): 10jc by *caro*; 6jc by camel; 2jc by donkey; and 1jc by people on foot. Despite variation in the reported carriage capacities of transportation agents of the same type, the relative carriage capacities of different modes were clear. Lorries had a greater carrying capacity than other forms of transportation: the lowest estimate of lorry carriage capacity was twenty barrels, which infact equalled the highest capacity recorded for a *caro*, however, the former record was significantly lower, and the latter higher than other records for their respective modes. Furthermore, although there was some overlap in reported carriage potentials between camels and donkeys, and *caros* and camels, these were atypical and could be explained by a school water collector's

Figure 6.5: Ranges of Volumes of Water Carried per Trip.

Transportation	Volume Carried per Trip	Norms
Government Lorries	20-30, 26, 30, 35, 50 barrels/trip	
Merchant Lorries	26, 28, 30 barrels/trip (+ jcs)	
Caros	10 or 20 jc/trip	10 jc
Camels	6, 8, 10, 12-16 jc/trip	6 jc
Donkeys	2, 3, 4, (7 by hooridge) jc/trip	2 jc
People on Foot	0.25, 0.5, 1 jc/trip	1 jc

use of *hooridges* (total capacity 7jc/trip) at Markib, and the possibility of exaggeration, respectively.

Beyond the generalisations described, various factors affected the carriage capacity of individual transportation agents, and these explain some of the variations recorded in carriage capacities between transportation agents of the same type. These included: age; strength; sex/gender; physical condition etc. With respect to people, social conventions define the acceptability, and detailed form of carriage 'appropriate' to the sexes, and age is associated with differing physical capabilities. It was stated that: "A jerrican is made to fit a woman's head". This is a social norm rather than a physiological fact[2]; men only rarely carried water on foot, and this was either in a jerrican on their shoulder (despite the difficulty of this operation), or quarter-sized jerricans by hand. White *et al.* (1972) noted, in their study of East Africa, that in some areas there was strong prejudice against men carrying water on their head. Age also affected physical carriage capability, with younger children able to carry less water than mature adults of the same gender. Therefore, adult women, who transported water on their head, carried more water per trip, and more commonly went to collect water than girls, boys, or men.

A variety of factors were reported to have affected the volume carried by animals, including combinations of: distance to source (a factor affecting the frequency of trips); family water requirements; the combination of animals going to collect water from a source; whether a donkey was ridden by the collector; and the age, sex, and health of the animals. For example, in Hariri it was reported that donkeys carried either 2jc or 4jc per trip and that this related to the sex of the animal, which affected the animal's strength. Another interviewee reported that when a single donkey was taken to collect water it carried 2jc, but when taken with a camel, it carried 4jc. This was because the daughters who accompanied the animals rode on the donkey when the camel was not present, but when both animals went, they rode on the camel instead. Furthermore, another interviewee noted that their camel carried 6jc-equivalent of water in the dry-seasons of 1988, but that in the Very Dry Year it could only carry 2jc-equivalent of water per trip because it was 'thin'. This highlights the effect of poor nutrition (and possibly illness) upon carriage capacity, and can be related at a broad level to drought and famine years, such as those of the mid-1980s. This factor can be expected to have widely affected both people and animals.

The characteristics of the containers used for water transportation have been noted by Cembrowicz (1982) to affect the volume carried. Although no data was collected systematically on this topic, it has already been noted that the atypical case of a donkey carrying a 7jc-equivalent was explained by the use of *hooridges*. Additionally, the difference between a donkey carrying 2 or 3jc could be associated simply with the use of two jerricans or two *girbas* (holding 1.5jc each) respectively: it would be impracticable to carry 3jc volume on a donkey in jerricans since the load would be unbalanced. In some interviews, four jerricans-equivalent was reportedly carried in *girbas* on a donkey. This would be impossible in jerricans due to their rigidity, but *girbas* are more flexible (Plates 35 and 36).

The carriage potentials of lorries and *caros* are also limited by a range of factors, analogous to those noted above, including: constructed capacity; condition of maintenance; and availability of crew and fuel.

The comments noted above have some important implications for water accessibility. Since adult women generally carry more per trip, and more commonly go to collect water than girls, boys, or men, the implications for pedestrian water transportation potentials of: a family having no female children; a family sending female children, especially adolescents, away from the home village for schooling; or a daughter's marriage and departure from the family home, can be readily appreciated. Illness and nutritional status may also limit the volume which people can carry per trip, although this was not noted in interview. Drought and famine were, however, noted to impact upon the carrying capacity of a family's carriage animals. Camels and donkeys provided the chief forms of water carriage in areas remote from perennial supplies, and poor nutrition prevalent at such times was found to have reduced carriage capacity by causing weakness or death. Additionally, the sale of animals was sometimes necessitated by the need to purchase food etc, although carriage animals were normally kept if possible (below).

Factors Eliminating Carriage Potential:

Some factors actually negated, rather than simply reduced, the speed of journey and the volume of water which could be transported by a carriage system, either permanently or temporarily. These related to more chronic problems of physical condition, but also

Plate 35: Water is carried on donkeys, for example by jerrican. Here, in addition to the normal-size jerrican, a smaller container is also being carried.

Plate 36: Girbas provide flexible containers for water carriage.

temperament, and included: women's early months of motherhood; fevers and other illnesses in people; animals' pregnancy, general 'weakness', a need to be rested in *seif*, and losses through death and sale; and lorry break-down. Some of these were clearly related to age and/or sex characteristics, which, for example, broadly defined: potential fertility; frailty; and susceptibility to certain illnesses.

Women were recorded collecting water (by head) locally up to 7/8 months after conception. However, one respondent reported still being unable to collect water, even from pools near her *hosh*, about two months after giving birth.

Illness also precluded individuals (generally wives and daughters) from collecting water. Substitute collectors from within the family were normally found (husbands and daughters), however, in one case pre-stored water was used, and in another the respondent reported continuing to carry water (locally) despite 'illness'. Obviously the term 'illness' may embrace a multitude of complaints, but it was not possible to investigate the subject, most particularly because of time constraints and repeated attempts by villagers to elicit medicine.

There was no systematic questioning concerning the sex of animals; their respective gestation periods; and individual animal's status in respect of them. The one reported case of carriage animal pregnancy concerned a donkey in Markib which, even prior to pregnancy, had not been used for water transportation because of its 'vicious temperament'; it had broken the respondent's hand and everyone in the family was afraid of it.

In an interview in Hariri, a donkey's 'weakness' was reported to have practically eliminated its ability to carry water. In *kharif*, the *sheikh's* two families obtained water almost exclusively from their *tebeldi*, located a few minutes distance from their *hoshes*. They did not generally collect water from *rahads* (used by all other interviewees in the village), because they were far and their donkey was 'weak' (and this local supply was available). Previously, in attempting carrying water from a *rahad*, it had fallen two or three times, dislodging the jerricans and one had broken. Such journeys were, therefore, only made on occasional days when the *tebeldi* was empty between rainfalls, and when the husband passed by a *rahad* as he returned from work in another village.

The effects of poor nutrition during and after years of drought and famine have already been mentioned in limiting the carriage capabilities of people and animals. However, a high mortality rate and increased sales have also been documented for many types of animal, with attendant loss of carriage potential (SUDANAID, 1986a). Furthermore, prior to death, the ability of animals to carry water is severely curtailed. Figure 6.6 shows the percentage of sample families owning carriage animals before the Very Year and in 1988, according to their residence in study settlements with and without a local perennial water supply. Both prior to the Very Dry Year and in 1988, the proportion of families owning one or more carriage animals was greater in those settlements which lacked local perennial water supplies. In particular, the percentage of families owning camel(s) was higher in such settlements and these were normally held in combination with donkeys. Changes in carriage animal ownership from the pre-1984 to the 1988 situation included a greater increase in the proportion of families owning no carriage animal in those settlements lacking local perennial supplies, compared to those with them (17% and 14% respectively), however a higher proportion of families still owned carriage animals in the former. In particular, there was a greater decrease in the percentage owning no camel(s) (47% and 25% respectively), and an increase in the proportion owning only donkey(s) (29% and 11% respectively). Such losses of carriage animals have serious implications both for families' carriage potential and capital reserves. In settlements lacking local perennial supply, this impacts upon ability to access sufficient supply. Prior to the Very Dry Year, 76% of sample families in settlements lacking local perennial supplies owned both camel(s) and donkey(s) together: in 1988, this figure was only 30%.

Additionally, when water lorries break-down, or can not be supplied with the necessary fuel, they are unable to operate. They are susceptible for a variety of reasons: the conditions of 'roads'; lack of spares and technical expertise; poor maintenance; and shortage of finances at all levels. Consequently, three out of the six lorries controlled by Khuwe RC were reported broken in November 1988 (see Chapter 4).

Influences on the Types of Carriage Systems Employed:

The carriage system employed for water collection varied with distance to source. Figure 6.7 shows the various forms of carriage and members of family associated with them when

Figure 6.6: Percentage of Responding Families Owning Carriage Animals (by Residence).

Type of Carriage Animal(s)	Settlements without a Local, Perennial Water Supply			Settlements with a Local, Perennial Water Supply		
	Pre 1984	1988	change	Pre 1984	1988	change
Both Camel(s) and Donkey(s)	76%	30%	-46%	33%	10%	-23%
Donkey(s) with/without Camels(s)	92%	75%	-17%	75%	63%	-12%
Camel(s) with/without Donkey(s)	79%	32%	-47%	35%	10%	-25%
Donkey(s) only	16%	45%	+29%	42%	53%	+11%
Camel(s) only	2.5%	2.5%	0	2%	0	-2%
No Carriage Animals	5%	22%	+17%	23%	37%	+14%

		One Hour or More From Hosh to Source						One Hour or Less From Hosh to Source					
		husband	wife	daughter	son	other in hosh	others	husband	wife	daughter	son	other in hosh	others
Kharif	Lorry												
	Caro (own)											○	●
	Caro												●
	Camel	●	○		○								
	Donkey	●	●	●	●			●	●	●	○	●	
	Head		●	○					●	●		●	
	Hand							○					
	Shoulder							○					
Seif	Lorry						●						
	Caro (own)							●			●	●	●
	Caro												●
	Camel	●	○	○	●		●						
	Donkey	●	●	●	●		●	●	●	●	●		○
	Head								●	●		●	
	Hand											●	
	Shoulder												
Shita	Lorry						●						
	Caro (own)							●			●	●	●
	Caro												●
	Camel	●	○	○	●		●						
	Donkey	●	●	●	●			●	●	●	●		
	Head								●	●		●	
	Hand												
	Shoulder												

○ = one case only clearly identified
● = more than one case clearly identified

Figure 6.7: **Seasonal Variations in Family Responsibilities for Water**

distance to source was less than or more than one hour for each season. In every season, when the source was more than one hour's distance, camels and donkeys were used to transport water. Additionally, in *shita* and *seif* lorries transported water, and in *kharif*, pedestrian carriage was employed (although only in Hariri, where journeys of up to a one day round-trip on foot were made). When the distance to source was less than one hour, donkeys, *caros*, and pedestrian modes of transportation were employed.

Most water transported on foot was carried by women (wives and daughters) carrying a jerrican on their head. However, over distances of less than one hour husbands were found to have sometimes carried water by hand or shoulder. Husbands, wives, daughters and sons were all found to have accompanied donkeys to sources at various distances. By contrast, very few females had taken camels to collect water. Indeed, there were only two specific examples: one concerned a woman who lived in Hariri, with pre-school aged children, whose husband was working long-term in Saudi Arabia; the other involved several daughters travelling together to collect water.

Certain norms for ranges of collection by the different carriage teams could be identified. Pedestrian transportation was commonly restricted to very short distances, although (as noted above) in Hariri it appeared viable within a range of a one day return-trip on foot; beyond this some access to carriage animal resources was required (perhaps because of stamina limitations and/or the time-cost, but most certainly because it was impossible to secure sufficient water for a family by such a method). For donkey transportation, a collection range of less than a one day round-trip was commonly recorded. One family was found to have travelled further than this by donkey (from Hariri to En Nahud), but could only support two members of the group with the water obtained (and this was supplemented by lorry supplies); the other family-members *dammered* to En Nahud town. With camel carriage, however, sources within a reported two to three-days round trip could be accessed to provide supply, although commonly with some degree of supplement from lorry (and sometimes *kazan*) supplies.

BORROWING OF CARRIAGE SYSTEMS

The carriage potentials of various methods of water transportation have been discussed above. In this section, the origins of carriage resources utilised by families, and the associated costs are examined. These carriage systems may be: wholly or partially owned by the family; wholly or partially borrowed; or effectively 'purchased'.

The time and effort costs of transportation are borne directly by the collectors, but also indirectly by the family units to which they belong in terms of lost labour potential. When a water carriage system is wholly owned by the water-using family, all such costs are borne by them. When any part of it is borrowed, the nature of the borrowing arrangement determines the distribution of the total cost among the parties concerned, but no monetary payment is made. This contrasts markedly with purchased transportation, in which the water-using family incurs no time or effort costs for bringing the water to the village from the primary source, and no or minimal secondary transportation costs of time and/or effort within the village, but pays financially for the transportation service.

Family resources and the inter-relationships between these and the market have been examined in some detail in Chapter 3. Here discussion focuses on borrowed and purchased resources and their availability and cost to the user.

The Nature of Borrowing:

The borrowing of resources to improve access to water by overcoming transportation-costs has been virtually neglected in studies of water supply in semi-arid Sudan, and indeed, elsewhere in the world. In 'The North Kordofan Rural Water Supply Baseline Survey' (Mohamed *et al.*, 1982), it was restricted to the comment that:

> *"Villagers often borrow water from neighbors, giving it back when their donkeys bring supplies from the water source." (p.65).*

This only concerns the borrowing of water, over a very short time-span (ie 'tiding a family over'), and with its imminent replacement. In other major studies, such as 'The Social and Managerial Aspects of Rural Water Supplies in the Sudan' by Mohamed *et al.* (1986), borrowing was never mentioned. Consequently, it did not initially seem to merit attention, and no direct questions were asked about it; its importance and scope, however, became evident as interviewing proceeded and later as interviews were analysed. Therefore, the present study is confined to a description and examination of the borrowing which was revealed in interview-discussion of seasonal water supply strategies for 1987/88. There is no indication of incidences when borrowing was sought unsuccessfully.

Terminology:
At the outset of this section it is important to define the various terms used. The term 'borrowing' is used to describe one family's use of another family's resources, without monetary payment for the benefit. The resources which were borrowed in order to obtain water supply included: carriage animals; people (either to carry water, or to accompany a carriage animal); person-and-animal teams; and water which had been collected. When a person, person-and-animal, or water were borrowed, both abstraction and transportation labour-resources were, in effect, borrowed.

Two types of inter-family borrowing arrangement were identified: aid, and mutual aid (Figure 6.8). In aid arrangements, one family borrowed resources from another to collect water, but retained all the water collected. Resources borrowed in this manner varied: sometimes an animal was borrowed and the human labour supplied by the borrower-family; in other cases, person-and-animal teams; persons[3], or pre-collected water were borrowed. Mutual aid relationships, by contrast, were mutual borrowing arrangements. Resources from two families were combined to collect water, which was then divided between them both[4].

A distinction was made between 'long-term' and 'short-term' borrowing arrangements, defined as lasting half a season or more, and less than half a season, respectively. Where possible, some note of the reliability of the borrowing relationship was included.

Borrowing arrangements are now discussed although it should be noted at this juncture that, whilst water acquisition strategies were examined by season from *darat/shita* 1987 to *kharif/darat* 1988, basic questions concerning animal-ownership referred only to the time of interview (September/October 1988) and their numbers and types may have changed during the preceding year. Some additional stochastic information was, however, provided

Figure 6.8: Costs and Benefits of Borrowing Arrangements.

Type of Arrangement	Source of Inputs Families x and y	Recipients of Benefit
Aid	x animal y person	y benefits
	x animal and person y nothing	y benefits
	x pre-collected water y nothing	y benefits
Mutual Aid	x animal y person	both families divide the water

in interview about the sale and birth of animals, especially donkeys.

Long-Term Borrowing:

Where relationships were of the aid type three stimuli for borrowing could be identified: opportunity; lack of carriage-resources; and lack of labour-resources. Each of these will be defined and examined below. When long-term mutual aid relationships were reported, however, it was not always apparent whether they were essential to the locational stability of both, one, or neither of the parties involved, or were entered into rather for mutual advantage. Therefore, these cases are examined separately.

Borrowing for Reasons of Opportunity:

This occurred when a family was presented with an opportunity to borrow a resource for water collection. Two clear cases were identified, both in Markib and involving animal borrowing by families which had no carriage animals of their own. They were reliable relationships, associated with the provision of a reciprocal service. In one case a donkey had been stabled at the *hosh* by a relative, and whilst there was used for carrying water; in the other, a man employed to collect water for a school was able to use the donkey provided for his work to carry water for his family.

The impacts of borrowing for the first family could clearly be seen: the responsibility for water collection was transferred from the wife (who collected water when the donkey was not available) to her primary school-aged children (who accompanied the donkey); no family labour had to be used in carrying water; twice the number of jerricans could be carried per trip, and, since the same volume of water was collected, the time/effort costs of transportation were halved. In the second case, the husband was able to transport more than seven times the volume of water by donkey that could be carried on foot in one trip (although in *seif* when the school was closed he collected only 4jc/day because he had to pay for the water in this season). If this donkey had not been available, it is probable that his wife would have had to carry water on foot, since they had no daughters who were old enough to collect water and the mother living with them was old.

Borrowing opportunities of the types described above were clearly not widely available; family location and male-headship may have been important in securing them. Both cases were reported by families living in a wateryard settlement. The location of schools, and hence the need for a school water collector, is influenced by the availability of sufficient water supply, as found in such locations (see Chapter 3). Furthermore, it can be speculated that the decision to stable a donkey with relatives in Markib was due to the wateryard-location, which would have reduced the burden of animal watering for an owner who did not live so close to a perennial supply. Additionally, both reported cases concerned households which were normally male-headed, and the job of school water collector is a 'man's job'.

Borrowing due to the Lack of a Carriage Animal:

Three cases were discovered in which distance to a source stimulated long-term borrowing of carriage animals by those without them. Both reliable and unreliable aid borrowing relationships existed.

In Hariri, a female-headed family[5] of four, with all children of pre-school age, possessed no carriage animals. The respondent borrowed a camel from a neighbour during half of *shita* and half of *seif*, in order to market produce in En Nahud and collect water from the wells there. The borrowing relationship was, however, unreliable: the interviewee was not allowed unlimited or even regular access to the camel. Normally she could use it once every six days; sometimes only once every twelve - and in the intervening time the owner brought her half the volume she otherwise secured. When all marketing activities were concluded, the respondent and her family *dammered* to Abu Rasein where she could access water from wells on foot.

In the case above, En Nahud was too distant for the tasks undertaken there to have been carried out without the use of a camel; even a donkey would have been unable to transport sufficient water. (Other sample families in Hariri without camels *dammered* (wholly/partly) after harvests/early *shita*). *Kazans* and occasional lorries, which provided closer sources, were considered too expensive for regular use and only one sample-household reported using these as their normal supply in the dry-seasons. Although the well-water at En Nahud was also described here as 'expensive' (LS10 for a 6jc volume and camel watering), it was affordable because the respondent was able to sell her produce at the same time and thus earn some money. This example demonstrates the complex benefits of borrowing to access water, and the importance of being able to borrow the appropriate type of carriage animal for the task in hand.

Another example, comprising several aid arrangements, came from Umm Samra. The family was smaller than average (3-4 persons); was normally male-headed; owned no animals; and resided in the village all year, borrowing donkeys from various people at different times in each season to transport water from: far *rahads* in *kharif*; Bur Islam in *shita*; and Marahig wateryard in *seif*[6]. It was one of only two families in the village which did not own a donkey[7] and, therefore, there were many potentially available for loan. It was reported that, in every season, the respondent's brother (not a member of her family unit) had sometimes collected water for the family. His family owned a donkey, and this provided some back-up when borrowing was "difficult".

A further example of reliable aid borrowing was noted in Umm Samra, when a 'young' family borrowed a donkey from one of their parent-families in all seasons[8]. This type of borrowing does not need to be described in further detail.

Those families which borrowed carriage animals were: both male- and female-headed; lacked carriage animals; and came from villages on the Basement Complex which lacked local perennial water supplies. Borrowing carriage resources enabled them to maintain locational permanency or to live in a desirable *dammering* location (see Chapter 7). When families were closely related, borrowing arrangements were essentially reliable. The character of borrowing in each case may be expected to have been defined by a composite of a number of factors, including: the distance to an affordable basic source; alternative source-opportunities which could be occasionally incorporated into a water supply strategy (eg *kazans* and lorries with high financial abstraction costs); the resources potentially available to be borrowed (ie held in a village, and their proximity to would-be borrowers); and the disposition, family-tie, or needs of a potential lender.

Some families which lacked carriage resources may have been unable to borrow despite wanting to, because of factors noted above. For example, it was noted in some interviews that the family did not loan their donkey to other families because it would be too tired if it carried water for two families. Furthermore, the fact that in Hariri pedestrians commonly transported water from *rahads* further than in other study settlements may be due to: the scattered morphology of the village which may have separated potential lenders from would-be borrowers; the fact that (among interviewee families at least) there were fewer carriage animals available in absolute terms; and distances to primary sources were great (ranging from 1½ to 6 hours by donkey in *kharif*). Indeed, in other settlements, carriage animals were borrowed for shorter distances, such as those exceeding twenty minutes in Umm Samra.

Borrowing due to the Lack of Labour:

Four examples were discovered where a lack of 'appropriate' human labour was a stimulus to borrowing. The resources borrowed were both people, and person-and-animal teams (although the distinction was not always clear). These aid arrangements were all reliable.

The first example concerned two neighbouring families in Hariri - an elderly widowed mother (living alone with a grandson), and her son (also involved in a mutual aid relationship with her in *kharif*: see below). In *shita* and *seif*, the mother borrowed person-and-animal labour from her son's family: he transported water for both families from *kazans* on his own donkey. The mother did not collect water in any season, and may have been incapable of it, whilst the child with her was too young. In *shita*, the loan would not have increased transportation time-costs, because only one trip was made to the *kazans* as the son returned from work (however, his family was not able to receive as much water as they otherwise potentially could). In *seif*, however, two journeys were made to the *kazans*, with half the water (and hence all time costs associated with the extra trip) associated with transportation incurred collecting water for the mother's household. Although this appeared to be an aid-type relationship, it is probable that the water was not strictly for individual family usage.

In Umm Samra, a similar case was found of an elderly widow who lived alone in a hut adjacent to one of her son's families. She was supplied with water by two sons (who headed independent families in the village) travelling on their own carriage animals. The interview was not concluded, therefore, it is unknown whether the widow had animal resources of her own, or whether she in fact lacked both animal as well as human labour resources. It was, however, revealed that the water received was not used by her alone.

Two further examples came from Mustafa and Umm Barouda and concerned young mothers. Both women borrowed transportation resources in *seif* while their husbands were absent on work. In the first instance, the family owned no carriage animals; upon return from *dammering* in *seif*, the family was supplied with water by the respondent's father-in-law, who transported it on his own donkey from Treya *kazan* (the nearest fixed source), one and a half hours distant. In the second case, the family owned a camel and a donkey; whilst the family was *dammering*, and upon return to the home-village, water was collected by the respondent's brother-in-law (presumably using his own animal) from Wakeel wells (estimated at two, and four hours distant from each location respectively). Normally it would be expected that the men would have collected water, because available sources were distant and there were no male (or female) youths. In other seasons when the women's husbands were absent, the women were able to carry water themselves from sources which were more local to their *dammering*/village of residence.

In each case mentioned in this section (as in the section above), borrowers came from villages located on the Basement Complex, lacking local perennial water supplies, and a consequence of the borrowing was that they were able to live in their own village, or in a *dammering* location with watermelons, which would have been unlikely otherwise. All borrowing relationships were reliable, operating between closely related families. Furthermore, the borrowers were female-headed families: either elderly widowed women living near their children's families but technically separate from them; or young mothers, with husbands working away from home. This highlighted the importance attached to having access to active male labour for water collection when water is transported over long distances. Women were rarely reported to have ridden camels, perhaps by social norm or division of labour (and this applies to some extent to donkeys also). Additionally, the elderly most probably could not physically have abstracted and/or transported water.

Mutual Aid Borrowing:

Two cases were cited in which long-term mutual aid relationships existed. They existed between the families of a parent and child, and were reliable.

In Hariri, long-term mutual-aid borrowing was identified between the neighbouring family units of an elderly widowed mother and her married son (see above). In *kharif* 1988, the son's family sold their donkey and for most of that season collected water from local pools, transported by all family members (including his wife until she gave birth in August), with the assistance of his mother's donkey. Although it is unclear whether the water collected in this manner was shared between the two families, it is certainly likely, and would then have constituted a mutual-aid relationship. Furthermore, at the end of *kharif*, when there was no water in these local pools, the son borrowed the mother's donkey to collect water from more distant *rahads* for both families in what was clearly a mutual-aid relationship.

This case provides the only example of long-term borrowing in *kharif* discovered in Hariri. The loan of a carriage animal may again be surmised to have transferred the responsibility for water collection from *rahads*, to the husband, from the young wife: in other families lacking carriage animals water was transported from these sources by women on foot, and in other families with carriage animals men collected this water. Although, at that time, the wife was unable to collect water (having recently given birth), the loan appeared independent of this fact, because the water collection practices of the two family units had been linked throughout the year in various ways. The arrangement was facilitated by the close familial and geographic relationship between the families. It seemed probable (bearing in mind the borrowing which occurred in *shita* and *seif*) that it resulted at least in part from the need of the mother for labour, although it was certainly to the advantage of both families in *kharif*.

Another case of a reliable mutual aid relationship came from Umm Barouda and also operated between a parent and child family (borrowing human labour and a camel respectively). The respondent was from the younger family. She was seemingly the household-head in *seif* and *kharif*, and the family owned a donkey but no camel. In *kharif* she and her daughters carried water on foot from local *rahads*, and in *shita* from a nearby *tebeldi*; in *shita*, her son also brought water by donkey from Udeid (thirty minutes distant). In *seif*, however, the nearest water point, used by all the villagers, was Wakeel wells (four hours distance from the village). The other sample families in the village owned camel(s) (as well as donkeys) and used them to collect water from these wells both whilst *dammering* to watermelons near Jebel Afarit, and upon returning to the village prior to *kharif*. The respondent's family, however, did not *dammer*, but borrowed a camel from the parent family to collect water from Wakeel every three days. It was accompanied by the respondent's son and the water collected (6jc equivalent) was divided equally between the parent and child families.

Perhaps the respondent's family could have secured 1jc of water per day from Wakeel by using their donkey to carry water (although it is unclear whether the respondent's husband had taken this). However, through this borrowing arrangement, 1jc of water was secured per day for two families rather than one, and for a lower time-cost (one trip per three days rather than one per two days). As little is known about the parent family, it is difficult to say whether the borrowing arrangement was primarily the result of: its need to borrow human labour (but this is very probable given his age and family responsibilities); or the younger family's need to reduce transportation costs; or mutual support and co-operation. The importance of the type of animal borrowed is clear in this example.

Short-Term Borrowing:

Stimuli for short-term borrowing were more readily identifiable and greater in number than those associated with long-term borrowing. Families involved in short-term borrowings either possessed adequate resource-bases to overcome the 'usual' costs of water collection, or were involved in a long-term borrowing relationship for this purpose. Short-term borrowing was associated with a temporary change in their 'normal' circumstances of collection, for example: when additional demands were placed upon respondents due to the failure of the usual source, or when extra water was required for 'less-regular' activities, such as washing clothes; or when normal methods of collection were temporarily eroded through the illness or absence of a member of the collection-team. Additional motivations included lack of assistance in abstraction and opportunity.

Borrowing due to the Failure of a Source:

Five examples were found where families borrowed resources as a result of wateryard break-down; all were inhabitants of the wateryard study settlements (Markib, Khammas Hajar and Khammas Halab). Water, animals, and people-and-animals were borrowed through aid arrangements between relatives and non-relatives. When local wateryards were functioning, families in these settlements could access sufficient water with the meanest of resource-bases; when they broke-down, alternative sources comprised: *caros* and *kazans*, which offered local but limited supplies at a higher financial cost; or neighbouring wateryards (in each case about thirty minutes distant; estimated as one to one and a half hours on foot).

One family, which lived in Khammas Halab and owned a donkey, borrowed half a jerrican of water from a neighbour for tea and prayer when the local wateryard broke-down in *seif*. This was in addition to water collected from the alternative wateryard using its own resources, and bought from *caros*. The family was large, with eleven members resident, and the respondent reported that it was difficult to obtain sufficient water from *caros* at this time (often two or three families shared a *caro*-load of water).

Four of the five borrower-families did not own carriage animals. In the seasons in which they borrowed, they normally obtained water from their local wateryard, carried by wives or daughters on foot (and two also obtained some additional quantity of water from *caros*). When the wateryards broke-down, the families borrowed donkeys and people-and-donkeys to transport water from alternative wateryards. (Some also purchased water from *caros* and/or *kazans* when the break-down occurred in the dry-seasons).

Other families (non-borrowers) living in these settlements, and lacking carriage animals, either obtained water from local *caros* and *kazans* or failed to identify a total break-down of their wateryard. It, therefore, appears that borrowers either could not afford to obtain all or any of their supply by paying the higher price for local water, or preferred, and were able to borrow carriage animals to access supplies in a non-local wateryard. However, water could potentially have been collected from alternative wateryards on foot: interviewees in Markib reported that water had been carried on foot from a non-local wateryard, even in *seif* in 1986; certainly the distances involved were less than those travelled on foot by residents of Hariri in *kharif*. Furthermore, family *tebeldis* could have provided a financially free and often local supply, however, only two families in wateryard settlements reported using them in this circumstance[9].

The same situation may be assumed to have confronted those *dammering* to wateryards and lacking carriage animals. (Borrowing relationships may have been more difficult to establish as a temporary resident). For those *dammering* towards Marahig, however, there was no alternative wateryard. Alternative sources were: *caros* and *kazans*, and wells at Abu Dulduc, some twenty minutes distant. Abstracting water from all these sources was financially more expensive than from the wateryard, and abstraction from the wells additionally demanded much greater effort or social costs (Chapter 5).

People who stayed in settlements at a distance from wateryards, who collected water from them by carriage animal, may be assumed to have been least affected. When the wateryards broke-down, water could be collected from alternative sources using the same transportation resources. For residents in Abu Shura, the alternative source was another wateryard, only slightly further away; for those in Umm Samra, Marahig was the only wateryard in the area and alternative sources were variously: *kazans*; *tebeldis* (private and commercial); lorries; and wells, all of which were the same, or a shorter distance from the village. All supplies were, however, more expensive than at the wateryard (except personal *tebeldis*), and (as noted) wells were associated with much greater effort or social costs.

The exhaustion of pools and *rahads* at various times during *kharif* (Chapter 4) may also be considered as a form of source failure, and their sporadic replenishment after showers, as reinstatement. This leads to a changeable pattern of source-location for villagers depending upon them as their wet-season supply. Only one example of short-term borrowing was recorded in response to *rahad* exhaustion (although one case of 'long-term borrowing' included borrowing in *kharif* to collect water from distant *rahads* when nearer ones became dry). This example came from Hariri, and concerned a female-headed household without any carriage animals and with only young children. It was an aid arrangement, which occurred only when the nearest *rahad* was more than one day's round trip on foot from the *hosh* (ie Rahad Daglos). In this case, the woman left her children with one bowl of water, borrowed from a neighbour, while she went to collect water on foot. No other respondents who were dependent upon *rahad* supplies and lacked carriage animals ever took more than one day to collect water from a *rahad*. This example suggests a definite need to borrow in order to secure sufficient water; there were no alternative, more local water supplies available.

Borrowing due to Intermittent Additional Water Demands:

Four cases were discovered in which washing clothes had generated short-term, occasional borrowings. Resources borrowed included carriage animal, person-and-animal, and water.

One example concerned a female-headed family living in Hariri, with all pre-school aged children, and no carriage animals (above). In *kharif*, the respondent normally carried 1jc per day on foot from *rahads* as the family's basic supply. This volume was, however, insufficient to allow any form of washing to be done, and it was impossible to collect more per day with the resources owned. Therefore, a camel was occasionally borrowed from a neighbour, and 4jcs volume secured for the family. This provided sufficient water for clothes and bodies to be washed and the chickens and dog to drink, as well as to satisfy their basic water requirements.

One family in Umm Samra routinely purchased one barrel of water every two or three days from a lorry as their basic water supply for half of *shita* and all of *seif*. When clothes were washed in *shita*, 6jcs of water were used, and four remained in the barrel. These were used until the next day, when two more were borrowed until the following day, when a barrel of water was again bought from a lorry, and the 2jcs which had been borrowed were returned.

Another case concerned a female-headed family in Umm Barouda, which obtained its basic water requirements in *seif* through a long-term borrowing of the labour of the respondent's brother-in-law (and possibly his camel) to collect water from Wakeel (above). Different borrowing strategies were, however, adopted for clothes washing: either water was borrowed directly from a neighbour, or the respondent sent dirty clothes with her brother-in-law to Wakeel to be washed by her niece or a neighbour who were *dammering* there. In this way, there was no increased pressure on the brother-in-law.

A further example came from Umm Samra. The borrower-family owned a donkey, and in *kharif* used this to carry their basic family water requirement from *rahads*, and to contribute to the support of an elderly mother who lived in the adjacent *hosh*. Only two jerricans of water were carried per day for the family's own use, employing the family's own resources. This was insufficient to allow clothes to be washed. This could only happen when the husband met someone at the *rahad* with a camel who was willing to transport an additional jerrican of water back to the village on the family's behalf. The interview was never concluded, therefore, it is difficult to evaluate this strategy more fully.

Other people in these villages washed clothes in water from the volume normally collected, washing a few clothes at a time. Alternatively, they sent clothes to people (relatives or neighbours) living or *dammering* near to the water source from which they obtained their supply, normally with a man-and-animal team. In still other cases, a woman or girl from the family would travel with the (male) collector to the source to wash clothes nearby; a man or boy would not wash any clothes but his own near the source.

Borrowing to cope with intermittent demands was, therefore, found to occur amongst residents of villages on the Basement Complex in various seasons, and was solicited by families of varied 'resource-status': a family almost self-sufficient in its basic water requirement in the relevant season, collecting by foot; a family able to purchase water from lorries to maintain its basic supply; a family able to collect its basic supply and a part of the mother's, using their own donkey and labour resources; and one borrowing for both basic and washing water supplies (by different strategies). In these respects, this form of borrowing contrasts with others previously noted. Perhaps this is because it is occasional, and flexible in its timing. Although examples were not discovered, it can be surmised that similar strategies may have been adopted for special celebrations, such as the *eid* or weddings.

Borrowing due to Illness:

Only one case of short-term borrowing associated with illness was discovered. It concerned a two-person family, comprising a mature, deserted, childless woman and her cousin of approximately equal age, living in Markib. The respondent farmed and the cousin was responsible for water collection. In *kharif*, when the latter was ill, the respondent borrowed water from neighbours. The size, composition, and support-network of this 'family' was atypical. Most mature women either: lived together with a husband and/or children; or, when widowed and/or elderly, lived alone or with a grandchild, adjacent to one of their children's families, and were supported (in terms of water collection at least) by them; or were accommodated within one of their children's families. This respondent, however, had no husband, children or grandchildren to provide these supports and securities, and no animals. The only alternative to borrowing would have been to purchase water from a *caro*, but the family's water requirements were small and the *caro* water expensive.

Borrowing due to the Absence of part of the Carriage System:

Only two cases of short-term absence-related borrowing were discovered. They came from Hariri and Umm Qarn, and both involved the borrowing of a donkey from a neighbour when the family's own donkey was absent. These were aid arrangements. In *shita* and *seif*, the co-wives of the *sheikh* of Hariri were in Qoz El Habil with their families, the first *dammering* from Hariri and the second not yet taken from her village. Both collected water from Abu Rasein wells. They owned one donkey in common and when it was being used, the second wife, who collected water by donkey, borrowed one from a neighbour for this purpose. A respondent in Umm Qarn also reported borrowing a donkey from a neighbour (a relative[10]) in *kharif* when her husband was absent with theirs and the *rahad* in use at that time was 'far' away (eg over 45 minutes by donkey).

Borrowing due to Lack of Assistance in Abstraction:

Only one case of this type was discovered. It concerned an elderly woman who lived together with her disabled husband and a young grand-daughter, in Wakeel, and collected water for the family from local wells. She was able to carry a jerrican of water on her head (ie to meet transportation-costs), but was unable to raise it from the well shaft[11], or lift a full jerrican onto her head alone (ie unable to meet abstraction-costs). Normally she was assisted in these tasks by a neighbour, going with her to the well. When this did not happen, however, she raised only half a jerrican volume; returned to her *hosh*; and borrowed water from a neighbour. Only when this borrowing was not possible did she return to the wells to collect more water herself (a further 1jc if she found someone to go with her, or half a jerrican if not). The respondent was old and ill and, therefore this was difficult for her. There were no alternative sources in Wakeel and the grand-daughter was too young to collect the water.

Borrowing for Reasons of Opportunity:

There were at least four examples of short-term opportunity borrowing recorded in interview. Four clear cases came from settlements on the Basement Complex lacking local, perennial supplies and other, more problematic examples, from Markib. Animal and person-and-animal teams were borrowed in aid and mutual aid relationships. The clear examples are discussed first.

One case concerned a respondent in Hariri who usually carried water for her family by foot from *rahads* in *kharif*. Sometimes, however, she met someone at the *rahads* with a carriage animal who would take her container back to the village on their animal for her. In this way both carriage animal and human labour were borrowed (although the respondent herself expended time and effort in travelling, and abstracting water).

Another example also came from Hariri in *kharif*. The beneficiaries in this case were two families whose water collection activities were closely bound in all seasons by various long-term borrowing arrangements: that of an elderly widow and her married son. In late *kharif/darat*, the son had borrowed his mother's donkey to collect water for both families from *rahads*; when possible, he also borrowed a donkey from "a man" (probably a relative or neighbour), which he, together with one of his sons, took to collect the water. The latter arrangement was of an aid type and was 'less reliable'[12].

A third example came from Umm Samra, and concerned a family which transported its basic supply by borrowing a donkey from a parent-family through a long-term aid arrangement. In *seif*, however, when the young family was *dammering*, it also occasionally borrowed a donkey from "someone else" (presumably not a relative) to transport additional water from Marahig wateryard. The water was then divided 50:50 with the lender, in a mutual aid arrangement.

The fourth example came from Umm Barouda and concerned a female-headed family, with pre-school aged children. In early *shita* (prior to *dammering*), the family relied principally upon water stored in their *tebeldi*, carried by the respondent on foot. However, sometimes it obtained water from Udeid *tamads* by sending containers with other people from the village who collected water there. This source was inaccessible to the respondent's family because the *tamads* required much digging; and furthermore, her children were small and apparently could not be left behind (see Chapter 5).

Each of these loans provided some occasional luxury for collectors: they eased the collection of normal family water requirements from usual sources; allowed additional water to be collected using the families own human-labour resources; and allowed water to be obtained from sources which were inaccessible with a family's internal resources (due to limitations of children's walking ability, and of effort costs expended in digging *tamads*).

The questionable cases of opportunity borrowing in Markib both concerned the use of visitors' donkeys to carry water for the host-family and their guests. It may be argued that this constituted a mutual aid borrowing relationship, because visitors' donkeys were accompanied by members of the host-family, and the water collected 'divided' (in some way) between both parties. However, it may also be reasoned that the guests temporarily became 'part of the family' (since they created demands upon host-households resources, as well as offering additional resources to it), and that, therefore, their resources were co-opted as family resources, rather than borrowed resources. In this respect, a parallel may be drawn with a family in Mustafa, comprising a deserted woman, her two young daughters, and her mother. In *shita* and *seif*, their water was collected using the mother's donkey and the respondent's labour. The 'family unit' did not borrow because two, probably previously independent units, were now one and their resources, although not jointly owned in title, were used to obtain a common water supply. However, even if the former interpretation is accepted, such borrowing was clearly qualitatively different from all other sorts described above, and the effect of visitors staying would appear to be of dubious benefit overall.

PURCHASABLE CARRIAGE SYSTEMS

So far, this chapter has considered families' use of owned and borrowed resources to overcome various transportation costs. However, an alternative approach was to purchase water with transportation costs included in the overall price. In the study area, transportation services could be purchased from *caros* and lorries, although, as will be shown, their areas of operation were limited.

It has been shown in the previous chapters that lorries and *caros* may be considered both as transportation media and as secondary water sources in their own right. This section explores a number of aspects of the delivery systems, among them the relationship between requested deliveries and opportunistic deliveries. All Government lorries were commissioned and there is evidence that at least some merchant lorry deliveries were also requested. *Caros* were also commissioned, and water was delivered to the *hoshes* of those who requested it.

When water is sold from a lorry or *caro*, the price charged per unit incorporates a variety of cost components. These may be divided into two types: the original purchase price of the water; and what may be termed the 'transportation/service cost'. The latter encompasses: a charge reflecting the time and effort involved in abstracting water from the primary source and filling the vehicle; the costs of fuel and wear and tear; wages for any employees, such as lorry crew; contributions towards vehicle maintenance; and a profit. The full range of sub-components may not always be included in the price charged, but some financial contribution must be paid if transportation is indeed 'purchased'.

When water is bought from lorries and *caros*, purchasers pay money to minimise their time and effort costs for water collection. Usually further transportation is minimal, and abstraction also much less demanding in terms of effort and time expenditure, since water can easily be siphoned into barrels and other containers (normally undertaken by the lorry/*caro* team). The structure of transportation cost, therefore, contrasts with that of carriage using a family's own or borrowed resources.

The purchase of a water transportation service is, however, not a universally available alternative to collection using owned or borrowed resources. It is constrained by the nature of service provision, and by the financial capability of the would-be buyer. Delivery services operated within limited spatial and temporal ranges, and in areas or seasons beyond these, people with adequate funding and a desire to purchase such services were unable to do so. For these reasons, the delivery of water by *caros* and lorries needs to examined in a different way to methods of borrowing described earlier in this chapter.

Caros:

Geographical Distribution of Caro Deliveries:

No *caros* were discovered in any of the study villages on the Basement Complex. On the Nubian Series, their availability was restricted to settlements containing a wateryard. *Caro* owners interviewed in Markib and Khammas Halab indicated an extended range of influence into some of the surrounding villages: to Shagooga, Umm Meriekib, Umm Hashim, and Gangei (not the village of the same name near Hariri) from Markib; and to Umm Eriq and (occasionally) Humeir El Bakheri from Khammas Halab. The son of the *sheikh* of Khammas Hajar also reported *caros* from that village taking water to Awamera when requested, at an estimated frequency of about 25 journeys/month in *seif*; Awamera also had five of its own *caros*. None of these surrounding settlements were found on the Sudan Survey Department maps, but from village council records (consulted at Khuwe) it is known that the former two served by Markib are located within the same village council; also Umm Eriq was reported to be fifteen minutes from Khammas Halab, and Awamera about 6km to the East of Khammas Hajar. It may be reasonably presumed that others are also within a small radius of the wateryard villages.

Cost of Delivered Water:

The vast majority of families purchasing water from *caros* paid a price which included both the commodity and transportation costs. In Markib there were an estimated sixty *caros*; in Khammas Hajar nine reportedly functioned commercially; and in Khammas Halab, thirty (KAEP, 1987). Assuming not more than one *caro* is owned by any one family, over 90 percent of families in each of these villages did not own one, and would have had to pay the transportation cost if they requested water delivery[13].

The transportation cost is represented by the overall price charged, minus the commodity charge. The cost of water must, therefore, be established in order to calculate the transportation cost, or else examples found where the transportation component only was purchased. An indication of the price of the water in each season can be derived from: the price paid by *caro*-owning sample families per barrel delivered to their *hosh* (who, therefore, paid money only for the water); and the statements of *caro*-owners/drivers and wateryard clerks. Figure 6.9 lists the charges reported at Markib; some discrepancies arose,

Figure 6.9: Charges for Water Delivered by Caro (pt) at Markib.

Respondent's Status	Shita	Seif	Kharif
Sample Household with Caro	50	75	100
	-	75	100
	75	75	75
Other Caro Operators	75	75	75
	75	75	75
Wateryard Clerk	50 - 75	50 - 75	50 - 75

with prices variously quoted between 50pt-100pt. At Khammas Halab, two sample households which owned *caros* reported costs of 50pt per barrel (although one noted that when there was insufficient fuel at the wateryard in *seif* the price was 100pt). This generally accords with information supplied by the wateryard clerk of 50pt per barrel charged in all seasons. At Khammas Hajar, the lowest price of any wateryard was reported by the wateryard clerk - 40pt per barrel - which was corroborated by several interviewees, who described buying a jerrican of water for 4pt.

Only one example was found where only the transportation component was charged. This concerned the family of the wateryard guard at Khammas Halab, which was permitted to take water free of charge from the wateryard in all seasons. The cost to this family for transportation-service alone, was 200pt in *kharif* and 250pt in both *shita* and *seif*.

Various figures for water cost have been noted. For the purposes of analysis, it was assumed that a standard price existed in each settlement and that it remained constant through the year: 75pt in Markib; 40pt in Khammas Hajar; and 50pt in Khammas Halab. By using these figures to calculate transportation costs it was found, from household interviews in each of the three wateryard settlements, that they ranged from 110-525pt, when local wateryards were functioning, to 950-1,150pt, when wateryards at Khammas Halab and Khammas Hajar broke down in *seif*, and water had to be brought from alternative wateryards (at an inferred water costs of 50pt per barrel).

This raises questions as to why variations should be so considerable. Firstly, are transportation costs consistently higher over greater distances from the primary source? Secondly, are there any particularly marked seasonal variations within a village? If so, are these uniform between villages? For the purpose of this analysis, unless otherwise stated, data refer to times when local wateryards were operating normally.

Transportation Costs Related to Distance:

Within wateryard settlements, there was no apparent variation in transportation costs according to distance from the source to the *hosh*. Each operator quoted one price per season for delivery of water within his respective settlements. This reflects the limited variations in time and effort costs demanded for delivery within a small radius of the

Figure 6.10: Variations in Prices of Delivered Water by Distance to Village of Sale.

Village of Origin	Village of Sale	Price (pt)	Season
Markib	within Markib	350	Kharif
	Gangei	500 - 600	Kharif
	Shagooga	400	Kharif
	Umm Hashim	500	Kharif
	Umm Merlekib	350	Kharif
Khammas Halab	within Khammas Halab	400	Seif and Shita
	Umm Eriq	500	
	Humeir el Bakheri	500	

wateryard.

When either the source of water or the delivery point was not local (ie outside the settlement), transportation costs increased markedly. It has already been noted that some *caros* based and operating in the study villages also served some surrounding settlements. In these satellite settlements, a higher price was charged per barrel of water delivered than in the wateryard settlements themselves. Figure 6.10 shows tariffs per barrel which were quoted by two owner-drivers, one from Markib and one from Khammas Halab, for selected seasons. The increase in price in satellite settlements was explicitly attributed to the increase in distance travelled.

Longer distances were also traversed by *caros* when local wateryards broke-down. *Caros* which continued to provide commercial service to their home-village had to collect water from a more distant source. In such circumstances, two out of the five *caro* owners/drivers interviewed at Markib continued to sell water in their home villages and three desisted. Of those interviewed at Khammas Halab, both providing full interviews continued selling water in the village; one of these explicitly stated that he did not sell water in Umm Eriq at these times. The increase in prices charged reflected the need to travel further, and could be explained in part by: opportunism - raising the price to what the market could bear (as noted in *kharif* and *seif*); and a reduction in the number of barrels that could be delivered for a given amount of time and effort invested, when compared with normal conditions (Figure 6.11).

Transportation Costs Related to Season:

One aspect of pricing explored was the degree of co-operation between *caro* operators in the setting of their charges. If there had been some form of agreement it would have been relatively easy to have identified seasonal fluctuations in transportation charges in each village and compared them. In practice, there seemed to be little agreement as to what happened. Some *caro*-owners/drivers did claim that charges were fixed amongst all *caro* owner/drivers together; others claimed this practice of group decision-making occurred in *seif* only, and that in *shita*, each set his own price; still another asserted the independent decision of the owner/driver; and another, who formerly noted centralised pricing, when challenged passed it off with a smile, and changed his response to 'the individual's decision'.

Figure 6.11: Variations in Prices of Delivered Water by Distance from Source.

Village of Sale	Price (pt)	Season	Source (wateryard of origin)
Markib	500	Seif	Suleiman
	700	Seif	Areibish
Khammas Hajar	500	Kharif	?
	1000 - 1200	Seif	?
Khammas Halab	1000	Kharif	Khennaga
	1000	Seif	Khennaga / Khammas ad Donkey
	1000	Seif	Khennaga
	1000	Seif	Khennaga
	1000	Seif	Khennaga
	1000	Seif	Khennaga
	500	Shita	Khennaga

Even in one village reports varied. Information was, therefore, contradictory. An interpretation is that there appears to be some degree of mutual assent between some operators but that, overall, prices are influenced by market conditions.

Some *caro* owners stated the prices they actually charged. Three of the five interviewed in Markib were able to provide complete information concerning the price at which water was sold in each of the three main seasons. In the two other interviews, partial information on tariffs was obtained. In the three complete accounts, different seasons were attributed with the maximum cost: *kharif*, *seif* and *shita*; and *seif* (Figure 6.12). In Khammas Halab, prices for all three seasons were obtained from two interviewees; one noted a price levy of LS4 in every season, the other, a maximum of LS4 in *kharif* and LS1.5 in *seif* and *shita*. Consequently, no uniform pattern of seasonal pricing was revealed from this information either within or between settlements.

Further details of seasonal variations in transportation costs were acquired in the course of household interviews. These were calculated from the total price paid for delivery at-*hosh*, and data analysed for each settlement using two approaches: the summarizing of all available transportation cost data for each season; and charting the relative seasonal transportation costs as reported in case studies of families who requested deliveries of water by *caros* in each of the three main seasons[14 15].

All household data on transportation costs have been summarised in Figure 6.13. These statistics provide substantial evidence for a common seasonal pattern to transportation costs between the three settlements. Despite minor variations according to the summary statistic used, *kharif* was normally the most expensive season, and *shita* tended to be the cheapest. In terms of price ranges though, *kharif* was the least varied and *seif* the most[16]. In inter-village terms, it is interesting to note that Khammas Hajar had consistently cheaper prices than Markib and Khammas Halab throughout the three seasons measured.

The case studies approach evaluated the responses from twenty interviews. Figure 6.14 illustrates the relative transportation costs paid for water in each season. Broadly similar conclusions can be drawn to those using the statistical method, but the higher costs in *kharif*, when compared with *seif*, is less striking. In Markib, six interviewees reported a maximum or joint maximum price of water occurring in *seif* (compared with four in *kharif*),

Figure 6.12: Seasonal Variations in the Price of Caro-Delivered Water (in Markib).

Shita	Seif	Kharif
300	300	400
500	500	300 - 400
400	500	no sale

Figure 6.13: Summary Household Data on Transportation Costs.

A: Minima, Maxima and Ranges of Transportation Service Charges (pt)

Village	Shita			Seif			Kharif			Annual		
	min	max	rge	min	max	rge	min	max	rge	min	max	rge
Markib	125	325	200	125	525	400	225	325	100	125	525	400
Kh. Hajar	110	210	100	110	260	150	210	210	0	110	260	150
Kh. Halab	150	350	200	150	450	300	150	350	200	150	450	300

B: Modal Classes for Transportation Service Charges (pt)

Village	Shita	Seif	Kharif
Markib	200 - 290	200 - 290	300 - 390
Kh. Hajar	100 - 190	100 - 190	200 - 290
Kh. Halab	200 - 290	200 - 290	300 - 390

C: Mean Values for Transportation Service Charges (pt)

Village	Shita	Seif	Kharif	Annual Average
Markib	218	295	300	271
Kh. Hajar	125	164	210	163
Kh. Halab	250	272	300	274
Season Average	209	261	282	

D: Median Values for Transportation Service Charges (pt)

Village	Shita	Seif	Kharif
Markib	225	275	325
Kh. Hajar	110	160	210
Kh. Halab	250	250	350

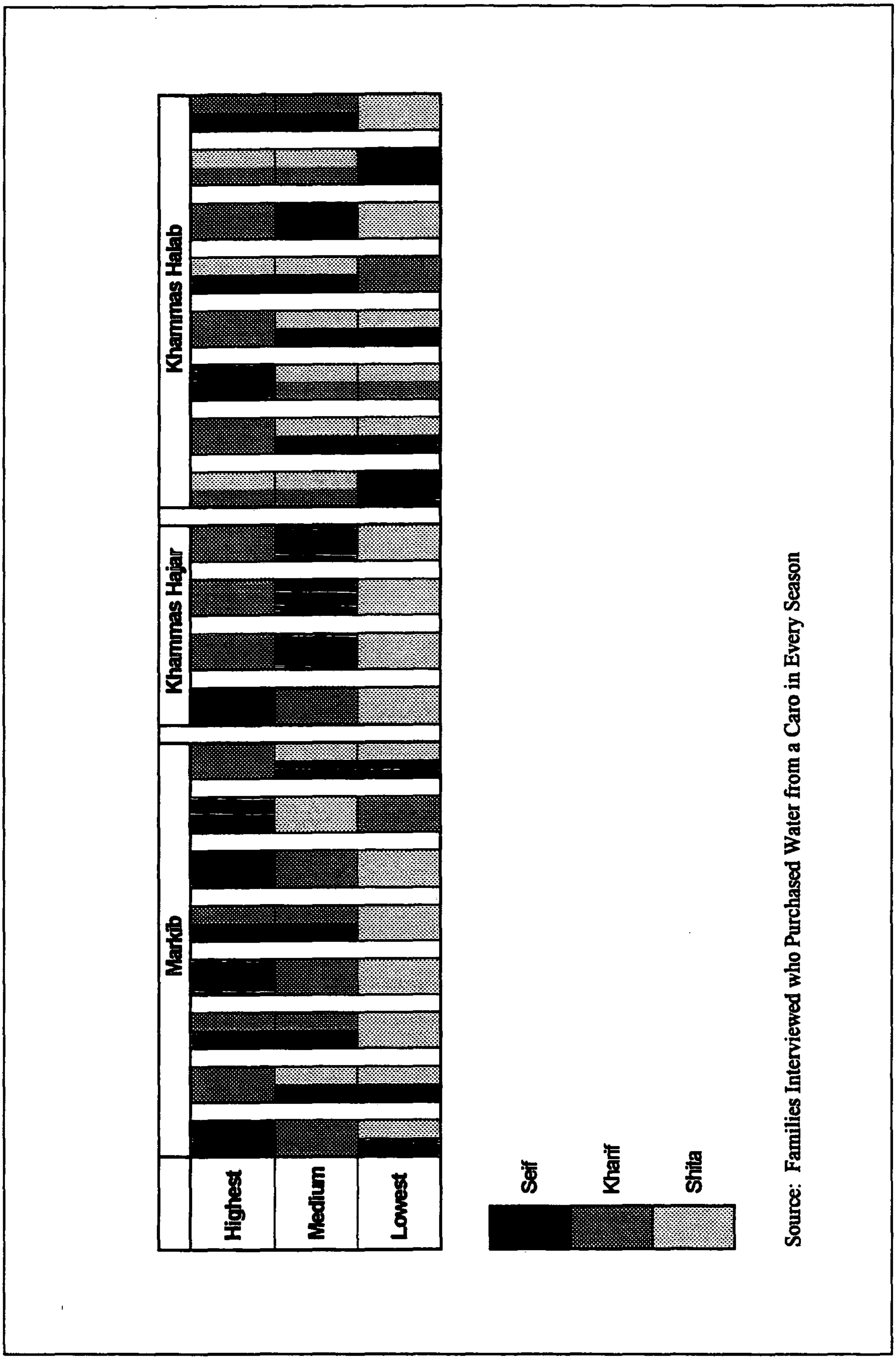

Figure 6.14: Relative Seasonal Variations in the Transportation Cost of Caro-Delivered Water

although in Khammas Hajar and Khammas Halab, greater costs were attributed to *kharif* in a majority of cases.

Having identified seasonal variations, it is important to try to ascertain the underlying causes. Superficially, the results are surprising: why should charges be greater during the *kharif*, when water is at its most abundant?

In both Markib and Khammas Halab, reasons for the seasonal variations were tendered by the *caro* drivers/owners. The relatively higher cost in *kharif* was ascribed to the premium placed on time in this season. People worked in their fields and so sought to minimise their time and effort costs in water collection by having water delivered to their *hosh* (ie by *caros*). In response to this demand, *caro* operators raised their costs to maximise their profit margins. An additional element was reported at Khammas Halab: one *caro* driver had to work on the family's land and so could deliver fewer barrels per day than at other times of the year (eight or nine compared with thirteen or fourteen). Raising prices enabled him to maintain his earnings. Indeed, simple calculation shows that the potential reduction of earnings caused by selling fewer barrels was more than offset financially by this increase in price (earnings of LS32-36 compared with LS19-21 per day in *seif* and *shita*)[17] [18]. Information derived from family interviews gave general support to the interpretations offered by *caro* owner/drivers. In particular, there were reports of increased cost and reduced *caro*-availability in *kharif*, because all families (including those of *caro* drivers) worked on their land. People commented that they were tired, needed water, and were willing to pay to receive water with minimum effort cost.

The relatively higher prices for water in *seif*, when compared with *shita*, could be explained mainly through shortages of supply at a time of increasing demand. In Markib, for example, high prices were explained by the difficulty in obtaining water at the wateryard combined with the increased demand from people who were living in or *dammering* to the village.

Frequency of Delivery:

Several deliveries were made daily by each *caro* operator. More were made when water was transported over short distances from local wateryards to residences within the settlement. It has been noted already that, in Khammas Halab, one operator reported making 13-14 deliveries per day in *shita* and *seif*, and 8-9 in *kharif*. Sometimes a purchaser did not obtain a delivery at the exact time of day it was required but it was reported several times in interviews that delivery could be secured on the day it was wanted. A problem with this system normally only arose when local wateryards broke-down and demand was at its maximum.

Lorries:

Information on lorry transportation was obtained from a variety of sources, including: interviewees in the study villages; commercial lorry crews interviewed in Khuwe; rural council officials in Khuwe and En Nahud; the government wateryard clerk at Khuwe; the *kazan* owner in Abu Shura; a *kazan* and commercial lorry owner in Markib; an official from the Governor's Office in El Obeid; the MADP 'wateryard' clerk in Khuwe; an official of The Soil Conservation Department of the Ministry of Agriculture in El Obeid; and a representative of The Gum Arabic Company in Khartoum. For the purpose of this thesis, lorries are termed 'merchant', 'government (RC)' and 'MADP' according to the agency which controls them, regardless of the body which supplied them.

Geographical Distribution of Lorry Deliveries:

Less than half the study villages were served by lorries. Of those that did receive lorry deliveries, more were served by merchant lorries than government (RC) or MADP lorries. No villages on the Nubian Series received government lorries and only Hariri, and possibly Umm Samra, benefited from them on the Basement Complex. Merchant lorries, however, served Abu Shura on the Nubian Series and Hariri, Mustafa, and Umm Samra on the Basement Complex. Additionally, Umm Gemeina received some lorry-delivered water but it was not discovered whether this was from government or merchant sources.

The wider pattern of delivery was examined from other sources of information. At En Nahud, centralised records were available of deliveries made by the five-lorry government (RC) fleet, based at the headquarters of En Nahud RC. Six government (RC) lorries operated from three bases within Khuwe RC, but delivery records were unobtainable at the time of the visit; only the working-record of deliveries made by one lorry, which was at the RC base at the time of interview, was available[19]. A list of villages which received deliveries from MADP lorries outside of the project's mandate was also obtained from the Soil Conservation Department of the Ministry of Agriculture in El Obeid. No records of the actual deliveries of 1987/88 were, however, available. There was no information on destinations or actual deliveries for merchant lorries; records are not kept formally and there is no centralised administration. Those settlements which were mentioned in these records, and which could reasonably be identified on the Sudan Survey Department maps are shown in Figure 6.15; many others could not be found and are, therefore, not included[20].

In order to understand the geographical variation in lorry deliveries, it is helpful to identify the operating considerations. A clear policy of targeting certain areas emerged in discussions with staff of the RCs of En Nahud and Khuwe, and the Ministry of Agriculture. Of En Nahud RC's five lorry fleet, four had been presented by the Gum Arabic Company, and one by the Governorate in El Obeid. This latter one was specifically to serve Talib village and its surroundings, because this settlement was large and particularly needy. Records showed thirty deliveries to Talib in 1986/87 and twelve in 1987/88.

In Khuwe RC too, some degree of sub-area targeting was practised. Lorries were stationed at different bases within the RC, to serve their local area. Each base had its own lorry management committee to control patterns of movement. There was, however, possibly some discrepancy between the lorries' reported locations as noted by the RC and the Regional Governorate. The former described the six lorries being stationed at Umm Bum, Iyal Bakheit, and Khuwe itself. The latter, described directing the four lorries which it had supplied to serve the areas of Iyal Bakheit and El Batha (to the East of Khuwe), and one other area which could not be recalled. Certainly delivery records show that El Batha was served from one of the reported bases. It is near Dudiya wateryard from which RC lorries reportedly took water to El Batha, and other village councils.

In addition to sub-area targeting, Khuwe RC operated a system of pre-designed delivery programmes for *shita* and *seif*. Water lorry committees decided their lorries' movements, taking into account village sizes and their water demands. However, in addition to these programmes, the committees received applications for delivery of additional water, for example in the event of a celebration. These were considered as they arose. It was clear

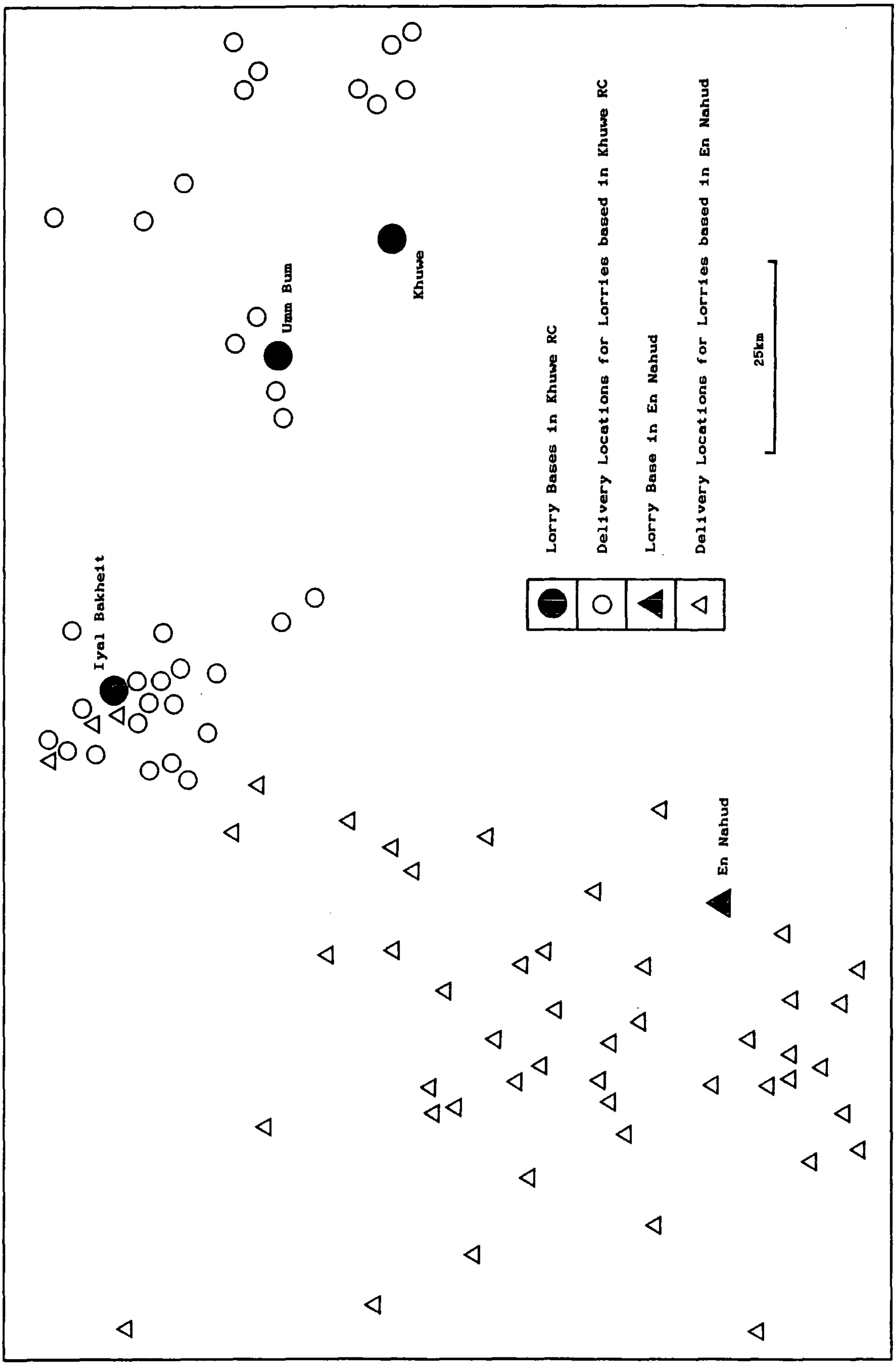

Figure 6.15: Delivery Locations for Government and MADP Lorries

that there were insufficient lorries to meet all requests (indeed, it was noted that sometimes they were not able to cover their own programmes). In *kharif*, few applications were received and lorries mostly received maintenance. In *shita*, there was some demand for lorry-delivered water, but there was sufficient slack to accommodate some specially-requested deliveries. In *seif*, however, there was considerable demand for water and their planned programmes were full. Furthermore, lorries faced a number of operating difficulties at this time, mainly due to over-use and poor maintenance. Therefore, only the neediest settlements were included on the rota, and 'additional request' deliveries could not be considered.

Targeting policy was also embodied in the MADP. The area of Kul Yusuf and Umm Bum was selected (with these villages as project sub-centres) as a result of a socio-economic survey across a large area which spanned Dar Hamar and Dar Hamid. The survey examined settlements facing major water problems where there was inadequate surface or groundwater available. This specific area was selected because it was particularly needy in this respect and also produced a considerable amount of gum arabic. The documented aims within this water-crisis area included: 'solving the problem of drinking water'; 'minimisation of difficulties that face people to find drinking-water'; 'saving of effort and time for people in finding drinking water that should be directed toward production'; 'encouraging of settlement in that area for greater utilisation of natural resources'; and 'minimisation of migration from rural area to the town' (Soil Conservation Department, 1987). So the need for water and opportunities for productive employment influenced the decision. In *shita* and *seif*, lorries delivered water from the MADP wateryard at Khuwe to *fantasses* at Kul Yusuf and Umm Bum, but when there was additional capacity, deliveries were sometimes made to other 'needy' settlements in the area, upon request, especially in *seif* (see Chapter 1).

Other positive influences affecting patterns of water delivery were less explicit. The practices directing delivery in Khuwe RC contrasted markedly with those adopted in En Nahud RC, where lorry deliveries could be secured only by a personal application by a village representative at the RC office, and the payment of a fee (at the time of visit, LS125 plus fuel). The timing of the delivery to a village depended upon how many requests preceded it in the list of applicants. RC officers reported a maximum of a five day wait in *seif*. In Hariri, it was said that the maximum potential frequency of delivery was once a month, because of the level of demand.

Merchant lorries may be considered as operating on market principles. Little is known about the criteria used to select spheres of operation[21], but some comments can be made with respect to Abu Shura. All interviewee families owned barrels for water storage (estimated at between one and five per family, by the *sheikh's* son). Merchant lorries visited the village in *shita* and *seif*, bringing water and collecting produce from the village: field crops in *shita*, and gum arabic in *seif*. When there was 'no produce', such as in 1987, the lorry came less frequently than it was expected to in 1988/89, because the good *kharif* of 1988 promised a good harvest. This pattern of small crop collection and water delivery, which was described by the *kazan* owner in Abu Shura, was corroborated as general practice by three lorry crews interviewed in Khuwe, and may be presumed to involve financial rewards. Additional relevant criteria are believed to include: size of village populations; personal contacts; the proximity of a settlement to others wanting water, and other distance-related factors, but little hard evidence was discovered.

Some factors mitigated against lorry deliveries. Some were obvious, most notably the presence of an operating wateryard in the village[22], but one which needs qualification concerned population size and settlement status. The term '*arit*' first arose in discussion with staff at En Nahud RC. It was used to describe Mustafa and meant a small community which had broken away from a larger settlement to facilitate access to fields for agricultural reasons, but which still owed allegiance to the *sheikh* of the parent settlement. This was despite the fact that Mustafa was recorded on the Sudan Survey Department map (1935). Staff commented that their water lorries did not deliver to such settlements[23]. The head officer of Khuwe RC later commented that in *arits* the number of people wanting water is usually insufficient to demand a lorry-load of water, such as the government lorries provided, and so they must rely upon merchant lorries, which sell water by barrel. This accords with the type of delivery received in Mustafa. Some confusion still remains, however: the distinction between village and *arit* is less clear in reality than was intimated in interview. Delivery records examined at En Nahud RC revealed that three settlements whose names were prefixed with the word '*arit*' had received water. One of these was 'Arit Gekalli'. Furthermore, another entry recorded delivery to a settlement called 'Gekalli'.

Although no conclusive answer could be discovered, it may be that both entries referred to the same settlement[24].

Cost of Delivered Water:

The price of water sold from lorries varied, and was influenced by a complicated web of factors such as: season; ownership; pricing agreements; distance covered; the degree of clustering or dispersal of the villages served; lorry capacity; the ability to carry commodities other than water; and fuel and maintenance costs. Because of the difficulty in isolating the effects of any single factor, subsequent observations need to be treated with some degree of caution.

Figure 5.4 shows the range of prices paid for lorry-delivered water by interviewees. (In Hariri, prices of LS10/barrel and LS15/barrel were ascribed specifically to government (RC) lorries). Different pricing considerations were adopted for deliveries by merchant, government (RC), and MADP lorries.

Merchant lorry crews, interviewed in Khuwe reported they only sold water in *shita* and *seif*, and that the prices for 1987/88 ranged from LS15-LS20 per barrel in *shita* and LS20-LS25 in *seif*. The different prices in each season were related to whether the delivery was 'near' or 'far'. Clearly transporting water over longer distances and difficult terrain would increase the amount of fuel and this would be translated into higher prices per volume of water sold, however, the exact definition of the terms was not clear. The distances referred to could have been measured from the lorry station; the primary water source; or even, other settlements which were to be supplied (see below with reference to government (RC) lorries); or could have been a more general statement of the overall distance travelled. Certainly the water source from which they filled varied according to how many lorries were already queueing when they arrived, and wateryard break-downs. The crews interviewed at Khuwe revealed many sources which they personally utilised for these reasons, including wateryards at Haraz, Dudiya, Beni Badre and even points as far north as Marahig.

There was no consensus concerning the timing of payment for deliveries, and perhaps it varied in reality: some interviewees reported paying for water upon delivery, whilst others refuted such claims, noting that payment must be made in advance. However, one clear example of payment upon arrival (in kind and/or cash) was described in Hariri[25].

Different payment procedures and pricing systems were applied to government lorries operated by En Nahud and Khuwe RCs. En Nahud RC would only allow delivery to be made if payment was received beforehand. It demanded LS125 in cash, plus the cost of fuel. Clearly, price-variations were determined by the fuel required, and this in turn related to distance and the terrain encountered from En Nahud (where the lorries were stationed and filled with water).

At Khuwe RC, by contrast, it was reported that payment could be made before or after receipt of delivery. The issue of water pricing was also more complex, owing to: the lorries being stationed at three different bases, and only one base being co-incidental with a primary water source; and conflicting reports received. Rural council sources reported that, prior to 1987/88, the cost of water delivered by their lorries was determined by the organisations which gave or designated them (ie the Gum Arabic Company and the El Obeid Governorate), and fuel was provided from 'the market' by villagers requesting the service. However, due to increasing costs for fuel, oil, spares etc and a new policy directive from El Obeid that lorry drivers should be paid their basic wage whether their lorry was operational or not, the prices charged could not cover operating costs. Therefore a new pricing structure was introduced, developed in consultation with village councils. Villagers requesting the service also had to buy fuel from 'the market'[26]. Besides the capacity of the lorry, the price increases reported related to whether settlements in the area were near together or far apart (and were lower and higher respectively).

Contrasting with the above method of pricing, an authority in the Governor's Office at El Obeid reported that the administrative officer of the RC had always decided the price at which water is sold. The only restriction imposed was that it had to be less than the price charged by commercial lorries. The Gum Arabic Company (Khartoum) also denied specifying the price at which water should be sold; the lorries which they gave were outright gifts. (It was admitted that it would have proved impossible to monitor what prices were being charged anyway). However, the Company did claim that it was often called upon to pay for maintenance and spares for lorries which it had given (and even for lorries which it had not donated!).

The price of water deliveries by MADP lorries was fixed in El Obeid (Soil Conservation Department of the Ministry of Agriculture). Water delivered to the Project's *fantasses* was consistently charged at LS8/barrel. However, MADP tariffs, consulted in El Obeid, showed a range of prices per barrel or per lorry load (26 barrels) for delivery to villages. Although these varied according to whether the charge was to include the price of fuel, villages were also banded into different rates of payment in each case. There was, however, insufficient mapable data for any conclusive interpretation of the relationship between price and the various measures of distance to be reached.

It was observed by an RC official that MADP lorries charged prices which were intermediate between those charged by government (RC) and merchant lorries. They were higher than the former because they included money for maintenance, spares and fuel purchases made.

Frequency of Delivery:

The reported frequency of deliveries varied with: season; lorry agency; settlement; and the informant within each settlement. In Hariri for example, interviewees indicated that merchant lorries came more frequently than government (RC) lorries. It was variously reported that, in 1987/88: merchant lorries had come 0-3 times a month in *shita*, and 6-8 times during *seif* (ie about once or twice a month); and, in *seif*, government (RC) lorries had come a total of four times (ie about once a month), and once every 1-3 months (according to informant). Official records in En Nahud broadly supported these reports: in the same year (1987/88 - November to June), the settlement of 'El Hariri' was shown to have received seven deliveries from government (RC) lorries between November and April, including three in March and two in April, and one in December and February. Other settlements recorded received between one and sixteen government (RC) deliveries in this period.

Although it was reported that merchant lorries delivered more frequently than government (RC) lorries in Hariri, reported frequencies were lower than those recorded in Abu Shura on the Nubian Series. Here reports ranged from 4-5 deliveries per month, although these could not be verified. The various distance factors (eg distance from water source; lorry base; and other settlements requesting water) could explain this.

Additional comments are warranted concerning the reliability of deliveries. Like wateryards, lorry-delivered supplies are vulnerable to break-downs and shortages of fuel and spare parts. It has already been indicated that the government lorry fleets at En Nahud and Khuwe numbered five and six lorries respectively, and that there is considerable demand for their services. This demand has been exacerbated by the numbers of lorries which were not operating, but languishing in repair yards. The NWC compound in El Obeid houses many old and broken-down water lorries. Others were being maintained by the MTD.

CONCLUSIONS

It has been shown that the means of carrying water affects: the volume which can be transported on each trip; the time taken to complete a trip; and hence the number of trips possible in a day. However, deviations from the norms for each mode of carriage have been recorded. In particular, these relate to the health and physical condition, and age and sex characteristics of the people and/or animals involved in transportation.

Examples demonstrated that the means of transporting water may: belong to a family; be borrowed; or be purchased. When familial, or borrowed resources were used, time and/or energy costs were incurred by each party involved, but there was no direct financial expenditure. When the means of carriage was purchased, the reverse was true and financial outlay substituted for time and energy costs. A family's actual ability to secure water is, therefore, influenced by the resources it can command (either by ownership, borrowing, or purchasing) and their deployment. Tasks other than water collection make competing demands upon resources and thus the 'relative cost' of water is an important consideration. Family relocation occurred when the relative costs of transporting water and/or 'at-source' costs became too great to allow a family to obtain its water requirements, such that there was a real or perceived insufficiency of accessible water.

A central concept in this chapter has been the perceived undesirability of relocating a family unit, articulated in interviews. Low per capita water consumption and great expenditures of time, effort and money were endured to this end. The hardships of *dammering* have been widely noted, and few benefits were mentioned other than access to water (and in some cases availability of work and food: this will be shown in the next chapter).

The deployment of family-owned resources is a logical and expected means of transporting water. However, borrowed and purchasable carriage systems merit more specific comments.

The importance and complexity of borrowing systems has been clearly demonstrated. Variations included: long and short-term borrowings; aid and mutual aid relationships; reliable and unreliable arrangements; the stimuli associated with these borrowings; and the variety of resources loaned, including animals, people-and-animals, people, and water. This contrasts markedly with the inadequacy of attention which borrowing has received in other studies.

When borrowing was short-term, the reliability of the relationship was not so important. This was because the borrower-family's locational permanency was essentially independent of the loan, and 'help' on occasions of need, was a social 'duty'. When borrowing was long-term, however, reliability was vital to a family's ability to maintain locational permanency (except in the case of opportunity borrowing). Long-term reliability was greatest when the loan was supported by close family-ties between the borrower and lender households, whether in an aid or mutual aid relationship, (or when it was linked to a service provided for the 'lender' by the borrower: stabling an animal, or a job). In examples from the study villages, only two cases of long-term borrowing involved unreliable relationships, and in one of these relatives provided a final back-up support.

In the study area, the majority of cases of long-term borrowing concerned families living in settlements on the Basement Complex, lacking local perennial water supplies. The only recorded exceptions were long-term opportunity borrowings in Markib, promoted by the wateryard there. Most cases of short-term borrowing also came from settlement on the Basement Complex without local, perennial supply. The exceptions to this were associated with: the temporary break-down of local wateryards, resulting in a sudden increase in distance to source for those in the village who travelled to alternative wateryards; and the one case of the illness of the collector in an atypical family unit comprising two women.

In cases of long-term aid borrowing, female-headed families which borrowed resources were headed by young mothers and elderly widows, lacking human resources and, sometimes, carriage animals. Commonly people-and-animal carriage teams were borrowed from relatives living in the village, to collect water from non-local sources. Hall and Ismail (1981) noted:

> *"... sons ... have a continuing duty to help their parents even when they themselves grow to manhood and marry." (p.126)*

In one case, however, a mother of young children borrowed only a camel, and travelled on it to collect water from En Nahud wells. It took her one and a half days to complete a round trip. In this case, the woman apparently had no direct family connections within the settlement, to which she and her husband had moved about five years previously. Male-headed families, by contrast, borrowed carriage animals, although in the two non-opportunity-stimulated cases examined, the borrowed donkeys were actually ridden by their wives. In one of these cases, the husband was reportedly occupied in labouring locally in all seasons.

The shift in responsibility for water-collecting between different members of a family when animal resources became available was notable. This had implications for women in settlements using non-local supplies (and for those in wateryard settlements where opportunity borrowing existed) who collected water on foot when their family lacked carriage animals.

It seems probable that all borrowing, especially that of water *per se*, was more significant than was accounted for in interviews, and closely related to family ties. This assumption was justified, for example, by the case of an old woman in Umm Samra who reportedly maintained complete control and sole use of all the water brought for her by her two married sons. However, when this was challenged on the basis of the large volume used, it was eventually discovered that her grandchildren were at the *hosh* most of the day and used these water supplies freely. Thus there are probably some additions and subtractions to be made in many families' reported water budgets, perhaps particularly in the smaller villages where the majority of people are related.

A problem of definition has been highlighted in this study concerning the uses made by hosts' of visitors' donkeys: this can be considered as a form of mutual aid borrowing or dismissed, by considering the guests as temporary 'members of the family'. Two other examples of possible borrowing, however, have been omitted from this discussion so far, because they seem more probably examples of employment. They concerned the acquisition of labour for driving *caros*. In one case, from Markib, the respondent's nephew drove the family's *caro* throughout the *kharif*, while her husband drove it in the other seasons. In the second example, from Khammas Halab, a boy from the village was 'brought' to drive the family's *caro* when the respondent's husband and brother-in-law were both unavailable. It is probable that payment for this work was made either in money or in kind.

Free or cheap delivery of water has been noted to occur as a family favour. This was never stated in interviews, but was reported by a *caro* operator. It is consistent with reported favours discharged by well-workers to their relatives and friends, and may be considered a form of person-and-animal borrowing.

Any repayment of a loans was hard to assess. It was only described in one case, and this involved the replacement of water which had been borrowed as an interim measure prior to the arrival of a lorry. This was similar to circumstances noted by Mohamed *et al.* (1982).

Purchasable carriage-services (*caros* and lorries) clearly make important contributions to broadening access to water geographically, although they have mutually exclusive and uncomprehensive spheres of operation. *Caros* operated over relatively short distances and served the populations of wateryard settlements and some of their satellites. In the main, they provided opportunities to reduce time and effort costs at the expense of financial costs, but rarely were they a critical source (in the sense of providing the only supplies available). Lorries operated within areas of water scarcity, mainly on the Basement Complex. Distances travelled were considerably longer and they played an important role in influencing the viability of settlements without perennial, local water supply remaining occupied, especially in *seif* (see El Sammani, 1978; 1981). Compared with *caros*, they offer a necessary rather than a luxury service. This point is further illustrated when their times of operation are examined: water lorries operated essentially in the dry-seasons whilst *caros* provided a delivery service throughout the year, and were especially in demand in *kharif*.

Prices charged reflected both the level of technology and inputs employed, as well as the distances covered in providing the service and seasonal demand for it. For lorries these inputs are complex, comprising: petrol, oil, maintenance, crews, parts etc, as well as the vehicle itself. By contrast, *caro*-delivery requires only an able-bodied driver in addition to the cart and horse. Water purchased by residents of sample settlements from lorries cost between LS10-30 per barrel, whereas that purchased from *caros* was between LS1.5-6 per barrel when local wateryards were operating normally.

The primary constraint upon ability to purchase the transportation-service of *caros* was posed by their geographical spheres of operation. *Caros* only operated in wateryard settlements and a few satellite settlements around them. However, within these areas, they were relatively easily accessible when the local wateryards were operating normally. The expense of this service, however, did preclude some families from purchasing water from them. Within the confines of a given settlement, prices did not vary greatly according to distance. However, prices were higher for delivery to satellite settlements. When local wateryards broke-down, those *caro* operators who continued to sell water had to collect it from non-local sources and charged higher prices than usual for this transportation-service to customers within their home villages. More importantly, prices varied seasonally. They were greater in *kharif* (planting season) and *seif* (hot, dry season). In *seif* it was difficult to obtain water at the wateryard because of the greater demand and increased frequency of partial or total mechanical break-down. Therefore, for ease, those who could afford it often preferred to purchase from *caros*. *Kharif*, however, was especially a 'poor season', coming at the end of the agricultural year, when most of the finance and food derived from the previous year's harvest has been consumed, and when a premium is placed upon time spent in the fields preparing for the next crop.

The use of owned, borrowed or purchased means of carriage enabled some interviewee families to access sufficient water whilst remaining in their home villages. However, some families and individuals did not maintain this residential permanency. They relocated for reasons of necessity and opportunity, and these movements are the subject of the next chapter.

FOOTNOTES

1 Although it would not have been possible for the woman to abstract from these *tamads* anyway, because it was necessary to dig in order to abstract.

2 See discussion on the ability of African women to carry heavy loads on their heads in Maloiy, Heglund, Prager, Cavagna and Taylor (1986).

3 It is quite probable that a person's labour may also be borrowed in an aid relationship, although this was never positively identified in interview. Some possible cases were noted and are discussed at the end of the borrowing section. Others were seemingly described for elderly people in Wakeel by the *sheikh's* nephew, but were unverified in interview. In fact, a combination of person-and-animal resources may have been borrowed in these cases.

4 The exact division of water between the two families concerned was found to vary from 25:75 to 50:50.

5 Her husband was absent all year, making preparations for and then going to work in Saudi Arabia.

6 In Umm Samra it was reported that a donkey could only collect water from Marahig (3½ hours distant) on alternate days, and carry 2jc per trip generally - ie securing 1jc/day.

7 The other borrowed in a mutual aid arrangement.

8 The young family was male-headed, except in *kharif*, but in the other seasons the husband worked near to the family.

9 One was the family which borrowed a person-and-donkey in *seif* in Khammas Hajar; the other, a family in Markib who normally used *tebeldis* as a supply. Generally *tebeldis* had been neglected and were considered non-sources.

10 This would have been some relative but not necessarily a close kin.

11 In other interviews in Wakeel, some younger women even described being helped to raise their jerricans.

12 At the time of interview, however, *rahads* had only recently been used by this family.

13 No *kazan* located in a wateryard settlement was owned by a person who did not also own a *caro*.

[14] An assumption of the second method is that a family will tend to use the same *caro* operator(s) in all three seasons. (There is no systematic material basis for this assumption from observation or direct report, but some support for the principle was suggested in interview discussions). Therefore, if any *caro*-operator consistently charges a higher price to purchasers than others this may not affect the analysis, since the relative seasonal cost pattern is being examined for individual *caro*-operators/limited group of operators, by the surrogate of 'price paid by individual families'. This method will, therefore, be used to confirm the existence of any seasonal patterns.

[15] Some qualification about the nature of the data needs to be made. Familial relations may often affect the actual prices charged to consumers. In this way, tariffs reported in sample interviews may be affected by unstated intra-family favour. By contrast, in the *caro*-owner/driver interviews, a more generalised, yet commercial rate will have been quoted, although one owner-driver reported selling water to relatives at a cheaper price than to others; there were three or four people to whom he gave water free of charge. This practice is similar to that of well-workers in En Nahud who favoured friends etc.

[16] Although the range is greatest in *seif*, it should be noted that extreme outliers can have a significant effect.

[17] A further theoretical explanation for the reduction in the number of barrels sold, and the high price charged in *kharif*, which was not mentioned in interview, is associated with the perception of one interviewee who described the *kharif* as a 'poor time' before the next harvest (compared with *shita* and *seif* as seasons when there is more money after the harvest has been gathered). It can be postulated that in *kharif* there are fewer families generating a demand for *caro*-transported water because of this poverty, but amongst those which do still require this service, there is great ability to pay. It may not, therefore, be possible for *caros* to sell as many barrels in *kharif* as in other seasons. This is a retrospective hypothesis which was not tested in the field.

[18] This report of reduction of sale in *kharif* was supported by reports of reduction or cessation of sale in *kharif* from other *caro* owner/drivers in Khammas Halab and Markib.

[19] The officer responsible for them was absent at the time of the visit and they could not be accessed. Some information was, however, subsequently forwarded to the author.

[20] Even amongst those identified, there is some probable error: in some cases two (or more) equally possible settlements with the same name were discovered, whilst others of the same name may not even have been included on the Sudan Survey Department maps (either due to omission or to their relative recent origin - post 1930s). Rural council headquarters hold records of each village in their R.C., grouped by Village Council. Information kept includes populations and numbers of families in each settlement; these are used for sugar distribution, and, incidentally, tend to record more people than live within the village proper. The records are in Arabic and translation was not possible in the field in the time available. They would have assisted greatly in locating, in approximate terms at least, those villages receiving lorry-delivered water. It was intended to collect this data on the subsequently aborted trip in 1989 (see Chapter 2).

[21] Some interesting facts were discovered concerning the need to request water. Some lorries operated on a request system whilst others hawked water. Some interviewees at Umm Samra said that people from the village flagged down lorries and elicited promises of delivery, whilst interviewees from Abu Shura and Hariri sent messengers to Markib and En Nahud respectively to request water delivery. However, in Hariri and Umm Samra it was also reported that lorries arrived unexpectedly, hawking water. Interpretations of this include the possibilities that: requests for delivery were made by some villagers, unknown to others; or that there was uncertainty as to

when deliveries could be made. Additionally, one interviewee in Hariri mentioned that a requested lorry was annexed *en route* to the village by the people of Sherati; it had to return to En Nahud to refill before the delivery could be made.

22 The only example discovered of lorry-delivered water in such a settlement came from Markib when the wateryard broke-down. One interviewee recalled that year as 1986 and noted that Areibish wateryard (which was normally used when Markib's broke-down) also failed at the same time. Lorry deliveries were an interim arrangement until the necessary spares could be brought and fitted.

23 Umm Barouda, Wakeel, and Umm Qarn (mapped) may be similarly classified.

24 On the Sudan Survey Department maps for the study area, no settlement names are prefixed by the word '*arit*', however, there are examples of places called simply '*arit*'. It is conjectured that in the surveys of the area, names were ascribed to sizeable settlements encountered and '*arit*' to those few unnamed and smaller satellite settlements. For the purposes of this study, the term 'village' will continue to be used synonymously with settlement, irrespective of size (unless its clearly something larger such as a town or city).

25 One interesting example of the flexibility of payments permissible was disclosed in Hariri. Payment was either in money or animals at fixed exchange rates of one chicken equals half a barrel or one goat equals three to four barrels (presumably according to the condition of the goat!).

26 Plans were afoot also for the Council to obtain government supplies of petrol, as was practised in En Nahud, but at the time of study this had not been achieved. Conflicting information came from the El Obeid Governorate which stated that it did supply fuel to areas such as Khuwe.

CHAPTER 7: DAMMERING AND MIGRATION

INTRODUCTION

Migration has been described as the ultimate safety-valve in the rural water supply system (Graham, 1969; Hulme, 1986). Hulme (1986) noted that:

> *"There is virtually no control over the physical components which determine the initial water input, and the managerial options are too restricted and weak to meet adequately potential water demand in a locality. But the mobility and transhumance of the population in the face of economic pressure or water scarcity are sufficient means of ensuring a balance in the system between supply and demand." (p.103)*

Migration may be classified according to the types of people participating. In this study, a distinction will be made between family-unit relocation, and the relocation of individuals. The former will be the primary focus of attention, and its characteristics, causes, and consequences will be analysed. Some consideration will, however, also be made of the migration of individuals, since this affects a family's requirements and its resource base (for example, through loss of labour and, potentially, through increased finances if money is remitted), and hence its ability to access available water supplies. More specifically: different family-lifestyles will be examined as adaptations to varying conditions of water accessibility; push and pull factors influencing movements will be discussed in relation to distance, intervening opportunities, and family resources; the characteristics of relocation observed in the study area will be analysed in terms of the people participating, their accommodation and interaction with other people, and the benefits and hardships associated; and some consideration will be made of the prospects for water source development in villages experiencing regular seasonal outmigrations of family-units. Data used in this study primarily refer to the water year *darat/shita* 1987 to the end of *kharif/darat* 1988, however, some additional information for other years will be introduced as appropriate.

FAMILY MIGRATION RESPONSES TO WATER SUPPLY ACCESSIBILITY

In her study of man-water relations in Gedaref District, Graham (1969) identified four broad types of lifestyle-response to varying conditions of water supply as follows:

(i) Nomadism: Living in tents, spending much time moving. One of the most extreme responses to limited water supply. The use of various temporary water points. Routes determined by water availability. Willingness to move, enables best use to be made of available pastures.

(ii) Transhumance: Living in villages, but spending several months each year in another area. Traditionally a regular dry-season movement of the entire village population to an established camp. Usually, a response to limited water supply, or more rarely for economic reasons.

(iii) Local movement: Villagers typically travel four miles for 4-6 months of the year during the dry-season to collect water. Animal carriage required if the water point is further than three miles away. Not all villages may have the resources required, and the only alternative to moving is to pay for water to be transported. Where distance to the nearest water point is more than six miles, the village must normally become transhumant; only occasionally will 'a community' have sufficient access to camels or a lorry for transporting water. The collection of water is time-consuming, but the unpleasantness of relocation is avoided. This type of settlement seldom has public services. (Potential problems in adapting to exceptional water shortages).

(iv) Sedentarism: Fully settled life-style, based upon permanent water supplies. Problems include: costly fuel; high population density; over-cultivation and new fields and grazing at a great distance. (Potential problems adapting to exceptional water shortages).

Within Graham's (1969) classification, family residential-relocation was noted to be an integral part of both nomadic and transhumant lifestyles. In En Nahud District, the relocation practised by some sample households, and locally termed '*dammering*', seemed to correspond most closely to the account of transhumance: participants moved from established settlements; the migration occurred in the dry-seasons; and migration was generally a response to water shortage (see too Ahmed, 1988). *Dammering* migration, however, differed in several significant respects from the transhumant type described. Graham (1969) stated that:

> *"Transhumance is traditionally a regular dry-season movement by the entire population of a village to an established camp." (p.427)*

By contrast, *dammering* movement was not 'regular' each year. Some families *dammered* occasionally; others more often; some every year before or after a certain event (eg the construction of a water source or the Very Dry Year). Hulme (1986) seems to support this assertion by noting that a community may one year be sedentary and another year virtually nomadic. Secondly, the relocation was not a village decision, and rarely involved 'the entire population of a village'. *Dammering* was seen to be an individual family's response to water costs and/or opportunities elsewhere, determined by accessible resources and requirements. Thirdly, destinations were not 'established' either for families from a particular settlement in any one year, or for an individual family through time. In 1987/88, those villagers who *dammered* from a settlement did not all go to the same place. Families decided where to go individually or with a close relative's household. For example, *dammerers* from Mustafa went to Wad Taharah, Wad Abu Khazm and En Nahud town, and *dammerers* from Hariri went to Qoz El Habil, En Nahud and Umm Gelib. Furthermore, individual families were noted to have gone to different places in different years due to a change in the families' circumstances (either resources or demands), or in the external opportunities available (eg watermelons or other water supplies). Fourthly, accommodation in destination localities was not always 'camps'. Some *dammerers* went to towns and rented *racoubas*, whilst others who went to *wadi* areas constructed their own shelters. Additionally, the definition of the conditions under which local movement was forced to give way to relocation (so that a family could obtain water supply) is open to criticism. Furthermore, economic attraction to family-relocation (*vis-a-vis* secondary benefit of it) was not apparent, and may indeed be considered spurious from the evidence available. These themes are returned to in more detail in this chapter.

Relative Discreteness of Lifestyle Types:

Graham (1969) noted that the four response-categories are not sharply defined in practice, and that there are many intermediate stages. She noted, for example, that there is relatively little difference between a nomad taking up rainy-season agriculture and a transhumant, whose cattle spend most of the year elsewhere. Therefore, it is difficult to label any form of movement precisely.

Hulme (1986) has taken up this classification for human response to water availability. However, he introduced some additional points concerning the relationship between classes. He described the possibility of a community's response to water shortage progressing from one class to another. For example, beginning with local movement to a source, then permanent movement to that source, and finally migration from the locality. Furthermore, he noted that a community may one year be sedentary and another year 'virtually nomadic with respect to its water supply' (p.97). This latter point, however, appears somewhat exaggerated, since nomadism and sedentarism embrace very different rationales, goals and attitudes (Asad, 1964; Khogali, 1979).

Lifestyles may alter more permanently in response to changes which are external to the family (eg water source provision and government policy), as well as to changes within the family (especially reduction in animal wealth). Spontaneous settlement in response to water supply improvement has been widely documented (see Chapter 3). Graham (1969; 1973) described the development of a new settlement and much immigration, associated with mechanised *hafirs* in the Qala' en Nahl Hills (Gedaref). Similarly, the exponential increase in population size of Khuwe has been associated with the development of the NWC wateryard, and the increasing number of boreholes, now totalling four (El Sammani, 1981) (see Chapter 4). Furthermore, temporary and permanent 'drop-out' from nomadism has been linked with sophistication and destitution associated with drought (Khogali and El Sammani, 1986) (see Chapter 3).

In the current study, several examples were found in which animal loss (as a result of the Very Dry Year) had altered the characteristics of movement for those whose lifestyle had previously involved a high degree of mobility with their animals. Having recognised the problems of identifying 'nomadism' and 'transhumance' as discrete categories, this can best be illustrated with a few brief examples, one from Umm Samra and another from Wakeel respectively. In the first case, both husband and wife were born in Umm Samra and lived there at the time of interview. Prior to the Very Dry Year, all the family had moved with animals: in *kharif* after planting crops, they went to Rahad Kharigadoot (to the East), Zerga (to the North) and Wakeel. They returned in *darat*. The respondent stayed there alone to harvest the crops, and the animals went with her husband to Wakeel for *shita*. She joined them in Fogi in *seif*. In 1988, they had only one goat and chickens remaining. In *shita* 1987 the family *dammered* to an area of watermelon which they had planted, and in *seif* moved close to the wateryard settlement of Marahig. This movement was attributed to the lack of water for their family use in the village of Umm Samra. In the second example it was noted that before the Very Dry Year (before the wells at Wakeel had been built), the family used to go with their animals to a place with good grazing near to Wakeel for *kharif* and *shita*, and in *seif*, they moved to Fogi. In the year 1987/88, by contrast, the family remained in Wakeel without moving, and owned only six goats. Other families had also become members of other settlements with local perennial supplies because the animal wealth remaining could not sustain a nomadic lifestyle. The desire to return to the former lifestyle was not unanimous.

'PUSHES' AND 'PULLS': THE CAUSES OF DAMMERING

In the previous sections, the basic characteristics of *dammering* have been outlined, and this movement set within a framework of varied lifestyle responses to differing patterns of water supply. In this section, the motivations for *dammering* will be examined.

What are the Push and Pull Factors and How are they Defined?

The terms 'push' and 'pull' factors are commonly used in the literature of migration analysis to refer to the perceived repellent attributes of the immediate locality and the attractive attributes of a distant place respectively (eg Mabogunje, 1970; Trilsbach, 1987). If either is perceived as significant, migration may ensue.

A conceptual point merits attention at this juncture concerning the distinction between push and pull factors influencing migration. There is one sense in which push and pull factors are two sides of the same coin. Basically, the presence of a desirable attribute in another locality (eg male/female employment opportunities or plentiful, cheap, available local water supply) represents an attraction for people living in locations without that attribute. However, this is a somewhat simplistic definition, offering no explanation of how real decisions to migrate are made. Thresholds of 'need' and 'benefit' which influence the decision need to be discussed.

Firstly it should be noted that, as a general rule, seasonal relocation is undesirable. Graham (1969) made this point in discussion of the time and distance travelled in 'local movements' to collect water. She further noted that although families were normally economical in their use of domestic water (with a mean per capita consumption of 16.2 lpd), some families in the Qala 'en Nahl Hills were in fact found to have reduced consumption to a half or even a third of the normal amount to avoid relocation in the face of severe and atypical water stress (however, there were repercussion for housekeeping standards) (Graham, 1973). Similarly, long journeys and economies were noted in the current study: in 1987/88, some families in settlements lacking local perennial water supplies consumed less than two litres per capita per day in *shita* and 2-4 litres per capita per day in *seif* for some period of time (although sometimes they also obtained water from watermelons). Furthermore, the preference for locational permanency was expressed in interview discussion.

Because of the preference for locational stability, relocation can be seen to occur either when families can not even obtain their (perceived) minimum requirement in water and food, or when the benefits of relocation are considered to outweigh the disadvantages noted. These may be termed 'necessary' (or 'push'-motivated) and 'opportunistic' (or 'pull'-motivated) migration respectively.

In the current study, necessary and opportunistic *dammering* have been identified by analysing the interview-responses of *dammering* and non-*dammering* families to questions concerning: the possibility of remaining in the settlement all year; reasons for leaving (where appropriate); the carriage resources to which they had access (animals and persons); and the number and type of animals and people present in the family unit, which can be taken as a comparative measure of water, food and fodder requirements.

Pushes: The Interrelationship of Resource Shortages:

What are the Pushes?

In his study of the White Nile Province, Trilsbach (1987) noted that push factors originate in the environment. Hulme (1986), working in the same geographical area, noted three primary push factors prompting migration and mobility: crop performance; the extensiveness of grazing; and the availability of water (or, more accurately, accessibility of water). Graham (1969) also noted that transhumance in Gedaref District was mainly a response to water shortage. In the present study, the shortage of water at home was the most commonly stated reason for *dammering*. The way in which conditions of water supply influence outmigration deserve attention in this section, since this is not simply a response to 'supply' *per se*.

It has already been noted that the decision to *dammer* was found to be made by individual families, and did not involve the entire population of a village in the manner described by Graham (1969) for transhumance. In a similar way, the conditions under which local movement gave way to *dammering* were different from those noted by Graham (1969). She described this in terms of the physical distance to the 'nearest' dry season water source, and the availability at village-level of the appropriate carriage resources for transporting water from it. There was no consideration of: the nature of water availability at a source; abstraction costs; transportation costs; or individual families' abilities to meet them. These have been examined in detail in chapters 4-6, but the influence of these characteristics will be outlined here with reference to the study area.

Water may be present at a neighbouring water point, yet effectively unavailable because of: the yield; demand/supply relationship; opening hours; or usership restrictions etc. For example, some wells such as Bur Islam were reputed to provide some water all year if dug, but yields were too meagre to merit the effort at least after *shita*. Abstraction costs (time, effort, and money) may also be prohibitive of access. Financial costs were especially noted to be prohibitive (Figure 5.4). Although providing a dry-season water supply in some areas remote from perennial water sources, *kazans* were commonly reported to be too expensive for interviewee families to use as a sole source of dry-season supply for any lengthy period. Transportation costs may also be prohibitive. Distance was considered by Graham in physical terms rather than time costs. In the study area, however, the impact of *qoz*-terrain on travel times, and hence upon the accessibility of supply, was reported. In one interview, for example, it was observed that, although the two well centre of Behher and Abu Dulduc were the same physical distance from Umm Samra, Abu Dulduc was used and Behher was not, because of the presence of *qoz* on the way to the latter, causing extra time cost.

From this analysis, *dammerers* can be seen to include those responding to the push forces of: insufficient carriage resources to transport sufficient water from those sources at which abstraction costs can be met, and supply is available; or insufficient resources (most notably money) to meet abstraction costs at those sources which can be reached with the available carriage resources, and at which supply is available.

In this study, no respondents in villages on the Nubian Series *dammered* in the Very Dry Year or in the years since then (including 1987/88). Indeed, of the sample settlements, only Abu Shura did not have an immediately local wateryard providing a cheap perennial supply, supporting a sedentary lifestyle[1]. However, all sample families in that village collected water in the dry-seasons from one of two wateryards about three hours distance, using donkeys and/or camels (local movement), with some supplement from lorry-deliveries and a local *kazan*. In the Very Dry Year, when the normal *kharif* source (a *rahad*) failed to provide a water supply, the sample families collected water from these wateryards in every season. It was, however, noted in a casual interview that some poorer members of the village who did not have access to carriage animal resources did in fact *dammer* to wateryard settlements. No further comment can be made on this subject since there was no evidence of this among the sample population.

On the Basement Complex, by contrast, only two of the seven sample settlements did not experience *dammering* outmigration in 1987/88. These were Wakeel and Umm Qarn. Wakeel was the only village which had a local perennial water supply, provided by the well-field. Domestic water supply was free of charge throughout the year. At Umm Qarn, all seven families had access to sufficient animal resources to allow water to be collected from Wakeel wells, which were 2½ hours distant (local movement). Collectors could pay for water for their animals in terms of money or labour - digging in a well (ie financial or effort costs).

Where and Why Pushes were Evident:

It has already been noted that there was only one (supplementary) report of *dammering* occurring from any sample settlement on the Nubian Series. By contrast, many respondents living in villages on the Basement Complex *dammered*. The villages of Hariri and Umm Samra provided examples of necessity for *dammering*, brought about by the imbalance between a family's requirements for water, and: the resources available to it; the supplies available; and the costs involved in abstraction and transportation.

In Hariri, family size ranged from four to eight members. The sources available in the dry-season and noted to have been within the range of one or more families were: distant wells at Abu Rasein and En Nahud; *kazans* at Gangei, Sherati, and Abu Nitesher (about two hours distant); and the occasional deliveries by government and merchant water lorries. It was necessary to have good access to camel carriage to obtain sufficient water for any family from the wells at En Nahud and Abu Rasein because of the distance involved. A donkey was only noted to have supported two people in terms of their basic water requirement (ie not washing) in one case when the supply was at this distance. The majority of respondents also noted the inaccessibility of *kazan* supplies as a basic supply (either suggesting that supply was not available or that it was too expensive). Furthermore, water supplies derived from lorries were insufficient to support a family because of: the infrequency of delivery; the high financial cost of the water; and the volume obtainable (which was low from a government lorry).

In Umm Samra, the number of people per household ranged from three to eleven persons, amongst those which stayed throughout the year. Dry-season water sources described as being within the maximum range of one or more sample household included: Marahig (3½ hours distant); Abu Dulduc wells (3½ hours distant); Abu Rakhei cistern and *tebeldis* (45 minutes distant); local *tebeldis* from which water was sold; and deliveries of water by lorry. To stay and collect sufficient water for a family from Marahig wateryard required: good access to watermelons plus a camel; or a donkey capable of carrying 4jc per trip (with normal carriage capability being 2jc/trip); or sufficient money to purchase water regularly from lorries; or ability to maintain a satisfactory combination of carriage by donkey (at 2jc/trip) and purchase from water lorries. The wells at Abu Dulduc, meanwhile, were widely considered to have too great social costs attached to collection, and furthermore they were too deep for regular manual raising of water by men even (see Chapter 5). Use of *kazan* water was limited by reported problems of availability and its financial cost; personal supplies of *tebeldi* water, by their limited life-span; and purchased supplies, by their price (and possibly by availability also).

Pull Factors: The 'Prize' of Watermelons, Food, Water and Employment:

What are the Pulls?

Although transhumance was said to be mainly prompted by water shortage (push factors), Graham (1969), Trilsbach (1986), and Hulme (1986) have all noted that migration may also be pull-motivated. However, some observations should be made concerning this type of motivation. Graham (1969) described migration of 'Westerners' from Gedaref District to the Gezira Scheme as transhumance for purely economic reasons: to earn money for the pilgrimage. However, in the SCF Report (1988) it was noted that families from the Umm Ruwaba District of North Kordofan who relocated to the Gezira Scheme did not net any significant financial profit from their work there, and that in fact the migration was undertaken essentially to avoid the problems of water and food shortage in their home settlements. It is, therefore, possible that some necessity-*dammering* may be 'disguised' as pull-motivated relocation.

In the current study, opportunistic *dammering* was noted to be relatively rare and focussed essentially upon the attraction of watermelons in their role as a source of water, food and fodder. However, besides actually stimulating relocation, pull-factors have a secondary role in influencing the destination of migration which is motivated by necessity. Each of these influences will be considered below.

Where and Why Pull-Motivated Dammering Occurred:

In all cases of pull-motivated, opportunistic migration identified in this study, it was the attraction of watermelons (owned or purchased) which prompted families' to relocate. Watermelons provided a supplementary source of water and food for people, and the major source of both for animals. It was reported that although the financial cost of purchasing watermelons for animals was greater than the cost of watering them at conventional water sources, there was a clear benefit in their additional role as fodder, making the animals fat and productive. Furthermore, commercial watermelon fields provided opportunities for male wage-labour.

Watermelons were used by some respondents and their animals for the duration of *shita* and most of *seif*, depending upon the exact circumstances. If these were planted in fields very near their village, families did not need to move: these could be reached with local movement, and water requirements sustained with limited supplement from other sources (which could not be accessed in such a way as to provide the family's sole supply). Relocation was noted to occur when available watermelons were at some distance for example, from Umm Samra to watermelons at Qoz El Abaras and Khor Hidgleet near Marahig; from Mustafa to watermelons near Abu Khazm; and from Umm Barouda to watermelons around Jebel Afarit.

Pull-Factors Directing Push-Motivated Migration:

When outmigration became necessary, a destination had to be selected. Any potential destination can be characterised by the following: the characteristics and costs of the water sources and supplies it offers; the characteristics and costs of other facilities and opportunities it offers (eg employment, food, housing); its distance from the home settlement (note the friction of distance); and personal ties associated with it (for example: family ties; well ownership; familiarity from previous visits). The suitability and attractiveness of a potential destination can be defined by the relationship of all of these factors, and a family's resources, requirements, and aspirations.

Obviously when 'water shortage' (or more properly, water inaccessibility) is the key force prompting outmigration, the water source will be an important consideration in the choice of *dammering* destination. Different types of source have different characteristics, in terms of: availability of water (opening hours; limited usership; demand/supply balance); cost of water at-source (time, effort and money); and the transportation costs when families are in temporary accommodation. Meanwhile, different families have differing requirements of a dry-season water source, depending upon family size and the number of animals they have with them. They also have different abilities to access available supplies according to such factors as the available labour (animal and human) and finances in relation to abstraction and transportation costs.

The non-water facilities and opportunities of potential *dammering* destinations may also be considered, especially the: potential for different types of wage labour; availability of food; and the type, location and cost (?) of accommodation. Families have different requirements or aspirations for each of these non-water opportunities, and different resources with which to utilise them. For example, it was noted in the study that women who headed households and needed or wanted to perform wage labour could not find employment in watermelon fields where men could work cutting the crop, neither could they find it in remote well-centres such as Wakeel, where men could find employment raising water for animals. These jobs were too physically demanding (and perhaps too time-consuming and socially unacceptable for women to perform). Women in the study population, therefore, found work in towns (taking grain to the mill, washing clothes, and cleaning houses) and in larger villages (cleaning and plaiting hair). Men also found employment in these places in stores and shops.

Clearly a great many hypothetical destinations may be described by various combinations of source and site characteristics. However, any one family may be presented with only a couple of realistic alternative destinations because of the frictional effect of distance. This was noted by several families. In Umm Barouda, one family described how they once *dammered* to Fogi before wells were dug at Kabra (in the late 1970s), and then *dammered* to Kabra before the wells were constructed at Wakeel (in the early 1980s). In each instance, the distance involved was noted to have been a factor leading to change of destination. (Indeed, distance was often given as a reason for why a family did not go to a source). Furthermore, personal factors such as well and watermelon-ownership, and family ties (resulting in financial savings on the one hand, and social, and financial benefits on the other) provided additional significant influences: in the final analysis, these may determine the destination selected. For example, some families from Umm Samra relocated to Qoz El Abaras because they had planted watermelons there. Some subsequently relocated to areas termed '*Juraba*' and '*Ad Deeka*', nearer to Marahig village with its wateryard, when these watermelons had been exhausted; others remained all through the dry-seasons using their watermelons. Additionally, in Hariri, the relocation of one sample family to Qoz El Habil was found to be based on 'family ties'. This was the only sample family from the village which went to this destination. The decision had been made by the respondent's husband, and this was the village in which he had been born, and in which his second wife was still living at that time. Whilst *dammering* there, water was collected from the wells at Abu Rasein.

THE CHARACTERISTICS OF DAMMERING EXPERIENCE: 1987/88

In the previous section, the seasonal pattern of available and accessible water supply, food, and economic opportunities, has been seen to prompt and direct *dammering* movement, characterised here in terms of 'pushes' and 'pulls'. In this section, an attempt will be made to describe the characteristics of *dammering* in terms of: its timing; the accommodation used by families; the participants; the interaction of *dammerers* with other people; and the hardships and benefits incurred, as described by those who *dammered.*

Timing of Dammering:

In the literature, transhumance was noted to occur in the 'dry-season'. However, it has already been stated that this is a simplified term, embracing at least two seasons (*shita* and *seif*), each with distinct climatic characteristics and agricultural tasks associated (Chapter 3). In field-interviews, respondents mainly reported *dammering* in *shita*, after the harvest had been collected from the fields. Reasons for leaving in this season included: inability to access sufficient water from the home-base at this time, for example, because *rahads* had dried up, personal *tebeldi* stores had been exhausted, and local watermelon crops were very poor (ie push-prompted); and the existence of extensive areas of watermelons (owned or otherwise usable) located at a distance from the village, requiring a relocation for people and animals in order to use them (ie pull-prompted). Some *dammerers*, however, left their home settlements in *seif*. This was because: water became inaccessible in sufficient volume to allow family requirements to be met, as supplies which had been used in *shita* became exhausted (these included seasonal wells, large *rahads*, *tebeldis*, and own watermelon crops); they collected gum from their land before leaving; and (in one case) they marketed crops or chickens at a different place to that to which the family finally dammered[2].

Accommodation in Dammering Destinations:

The type of accommodation occupied by *dammerers* was noted to vary, most notably according to the type of destination. Higher-order settlements were associated with higher-order services, including: larger markets; rented accommodation; and more and varied labour opportunities. Those *dammering* from Hariri to En Nahud, the administrative centre of the Province, generally availed themselves of the facility of rented accommodation. All rented residences were near the wells and recorded rents ranged from LS10 to LS40 per month (although the latter figure may have been inflated).

One respondent, who arrived in *shita*, reported staying in En Nahud for ten days without shelter before finding somewhere to rent. Another reported being unable to find accommodation to rent; eventually she had been given the use of a mud-hut belonging to a relative because of her plight (below). It was not possible to ascertain whether these problems of finding housing were because of a general lack of rentable accommodation, a lack of it within an acceptable distance from the wells, or shortages at an affordable price.

Not all respondents *dammering* to En Nahud rented accommodation. Indeed, the respondent who was assisted by a relative in 1987/88 (described above) mentioned that in previous years the family had built a rough-looking *racouba*, using cloth and bags for the roof, and with purchased grass. In the year 1987/88, however, she had been ill and could not live in such a *racouba* because it offered inadequate protection from the wind. Furthermore, a respondent from Mustafa (who had children and had been deserted by her husband) reported constructing a *racouba* from grass when *dammering* to En Nahud in 1988. However, by contrast to the rented *racoubas* discussed above, this accommodation was far from the wells. Indeed, at the District Council offices in En Nahud it was reported that, according to the town council rules, *dammerers* could not build temporary accommodation within the town limits. Strictly speaking, these rules did not even permit temporary accommodation at the town edge, however, a 'blind eye' was turned because of an awareness of the seasonal problems of getting water and work, and the presumption that these people would return to their farms in *kharif* of their own accord.

Those who *dammered* to watermelon crops in the *qozes* of Abu Khazm, Wad Abu Taharah, Jebel Afarit, Umm Samra, and El Abaras, or who went to live in the *khor* or *juraba* areas near Marahig village in order to use the wateryard at Marahig, also reported constructing their own dwellings. These were variously built from grass and/or *shamlas*, or branches. Most respondents described them as '*racoubas*'. Two exceptions to this type of accommodation in the *qoz* were noted. One family reported owning a permanent house in their fields, distant from the settlement in which they resided at the time of interview. This dwelling comprised two huts and had been constructed three years previously in the area where watermelons and other crops were grown. Secondly, an Arab family, belonging to the village of Umm Gemeina, and interviewed in a tent encampment, reported owning permanent houses at Abu Zerga, and planted watermelons in Qoz Zerga.

Only two families reported *dammering* to live within another village. One went from Hariri to Qoz El Habil (see above), the other moved from Umm Samra to Marahig. Both found accommodation in *racoubas*. In the first case this was rented at LS10 per month, and reportedly found only after a difficult search; in the second, it was lent by relatives residing in Marahig.

Participants in 'Family Unit' Relocation:

In the sections above, a basic distinction has been made between family-unit relocation and the relocation of individuals. However, some qualification concerning the completeness of the family-relocation was recorded, and merits discussion here. Three variants of participation can be recognised: firstly, that all the family go; secondly, that all the family except a guard(s) leave; or thirdly, there is a division of the family and some stay in the home village and some *dammer*. The first needs no further comment. The second and third types, however, do require some elucidation.

Those who remained in the villages of Hariri, Mustafa, Umm Barouda and Umm Samra (from which *dammering* took place in 1987/88), included not only those family-units which were not motivated to relocate by push or pull factors discussed above, but also representatives of families which had otherwise left the settlement. These people were left as guards. They were older people, predominantly women. One interviewee in Hariri said that it was older people who were left because they: wanted to stay; could not find work if they *dammered*; and, furthermore, were able to watch and wait for water and be more economical with it than younger people. These guards obtained their water supplies in different ways. In one interview it was said that they travelled on foot from Hariri to *kazans* at Gangei, Abu Nitesher and Sherati, and collected one jerrican of water per trip, carrying it on the head if a woman or on the shoulder if a man. In another case, however, the guard (the respondent's mother) was supplied with water by her grandson who was *dammering* with his mother and family in En Nahud. He brought her 2jc every ten days by donkey from En Nahud.

One interviewee, however, described the subdivision of a family, essentially so that those who remained could undertake agricultural tasks unassociated with wage labour (discussed below). The family could not maintain locational permanence through the dry-season, and so *dammering* was necessary. However, two members of the family - the respondent's husband and a daughter - remained behind to collect gum and watch the house. The carriage animals which they owned were sufficient to support the requirements of these two people only; they were insufficient for the whole family unit.

Interactions of People Who *Dammered*:

People who *dammered* in 1987/88 had various types of 'social' interaction, not only with non-relatives at the destination, but also with members of their immediate and extended family (who had variously: *dammered* with them; not *dammered*; or left for seasonal employment elsewhere). The example has already been described of water being taken by a boy from his family's *dammering* location at En Nahud to his grandmother, who had remained in Hariri as a guard. Other cases of intra-family interactions included: occasional visits made by family members working elsewhere; the clothes of a daughter who remained in Hariri being brought by her father to En Nahud, where the rest of the family were *dammering*, so that they could be washed; the mutual use made of a carriage animal and human labour by closely related families to collect water in a *dammering* location; and, finally, the announcement that *kharif* had begun in the home village and provision of assistance in returning there.

Casual interaction with non-relatives in *dammering* destinations can be assumed (eg whilst shopping, collecting water etc). A limited number of deliberate interactions were, however, also described. Many of these have already been noted in the discussion of employment opportunities for those who *dammered*, and, therefore, need not be repeated here. A further type of interaction, however, involved *dammerers* in En Nahud using private taps belonging to residents who lived nearby. Those living within the town generally reported that they did not known their neighbours except by name, yet they were permitted to use these taps in *shita* to obtain additional water to supplement that collected from the wells. However, this favour was withdrawn in *seif* when water supply was more difficult for everyone.

Hardships and Benefits in Dammering:

Dammering movement necessarily involved both benefits and hardships. For those for whom relocation was perceived as a necessity (due to lack of sufficient, accessible food and water etc) the benefits may most clearly be seen in their ability to meet their basic needs, and for those for whom *dammering* was opportunistic (to access watermelons), in securing the advantages associated (water, fodder and food). Additional benefits, however, were reported. These included: the opportunities for wage labour in En Nahud (to earn money for basic needs; and the availability of "anything you want..." in the *suq* at Marahig).

The drawbacks to *dammering* were, however, the more clearly stated and included: the hardship of leaving home and making a long journey, with young children, sometimes taking up to four days and involving travelling and carrying belongings and provisions entirely on foot; the high demand for water at the destination, leading to problems of availability; the high demand for foods (*aesh*, sugar, coffee etc), making them difficult to obtain, both in terms of their availability and/or price; the hard work involved in conducting wage labour; the poor quality of self-constructed shelters, which offered little protection from the wind of *shita*, the heat of *seif* or the rains of *rusharsh*; and the hardship of carrying water to locations in the *qoz* when no carriage animals were accessible.

INDIVIDUAL MIGRATION

It was noted in the introduction to this chapter that the migration of individuals would be given brief consideration in this chapter because of the implications which this has for family resources and requirements, and hence ability to access sufficient water etc. Individual relocation was associated with four types of activity: unwaged labour; waged labour; schooling; and various social functions. This migration sometimes occurred whilst the other members of a family unit *dammered* and/or whilst they remained at home. Each is now examined.

Unwaged Labour:

Migration associated with unpaid labour almost exclusively concerned herding a family's own animals (especially sheep) away from the sample village for some or all of the year. This involved male members of the family only (sons, husbands, and brothers of husbands), and occurred on both the Basement Complex and the Nubian Series. Two exceptions, to this pattern were identified on the Nubian geology. They involved male and female family members farming some land at a distance from the village.

Waged Labour:

The especial significance of 'migration for waged labour' for the rural water supply system is through any provision of money, and clothes etc (items of cash-expenditure) for the family-unit, and a reduction in the requirements of the family for such basic needs as water, food etc. However, this migration also involves the loss of potential labour for a family's production and reproduction.

Two types of waged labour can be recognised according to the length of commitment in any one place: temporary (of less than twelve months duration), and permanent (lasting twelve months or more). This distinction, however, requires some qualification. Firstly, there may be little difference in the effective absence of a person involved in a long-term work commitment who makes frequent return-visits of one or more months, and someone who undertakes a series of short-term commitments in any one year. Secondly, the study focussed upon those people who were considered 'part of the family unit' in the village, whether present or absent at the time of interview. Therefore, information was provided about those who had returned, or were expected to return to the unit after working away from home. Those who were no longer part of the unit may also have contributed significantly to the family's finances through remittances; indeed, some information was volunteered about those who would not return, including daughters who had married and left the village, and sons who had jobs in cities. Thirdly, the study did not seek to establish the financial contribution of any waged labour to a family's budget. This would be a study in its own right and well beyond the scope of the current research, although once again some occasional information was volunteered.

Given these limitations, the reported motivations for these migrations can be grouped as follows: poverty or lack of money (for example, for food and water, or for brothers' and sisters' needs); the Very Dry Year and the loss of animals associated; failure of the crop and/or locust attack on crops; lack of food; lack of opportunities, for labour locally, or for sufficient income or, more specifically, for "those who write". These are interrelated themes essentially expressing a lack of production of and purchasing power for basic needs. Those who left were exclusively male in 1987/88 (sons and husbands etc).

On the Basement Complex, there were very few cases of permanent migration for waged labour: the majority of cases were of temporary migration, and occurred in all seasons. This work was almost exclusively associated with farming or animals. Cases of permanent migration were also largely concerned with animal herding. Very few people were noted to have travelled abroad to work, indeed, few even left the District. (Exceptions included workers travelling to: Saudi Arabia; the Nile; Kenana; and elsewhere in western Sudan).

On the Nubian Series, by contrast, there were very few reports of temporary migration for waged labour in comparison with those of permanent migration. The latter almost exclusively involved non-farm or animal work. Those who migrated for temporary work also were involved in similar types of work (in shops, street sales, and a sugar factory), as well as in gum collection. Jobs were almost all based in towns outside the District, including overseas (especially Saudi Arabia), and Khartoum.

This pattern of work-type, duration, and location may reflect the relatively superior level and concentration of services on the Nubian Series compared to the Basement Complex in terms of: transportation; primary and intermediate level schools (and associated with it, greater attendance and higher academic attainment of family members); and accessibility of water. These in turn reflect the different potentials for underground, perennial water supply (see Chapter 3).

Schooling:

Aspects of the costs and benefits associated with formal education have been discussed at some length in Chapter 3, however, some points are relevant to this discussion and will be briefly outlined here. The only sample settlements which had school(s) were those with wateryards, and were situated on the Nubian Series. All had primary schools for boys and girls (single sex or co-educational). Some even had intermediate schools for boys and/or girls (see Fig 3.9), and where these were lacking, the nearest was relatively close by. Therefore, for primary and sometimes intermediate education, no relocation was necessary. Secondary level and university education, however, did require migration, and a greater number of children left home for these reasons on this geology, having acquired basic education locally.

On the Basement Complex, children from all the sample settlements had to relocate in order to acquire even a primary standard education. For those families whose children went to school there were the following 'costs': a total loss of labour during term time; and additional financial outlay for boarding and of transportation to and from school, on top of the basic fee. Consequently, relatively few children in these villages were found to have received any years of schooling. Most remained at home.

The benefits of education may only be seen later in increased opportunities (and aspirations) for waged labour elsewhere, and thus for remittances received by the families; and indirectly through associated health benefits.

Various Social Functions:

In this final section, other forms of migration will be briefly listed. These included movement for: medical treatment in Khartoum; social visits to relatives living at a distance (lasting, for example, for one month); attendance upon a young mother for the birth of her child (in one case involving at least a seven month absence); looking after an elderly relative; imprisonment; and trips to 'visit' animals and travel to other villages.

CONCLUSIONS

The 'adaptability of lifestyle' for those practising *dammering* movements can clearly be seen to redistribute demand for water and other commodities, and to act as a safety valve in the rural water supply system, as noted by Hulme (1986) and Graham (1969).

The evidence presented supports Graham's notion of threshold distances beyond which local movement by various means (foot, donkey and camel) cannot support a family in its water requirement, and beyond which *dammering* (or transhumance) becomes necessary. However, the current study has qualified this concept by demonstrating the importance of distance in terms of time-cost rather than physical distance and the additional factors of: at-source costs; characteristics of water availability; and families' differential access to carriage resources, and levels of requirements. Different families clearly have different potential for accessing sufficient water.

Push and pull influences in defining seasonal migration, therefore, vary between families, even within one settlement, and reference to *dammering* or transhumant communities belies an enormous range of actual capability to secure sufficient water. Examination of the details of *dammering* movement which occurred in 1987/88 has also demonstrated the range of experiences associated, in terms of: those participating in the movement; the distance to destination; accommodation there; interaction with other people; and benefits and hardships encountered.

From the general observations contained in this chapter, and from hydro-geological information on the poverty of groundwater (and hence sources exploiting it) in areas underlain by the Basement Complex, it can furthermore be noted that there is a greater propensity to *dammer* in response to water shortages amongst the population of settlements on the Basement Complex than on the Nubian Series. Longer-term hardships for those living in villages without perennial water supply, and *dammering* in the dry-season, centre around their low prioritisation with water development agencies (government and voluntary). No attention is given to such 'planting' communities. The prospect looks increasingly bleak with the large-scale withdrawal of aid agency personnel following the coup of 1989, and the drought and famine conditions of 1991.

FOOTNOTES

1 It was, however, reported by in informal interview that some very poor people went to live near the wateryard in *shita* and *seif*.

2 This defrayed the cost of water.

CHAPTER 8: CONCLUSIONS

CONCLUSIONS

Nearly quarter of a century ago, Lebon (1968) noted that:

> *"Everywhere [in north-central Kordofan] improvements in the traditional modes of livelihood are hindered by lack of water." (p.546)*

This lack of water still remains a key problem, and has formed the context for the current study of access to domestic supply.

Constraints upon Access to Water Supply:

In examining variation in access to domestic water supply it was necessary to identify the nature of the constraints which operated upon access in the field. Three types of constraint were recognised and have been examined in this thesis: availability of supply; at-source abstraction costs; and transportation costs. Each of these has required careful definition.

Water availability has been defined in this thesis as the physical presence of water at a water point, and the permissibility of abstraction from it as determined by the source-owner. It has been shown that the pattern of water availability is not uniform in space and time. Variation in the characteristics of water points and aspects of their site, which affect supply-potential (including geology), together with a range of dynamic variables, which affect supply and permissibility of use, have been identified. These include: rainfall characteristics; pest infestation; operation and management problems; the priorities and capabilities of individuals; and management-control, which is associated with ownership of a source.

Geological limitations provide the primary constraint upon the spatial pattern of water sources by: defining aquiferous zones, and hence areas where sub-surface and underground water supplies can be successfully developed; defining natural potential for surface water retention; influencing the potential for watermelon cultivation; and, indirectly, prompting and defining other man-made water source developments in geologically unfavourable areas. Khogali and El Sammani (1986) noted the constraint imposed by the water-poor Basement Complex formation in Northern Kordofan upon the development of sub-surface supplies, in contrast with the potential afforded by the Nubian Series, where perennial supplies can be provided:

> *"...most of the [En Nahud] district is situated on Basement Complex formation and thus has a severe water problem during the dry period." (p.168)*

Shepherd et al. (1987) further noted that conventional *hafirs* - man-made surface water developments lined with local clay - are restricted by the presence of *qoz* sands in the District:

> *"The [hafir] technology itself is not problematic, except that surface water is difficult to tap where the soil contains an insufficiently high or a patchy distribution of clay...Sandy areas on the Basement Complex, such as the triangle north of En Nahud, are the most intractable of all." (p.184)*

The temporal patterns of supply and usership permissibility through the year have been noted to vary considerably between source types. At some wells, tapping restricted aquifers, and at many cisterns, private ownership was found to have resulted in usership-restrictions when supplies became scarce, notably in *seif*. At the majority of open surface water sources, supply was highly seasonal (dependent upon the vagaries of the spatial pattern of annual rainfall and its characteristics), however their utility was essentially unrestricted and they represented 'communal facilities' for their limited duration. Only at sub-surface sources which tapped the deep and extensive aquifers on the Nubian Series, were both the supply potentially perennial and usership restrictions rare. These sources included both state-owned (NWC) wateryards and some privately owned wells. This highlights the inaccuracy of equating physical presence of water with available supply.

Besides water availability, the costs associated with the abstraction and transportation of water were also shown to operate as constraints to water accessibility. Three components of these costs were recognised: time, effort, and money. Transportation costs comprised time and effort in collecting water (or financial expenditure in purchasing a delivery service) and varied according to the pattern of water availability (above). At-source abstraction costs comprised the time involved in queueing or waiting for water to collect or be made available at a water point; the effort of drawing the water; and, in some cases, a financial charge for its use. These varied most notably with source-type and season, although more detailed variations were also identified and related to such factors as: social custom; the precise timing of collection in the day; and individual source management practices. Time costs were highly seasonal at primary sub-surface sources. For example, water percolation at perennial wells in En Nahud was slowest in *seif*, and queueing times longest at all wateryards in this season, as other available supplies dwindled. Effort costs varied markedly according to the type of source, and were greatest at *tamads*, *birs* and *tebeldis* where the depth and/or height of water was greatest. However, the precise effort cost at these sources was also noted to rise with increasing time after *kharif*, as water levels dropped and well shafts had to be dug deeper, or the volume of water held in *tebeldis* fell. Furthermore, the financial cost of water at those sources at which charges were made was higher in *seif* than *shita*, except at government-constructed wateryards, and was greatest at secondary sources which provided dry-season supplies (especially cisterns, *tebeldis*, and lorries). This can be explained by the investment made in transportation and/or storage of water and market forces.

Water supply was, therefore, not uniformly available to residents in the study area (in space or time), and those supplies which were available were associated with a variety of time, effort and financial costs relating to abstraction and transportation. By identifying the specific dimensions of water availability for families in different settlements, and the nature of costs associated with water abstraction and transportation, a framework has been constructed for understanding individual families' choices between the various sources, in relation to their differing requirements and effective resources.

Variations in Accessibility according to Socio-Economic Status :

It has been demonstrated that families in different settlements experienced different patterns and conditions of supply availability through the year. However, families residing in any one village clearly had differing ability to access the available water sources.

The relative burden of effort, time, and financial costs in water collection clearly varied according to specific family circumstances: the resources which a family possessed (including carriage animals, other animals, family members, and also crops, material possessions and money), and the competing demands placed upon them, combined with prevailing environmental and wider economic conditions. Variations in age, sex, health, (and pregnancy) etc, also influenced the broad patterns of access associated with different resources.

It has been shown that the distance across which water could be transported to supply a family varied according to the method of carriage which could be utilised. Foot, donkey and camel carriage offered increasing (non-commercial) potential to access remote sources, according to the differing speed and carriage capacity which they afforded, and patterns of donkey and camel ownership varied between families. Labour resources, and in particular the ratio of active to dependent members, also varied between families, particularly according to their stage in the family-lifecycle.

Ability to overcome abstraction costs also varied according to the resources available. Although Bland (1981) noted long queues at 'modern' sources in Sudan as a factor prompting the use of more traditional sources, this was generally not found in this study: people waited at wateryards for several hours in *seif*. (The only variant on this was that *caro*- or lorry-delivered water was sought by some families in order to avoid experiencing the queues themselves. This strategy required financial capability). Effort and financial costs in abstraction were, however, more significant obstacles to use of available supplies. The former affected women-collectors, who reported inability to: dig at *tamads*; climb *tebeldis*; and draw water from very deep wells. Financial constraints were primarily mentioned with respect to cisterns, lorries, and commercial *tebeldis*. These, together with other well features, are the main sources of dry-season supply available on the Basement Complex.

In addition to the carriage potential afforded by donkeys and camels, animals were important as a source of produce, income or exchange. Similarly, crops, possessions such as gold, silver and *shamlas*, and labour represented marketable assets. The sale of material possessions, poor harvests, and the losses of large numbers of animals through sale and death as a result of the Very Dry Year eroded many families' wealth and directly or indirectly their carriage capacity and ability to meet abstraction charges.

Probably those families with least effective labour (and other?) resources were young couples. A family with few realisable assets might have to expend more time and effort in collecting water to meet its requirements, so as to minimise financial expenditure associated with collection from local sources (non-wateryard). This has implications for the performance of other tasks.

Clearly socio-economic status is an important factor in defining access to available supplies. The impact of the Very Dry Year upon access-potential was, therefore, very significant.

Strategies to Overcome Constraints upon Access to Water Supply:

Where the existing availability of water presented a constraint to access, some families were able to finance the construction of additional sources. Private cisterns were found in a number of settlements in the study area, however, the financial expenditure etc required in their construction and filling made this strategy unviable for the vast majority of persons.

When abstraction and/or transportation costs could not be met directly by a family through use of its internal resource, certain options were found potentially to be open. These included: the borrowing of resources; the purchasing of a delivery service; and the relocation of a family-unit (*dammering*).

Some families were found to have 'borrowed' the labour of people or animals to raise water from a well. Women who went to collect water were occasionally assisted in raising it, either by other women at the source or, at En Nahud well-field for example, by hired well-workers. Additionally, in Umm Samra, some women reported paying a high 'social cost' by asking men to raise water from wells at Abu Dulduc. There, the effort costs of manually raising water were too great for a woman, and difficult even for a man, but asking in this way was clearly an option of last resort, and occurred only whilst the wateryard at Marahig had broken-down.

More commonly, resources were borrowed to enable water to be transported from remote water points. Animals, people, people-and-animals, and pre-collected water were borrowed in this way. Although in the latter cases the time and effort costs of abstraction and transportation were met by the lending family, the motivation for borrowing was generally to overcome the costs associated with transportation. Besides identifying the resources borrowed, analysis has been made of: the various types of borrowing arrangements; their duration; reliability; stimuli; and implications. In summary, long-term borrowing was associated with a basic inability to meet the costs of collection with a family's own resources (excepting the cases of opportunity-motivated borrowing); short-term borrowing, by contrast, occurred to overcome a temporary depletion of the resource-base or to meet infrequent 'additional' demands placed upon it. Both were evidenced primarily on the Basement Complex, reflecting the generally higher costs of access to water supply on that geology. The significance of access to male labour was evident in the borrowing which occurred by female-headed households lacking this internal resource. The importance and complexity of borrowing strategies has been essentially ignored in other studies, and its examination here represents one of the main contributions of the current study.

Purchasing a delivery service represented a second strategy. *Caros*, and lorries of various types provided the only commercial delivery services in the study area. However, their limited spatial and temporal spheres of operation have been clearly demonstrated. Government (RC) and commercial lorries operated only in *shita* and *seif*, delivering water to non-wateryard settlements. In the current study, it was found that only four of the seven sample villages on the Basement Complex received such deliveries at any time of the year from any type of water lorry. Lack of infrastructure limits the success of all water-lorry delivery operations: the condition of the 'roads'; limited technical expertise; unavailability or high cost of fuel and lubricants, all present significant obstacles. *Caro* operations, by contrast, were restricted to wateryard settlements and to a few of their satellites and were unaffected by the above limitations. Although their service was purchased in all seasons, it was essentially one of convenience, and represented relatively minimal savings in abstraction and transportation costs to the majority of purchasers (except in terms of queueing time in *seif*).

A third method of overcoming internal constraints to access involved family-unit relocation (*dammering*). This occurred when the relative cost of abstraction and/or transporting water could not be overcome in any of the ways noted (although it occurred for other reasons too - see below). Hulme (1986) noted:

> *"The greatest virtue of the rural water supply system ... is its flexibility of operation. In the last resort, the option of migration maintains the equilibrium of the water supply system." (p.103)*

In relocating, a destination could be chosen where water supply was available and the abstraction and transportation costs associated with access could be satisfactorily met. In the current study, *dammering* movement was only recorded in interviews on the Basement Complex.

Strategies to Overcome 'Expected' and 'Unexpected' Variations in Water Supply Availability or Accessibility:

It has been noted that many of the influences upon supply availability are dynamic. Where there are long-term 'patterns' of seasonal variation this may be considered to some extent 'expected' variation, and strategies must be devised to deal with them. Lifestyle-adaptations to varying conditions of water supply availability have been described by Graham (1969) and Mustafa (1981): broadly, for conditions of water scarcity to permanency, nomadism, transhumance (corresponding most closely with *dammering*), local movements, and full sedentarism.

Many families on the Basement Complex *dammered* because of inadequate access to water supply. The precise timing and exact destination of movement, however, was found to have varied between different people in the same village and the same family in different years. Factors affecting timing and destination included: the quality and size of the local watermelon harvest; the duration of supply at *rahads*, *tamads*, and in *tebeldis*; the locations where watermelons could be used; the resources owned by a family, and its precise weighting of the importance of distance, water source, employment, and other opportunities in the choice of a destination. Not all *dammering* was, however, necessity-prompted. Some *dammering* was opportunistic and occurred to take advantage of watermelons planted elsewhere.

Not all mobility which occurred was *dammering* movement. Other individual migrations occurred for wage labour, as well as unwaged labour, schooling and social events. For 1987/88, it was found that, among sample families, waged labour migration had involved only men. They had left for periods ranging from a few weeks to a few years, and travelled to a range of destinations, including locations within their rural council to countries in the Middle East. On the Basement Complex, the majority of movements were of relatively short duration and range, and all involved working with animals and on farmland. By contrast, on the Nubian Series labour migration was characterised by more long-distance, long-duration migrations, and most of the work undertaken was unrelated to farming and animals. It is suggested that this reflects the better communications and more widespread existence of formal education, and more limited costs in water collection experienced by those in settlements on the Nubian geology.

At the time of study, the most obvious example of 'unexpected' (or, more correctly, 'exceptional') variation in pattern of supply discussed in interview was the Very Dry Year of 1984/85, which came after a period of sustained low rainfall and desertification. In that year, animal and material possessions were expended, hardships endured, and many atypical movement patterns adopted in an attempt by families to save their animals and obtain their water and food requirements. There were examples of movement from Hariri to watermelon fields in Basheroo, south of En Nahud, and of people leaving Wakeel and the perennial wells there, in search of grazing for their animals. In the same year, arabs with camels came to the settlement because of its well-water; although there was no grazing for the villagers goats, the trees around the *rahad* were adequate for the arabs' camels to browse.

The Implications of 'Modern' Sources for Sedentarism:

Many non-riverain communities in semi-arid areas have become sedentary where geology has permitted the construction of wateryards (and *hafirs*): traditional forms of movement and seasonal sources of water supply have been abandoned.

The vulnerability of sedentarised communities, dependent upon water sources deriving supply from variable annual rainfall, has been noted in the literature. Graham (1973) described how the development of *hafirs* in the 1950s in the Qala' en Nahl Hills of Gedaref District was associated with the abandonment of traditional patterns of transhumance, population expansion and sedentarisation. When the rains failed in 1961, and the *hafirs* did not fill, the response was disorganised: there was a reluctance to move; no longer sufficient baggage animals to permit relocation in the traditional manner; and, for immigrant families, 'makeshift emergency evacuation'.

In the study area, a sedentary lifestyle, affording many social benefits (see Figure 3.9), has developed most notably in wateryard settlements on the Nubian Series, based upon the exploitation of underground ancient water supplies. The expansion of the sedentary population of Khuwe with the construction of each new borehole has, for example, been recorded by El-Sammani (1981). This has been accompanied by the abandonment of traditional sources. In Khammas Halab it was reported that, prior to the construction of the local wateryard, *tebeldi*-stores had been an important component of the annual water supply. However, there was no evidence that the break-down of the wateryards had placed undue stress upon members of these settlements. At least one alternative wateryard was close by in each case, and some water was available locally from *caros*, transporting water from these wateryards, and from private *kazans* from which certain families reported having obtained water. Furthermore, at Markib (where there was not the large number of alternative wateryards that was available among the Khammas villages) water was, in one year, brought by lorry to the village: the lorry was owned by one of the residents. The absence of 'crisis movement' in these cases can be explained by the nature of the 'failure', which was related specifically to an operational problem with a particular water point, rather than the supply *per se*.

The Inter-Relationship between Wateryards and Sustainability:

Traditionally, lifestyles in semi-arid Sudan have incorporated a substantial degree of mobility, associated with a dependency upon contemporary rainfall in regard to the provision of water and pasture etc, and have thereby achieved adjustment to the carrying capacity of the marginal environment. However, with the introduction of new technologies in the Twentieth Century for agriculture, drilling and excavating etc, this traditional relationship has declined..

There have been many technical problems associated with wateryard technology, not least: shortage of trained maintenance teams; problems of mobility; lack of spares; poor administration; lack of equipment-standardisation; and general inability to cover recurrent costs (see Bland, 1981; Abdalla, 1985). This is not a problem confined to the Sudan. With regard to water supply in the Third World, Wood (1975) has noted that:

> *"The existence of a number of expensive installations, now wholly or partly idle or operating inefficiently, in various parts of the world bears witness that water supply problems do not cease when construction is completed, and that the setting up of a management organization to finance, operate, maintain and extend as necessary is as essential as is the initial provision of pumping plant and other physical components." (p.8)*

Many aid agency programmes have included a sizeable wateryard rehabilitation component (eg CARE-NKWSP; CARE-IWP; SCF-Umm Ruwaba Programme), and the NWC itself undertakes work in this field. However, real improvements in operational efficiency are dependent upon drastic changes in resourcing and administration, which in turn are linked to the economic and political situation.

Although wateryard communities in the study area have not been subject to 'crisis outmigration' as a result of source failure, they are, however, vulnerable in two fundamental respects: firstly, as a result of an almost total dependency upon ancient, finite, underground water supplies, which were accumulated during pluvial periods of geological history and which are being progressively depleted; secondly, due to the large-scale environmental degradation with which wateryard developments have been associated. It has been noted that wateryards act as a focus for immigration and sedentarisation. In areas lacking perennial sources, the physical distribution of water supplies decreases with increasing time after the rains, and restrictions upon its use and all aspects of associated cost generally increase. This reduction in supply availability has resulted in concentrations of demand (both seasonal and permanent in nature) at the limited number of supply points which do exist. Such concentration of demand has been perceived by some as highly desirable since it enables services to be provided centrally and, therefore, with greater administrative ease. However, the environmental problems attendant upon concentrations of human and animal populations are clearly demonstrated by the desertified zones surrounding the majority of wateryard developments in Sudan (eg Ibrahim, 1978; Bland, 1981). El Sammani (1981) has noted with regard to Khuwe that the 'balanced ecosystem' has become 'stressed by expanding human activity' associated with the development of the wateryard. This environmental degradation could have been averted with appropriate land-use planning, however, such consideration was largely ignored, with water provision the primary (and political) planning goal of the NWC and its forerunners.

The technocratic approach, which has focused upon wateryard development, with a lack of effective land-use planning, must, therefore, be replaced by environmentally conscious policy, emphasising both long-term sustainability of water supply and preservation of natural resources in the vicinity of water points. The capacity of water sources must be carefully designed to complement the ability of the environment to sustain population concentrations, and alternative methods of increasing access to water adopted: the provision of water sources is just one of a range of development options which may improve access to water, and 'hi-tech' installations only one type of source option. Techniques to conserve recent supplies must also be sought as a matter of urgency (see below).

Appropriate Development for the Future of the Basement Complex:

In considering what action should be taken to improve access to water supplies 'appropriately' it is clearly important to consider the lessons which can be learnt from past action. Two issues must be addressed when considering any proposed 'improvement' in access: is the improvement sustainable? and who would benefit from the development?

It has already been noted that much of the water development activity of government and aid agencies has been concentrated upon the Nubian Series and has taken (and continues to take) the form of wateryard construction and rehabilitation. The inappropriateness of this type of development in terms of operational, water supply and environmental sustainability has been discussed. In addition, the location of the intervention might be considered inappropriate for the inhabitants of the wider region.

Villagers, government and non-government agencies may have individual and differing perceptions of what constitutes 'appropriate' development of water supply. For aid agencies and government water authorities, appropriateness has been defined in terms of the production of large volumes of water and intervention has, therefore, been technology-led. It has focused upon hi-tech high capacity systems: boreholes and wateryards. Consequently, appropriate areas for development have been defined as those geologically suitable for the technology (the Nubian and Umm Ruwaba Series). Secondary site-selection factors have included the social cohesiveness of a community, and proximity to other developments being undertaken by the agency. These are the criteria for ease of operation for the agency concerned and also, reportedly, important for bringing about 'developmental synergisms', but are not necessarily in the wider interest of reducing the concentration of populations and stemming dry-season outmigration from Basement Complex areas. Consequently, the increased volume of water supply made available by such techniques not only comes at a high environmental cost (above) but leaves the needs of large sections of the population in the areas of Basement Complex geology unameliorated.

Development intervention must be conceived with this wider perspective: to focus upon the active maintenance of a healthy land-man-water relationship and evaluation of the populations' needs across all geologies. External agencies (including NGOs) should present, and be permitted to present, examples of 'good practice' and operate as catalyst of change rather than to reinforce existing patterns of inappropriate development. This requires environmental and social study, and investigation and implementation of alternative methods of improving access to water supply.

Environmental and Social Study:

Although socio-economic context and environmental impact assessment studies have recently been undertaken in the context of water development projects, evidence to date indicates that these studies have not been central in the conception of the projects, and have had no real impact in determining the type, or the location of development which occurs (for example, see Bjornson, 1985). The reasons for this may include intransigence on the part of the authorities concerned; a failure to produce usable, valid information; and the long periods of time which have elapsed before the results of research are presented.

Clearly there is substantial scope for improving both the type and speed of information provision, and for the re-education of those involved in the process of development (including officials, researchers and implementors) to recognise the significance of environmental considerations. Realistic, relevant policies should include the centrality of socio-economic and environmental studies in the development process.

Options for Improved Access, Including Various Source Developments:

A range of problems associated with wateryards has been considered regarding operational unreliability, supply sustainability and environmental impact, and a geological bias. There is, therefore, a clear need for more low-tech, 'appropriate' solutions, which are independent of centralised institutions for their operation and which can be more widely established. In this thesis, it is suggested that the problem of access to water may be addressed by seeking to cut any one or more of the several constraints of availability and accessibility: most especially significant would be a reduction in transportation costs to sources with low financial abstraction costs, effected by reducing distance to source through the provision or conservation of more local sources, or through the provision of carriage resources, such as donkeys, combined with adequate, more efficient containers.

Reducing transportation costs of time, effort and money:

can be effected by reducing the time-distance to source, through:

- construction of additional sources, available to all people
- maintaining and enhancing local water points
- conserving water at local sources
- increasing reliability of source supplies
- improving access to reliable methods of carriage which are quicker and have greater capacity compared to those currently used (eg by the restocking of carriage animals)
- improving container-efficiency for carrying/storing water

Reducing at-source time and effort costs:

- improved methods for raising water from wells (eg windlasses at wells)
- increased reliability of mechanical components of supply provision for wateryards and lorries
- increasing/conserving supply availability (see above).

Reducing at-source financial costs:

- lowering the charge for water use through co-operative/government initiatives to improve efficiency and combat the exploitation associated with high levels of demand and limited supply

Handpump technology may be considered 'appropriate' for semi-arid marginal environments like North Kordofan, and is becoming adopted as an increasingly popular solution to the drinking water problems in those areas which are geologically suited to it. At the time of study, the ongoing UNICEF programme in North Kordofan was becoming increasingly productive. In this programme, one handpump was installed for every 200 people in a settlement. Problems of maintenance and repair, which hinder wateryard developments, were being addressed through the training of local men and women as mechanics, and through the more widespread distribution of spares-stores, and attempts were also being made to encourage the establishment of a handpump factory in the country, although progress had been slow. Environmental impact assessment was being made at the time of research and initial indications were favourable.

The development of various forms of personal and/or community[1] rainwater catchment tanks/cisterns should also be pursued, as a means both of conserving 'free' water in situ, and providing an efficient storage system for water brought into the locality. These stores should be covered to reduce evaporation and lined with impermeable material. Cement-lined cisterns which were found in the study area were beyond the financial capabilities of the majority of families, and hence attention needs to be focused upon the development of alternative methods of construction within the financial means of individual households. Supply could be derived variously from: *rahads*; occasional pools in the surrounding area; and lorry-delivered supplies. Indeed, in field study these supplies had been used in some villages. Specially developed catchment areas may deserve some attention also, and were under investigation by the UNDP at the time of study.

The idea of catchment tanks is certainly not a new one. Experiments took place in Sudan in the 1960s, during the Kordofan Land and Water Use Survey, and were claimed to be successful, but the project findings were reputedly "killed because of professional jealousies" (Stern, 1985: p.13). Subsequently, some revival of interest in this source-type has occurred but this would appear to be relatively insignificant compared to that directed toward the development of underground water supplies.

Lessons can be learnt from projects undertaken elsewhere in Sudan and in other countries, and should be supported by appropriate social study. For example, Gould (1984) has discussed the development of various catchment tanks in Botswana. He noted:

> *"Due to the many problems [both practical and perceptual] related to rainwater collection from thatch it is the writer's opinion that time and resources would be better spent developing and improving small scale ground catchment tanks already widely in use, and constructing large communal tanks at schools, clinics and other public buildings having large iron-roof areas." (p.15)*

In the study area, nearly all buildings had thatched roofs. In wateryard settlements, a few private dwellings had metal roofing, as did some *suq* shops and some public buildings. In Khammas Halab, water was seen to be channelled from the roof of a domestic dwelling and a *suq* shop, into a private cistern and a barrel respectively (Plates 27 and 28).

Local initiatives to maintain and enhance local water points, such as the deepening of *rahads*, which provide communal supply, should also be actively encouraged with tool provision. This positive recommendation was made by Morton (SUDANAID, 1985a).

Besides constructing/enhancing sources, the relative distance of existing sources might be effectively reduced through a programme of donkey and camel stocking. This might also be initiated (following upon appropriate social studies) as a means of improving families' ability to transport and hence access water from alternative sources. The restocking of sheep and goats for destitute families was proposed by El Sammani (1986), and in 1988, OXFAM was involved in restocking sheep for families in Umm Badr. The importance of donkey and camel carriage has been amply illustrated in this thesis, together with records of the loss of these animals following the Very Dry Year. SUDANAID (1986a) noted:

> *"Virtually all farmers... prioritised donkeys as their most immediate need. It is difficult, however, to see how farmers will raise the necessary cash... only the larger landholders are likely to be capable even of purchasing a single donkey." (p.50)*

The Past: The Prospect:

This thesis began by outlining the objectives of the IDWSSD. A range of projects were described from various parts of the world which came within the objectives of the Decade.

In the Sudan, a number of projects were initiated in the 1980s, but an evaluation of their impact on the study area may at best conclude a qualified success. In En Nahud District, as elsewhere in the country, most of the new developments and initiatives have tended to perpetuate the advantages of areas and/or settlements which already had superior facilities, most especially those on the Nubian Series. The emphasis has been predictable because of the need to rehabilitate existing sources and so maintain supply (especially in response to the 1984 drought), and the lingering perception of wateryard technology as desirable. It has, however, worked to the disadvantage of the areas on the Basement Complex, which have a particular historic problem of shortages of permanent water supplies, exacerbated by the absence of adequate roads, which hamper distribution by water lorries, and other traffic. Physical and political isolation may be viewed as important general constraints upon access to water, and have made carriage animals a necessary requirement for families seeking some degree of permanent habitation in settlements lacking local perennial supply.

In policy terms, it is important that future considerations focus on the more remote areas of Sudan. In 1985, Hulme commented on the problems caused by major policy decisions being taken by bureaucrats in relatively well-serviced urban centres. Indeed, one employee working in the wateryards section of the NWC in El Obeid, who was interviewed for this study, mentioned that he had never seen a rural wateryard! It is important, therefore, that the final aim of this thesis should be to contribute to an understanding of access to water as an integrated problem in the broader context of water supply policies, and to encourage more detailed investigation of this subject at the scale of individual households.

Broader Implications for Semi-Arid Areas (and Associated Coping Strategies):

Problems associated with water supply and sanitation provision exist in every country in the world. The 1980s was designated the International Water Supply and Sanitation Decade in recognition of the urgent needs for water and sanitation provision, especially in the poorer countries of the tropics. Although every region and people have their own unique cultural, economic, religious and political characteristics, which define particular problems of access to domestic water supply, similarities can be recognised. The conclusions of this thesis can, therefore, have implications for other areas, particularly in the Sahel which share the characteristics of: a fragile semi-arid environment, poor infrastructure, national poverty, and an essentially rural agro-pastoral economy, with differing geological potential for water source development.

The most important conclusion of this thesis may be regarded as the clear demonstration that access to water supply is an integrated problem involving complex social, economic and environmental relationships. It is necessary for policy makers to recognise the difference between availability of and access to supply. The physical availability of water is only one component of accessibility and, therefore, an increase should not necessarily be equated with an increase in water accessibility: usership restrictions may preclude certain families from collecting water at a source, thereby limiting the extent of effective availability; families' have differing resource-bases and sustain different resource-demands, affecting their internal ability to access sources which are available to them; families' access to available supply is not defined simply by the physical resources which they themselves possess (nor yet as widely as the physical resources which the 'village' possesses) but may be extended through borrowing and purchasing arrangements and family mobility. This conclusion represents a challenge to conventional discussions of 'water supply problems' which tend to focus upon the presence or absence of supply *per se*. It also poses a challenge that more consideration should be given to uses made by families of resources which are accessed through various social inter-relationships (see 'Further Research; - below). Access is a complex concept and should be recognised as such when agencies formulate an intervention policy.

The investigation of access - ability to meet the transportation and abstraction costs variously associated with available supplies - which has been carefully constructed in this thesis has clearly identified a number of means by which access to supply can be improved in this and similar areas: by reducing any of the constraints affecting availability of water and/or time, effort, or financial costs at-source, or incurred in the transportation of water to *hosh*, which have been discussed above.

It has been shown that families deployed a variety of resources in their efforts to secure their basic need requirements including water. Animal and human carriage potentials were deployed in the direct collection of water, and family resources - animals, crops, labour and material possession - sold or exchanged to meet the financial costs associated with collection. Borrowing and purchasing carriage systems or water and family relocation have been noted as alternative strategies employed by families.

The effect of 'unexpected' variation in annual rainfall, such as the Very Dry Year' is significant in impact upon the extent and means of water accessibility. Ibrahim (1991) noted, with regard to famine disaster that:

> *"The three years between the two last famines [1984-85 and 1989-91] were far too short a time to bring about a rehabilitation of livestock, natural vegetation cover and the economic conditions of rural households. Most households had sold everything they had, even their clothes, to be able to buy food." (p.338)*

Holy (1980) similarly noted with regard to the Berti of Darfur that families' animals, crop reserves and possessions, accumulated during a period of favourable rainfall in the 1960s, were exhausted/severely eroded during a decade of poor rainfall commencing 1966. The present study has confirmed the impact of the Very Dry Year in depleting family resource bases: the loss of carriage animals in particular has been highlighted for consideration, directly impacting upon families' ability to access available supplies.

The Very Dry Year of 1994/85 - indeed the dry phase since the mid-1960s - has been experienced by countries across the Sahellian Zone. The lessons and policy implications associated with this climatic episode in the current study are, therefore, also clearly of wider applicability.

The wide annual variation in rainfall has implications for the development of water supply in the region. Hulme (1986) compared the operation of the rural water supply system in the White Nile Province in the wet year of 1978 and the dry year of 1983. Similarly, Graham (1973) recorded the enlarged sedentary population supported by *hafirs* in the Qala' en Nahl Hills of Gedaref District following their construction in the 1950s, and the impact of poor annual rainfall supply to the source in 1961. Both authors concluded the importance of mobility in maintaining the rural water supply system.

From the current study of En Nahud District, it is the author's contention that mobility, together with use of short-duration traditional sources, will continue to be an important aspect of the rural water supply system until access improvement strategies are implemented, founded upon careful and informed social and environmental information, and supported by appropriate infrastructure. In the current study, mobility remained an established part of many families' strategies for accessing water supply in the dry-seasons, especially family unit *dammering*, within communities on the Basement Complex. These residents lack local 'affordable' perennial/ dry-season sources and many are, therefore, unable to maintain residential permanency. By contrast, in study settlements on the Nubian Series, there was no seasonal relocation, and wateryard break-down was not associated with crisis-outmigration since alternative wateryards and supplies were available. With dependence upon variable annual rainfall in home-areas, reliability of supply has not been achieved; with dependence upon ancient rainfall, sustainability has been neglected.

FURTHER RESEARCH REQUIRED

Borrowing, purchasing and relocation strategies were seen to have been employed by families in response to constraints of accessing water supply. Borrowing was of major importance to the locational stability of many families in Basement Complex areas. In the present study, however, borrowing was analysed only in the cases where it was successful: no investigation was made of incidences when borrowing was unsuccessfully sought or of the detailed family time, effort and financial budgets which inform about need to borrow, ability to borrow and terms of repayment. The following paragraphs highlight some of the avenues of study appropriate to a fuller understanding of the operation of borrowing systems.

Definition of the 'need to borrow':

The 'need' to borrow appropriate resources in order to access water supply may be either absolute or relative (time and financial budgets). Consideration should be given to determining what distance can be ranged in each season with the differing means of transportation belonging to a given family. The absolute potential, described by the number, age, sex, health etc of persons and animals within the family unit, must be qualified by external factors (eg temperature, terrain) and internal commitments of available resources to other tasks. A family's ability to pay for water should also be assessed. This requires investigation of family budgets (input, output and capital) as well as water requirements.

Definition of 'ability to borrow':

Some discussion has been made of the physical and social factors which affect ability to borrow. These have included: the number of animals present in a settlement; settlement form; distance to sources; kinship ties etc. Further investigation should be focused upon identifying the physical and social barriers and pathways which limit and facilitate borrowing relationships.

The Repayment of Loans:

Only one case of repayment for borrowed resources was discovered in the current study. This involved the replacement of water which had been borrowed. However, direct and alternative forms of repayment may occur, and this topic merits study, not least in terms of the demands which might be placed upon existing family resources. Are aid-loans repaid in any way? If they are repaid, what form does this repayment take, how binding is the repayment tie and what are the implications of 'defaulting', and how costly is repayment in real terms?

FOOTNOTES

1 Socio-economic as well as logistical problems of supply have been associated with the development of communal cisterns in the Province (Morton, 1986; H.S. Gebrelassie, pers. comm.; CARE, El Obeid).

APPENDIX A

THE 'ABANDONED' QUESTIONNAIRE

(including amendments added in the field)

(Household = you & the people who live with you
'modern' = improved,
'borehole' = 'donkey'

STRUCTURED INTERVIEW

INTERVIEW NUMBER..... VILLAGE NAME.......... DATE..............
TIME BEGUN ....
TIME ENDED ....

THE FAMILY

Branch of the tribe

1 Tribe?

2 ~~Clan~~

3 How many people (are living) ~~live~~ in your home at the moment? For each please ~~state:~~ tell me:

Relationship to you	Sex	Marital status	Educational level	Age

4 If any of these people who are living here at the moment are temporary visitors, could you please comment on who they are, how long they are staying and why they are visiting you?

5 If there is anyone who usually lives here (husband, brother, wife, child...) who is currently away, please state:

	1	2	3
Relationship to you			
How long been away			
Where live now			
How far from here			
Direction from here			
Main occupation there			

6 What contacts do you have with those members of your household who are away at present? ~~(such as~~ do they send letters, money, make visits, goods, none, other....)

MOBILITY HISTORY

7 Where were you born?

IF NOT BORN HERE ask
- When did you first come to live here?
- Who came with you?
- Which relatives stayed behind?
- What was your marital status then?
- Why did you leave your former home?

- Were you able to obtain sufficient water there? (DESCRIBE)

- Why did you come to this particular village?

- Did you know anything about the water here before you came? (such as availablility, quality, cleanliness, cost). How?

- How was the particular site in the village chosen for the house?

- Had you visited the village before you came to live here?
- Did you stay with relatives who were living here?
  IF YES - Do you still live with them?

8 Have you ever lived in another place since you were born/or first arrived? — explain

IF YES - For each move (including returns to this village) please comment on: (tell me these things)

	move 1	move 2	move 3
Where you went			
Why to that place			
What knowledge of water there			
How long you stayed there (give details)			
Did you stay with relatives/friends			
Did you ever own a house there			
Marital status when you moved			
Who travelled with you			
Did any relatives stay behind			
Why left former home			
Comment on water supply at former home			

- Is this all part of a regular pattern of movement, or have there been changes in recent years (such as since the very dry year of 1984)?

9 How long have you lived here? (years/months)

10 How long would you like to stay here?

11 Is there anything that would make you leave earlier?

12 Is there sufficient water for you here now?

IF YES - Do you think there will always be sufficient water here for you?

IF NO - When will there not be sufficient water here?

- Why will this happen?

13 Do your family own any: (**Please Tick**) (which of the following they own)
Sheep ( ) Goats ( ) Cattle ( ) Camels ( ) Donkeys ( ) Horses ( )
Chickens ( )

14 Are all your animals with you in this village? Now

IF NO - Where are the rest of your animals? (in what place)

- Who is with the rest of your animals? (family and/or hired)

15 Describe briefly the movements of your animals throughout last year (areas visited and when).

16 When you compare the number of animals which you have now to the number of animals you had before the very dry year, do you have:

a) more of any type of animal now (what?)

b) less of any type of animal now (what?)

c) about the same number of any type of animal now (what?)

d) different types of animals (what?)

17 Please describe the normal movements of your animals before the very dry year (1984) (which areas you visited and when) and comment if it was very different from what happens now.

18 Who looked after your animals ~~then~~ before 1984 Very Dry Year? You, your family or hired people?

SEDENTARISM

19 Who owns this house you live in here?

20 How many houses have you/your husband got?

If **more than one**, where else do you have a house?

21 Have you made any improvements to this house since you began living here? Please describe what and why.

22 Is this the same sort of dwelling as you lived in before? Please describe the differences.

23 Do you own any of the following? For each please state:

	Own (TICK)	How long owned?
motor vehicle		
bicycle		
cart		
radio/cassette player		
refrigerator		
sewing machine		
watch		
....		
....		

24 How have your circumstances changed when you compare your present (situation) ~~circumstances~~ with those before the very dry year (1984) in terms of: (**Please Tick**)

	Improved a lot	Improved ~~a bit~~ a little	Same	Worsened a lot	Worsened ~~a bit~~ a little
Income					
Value of possessions					
Housing					
Water availability					
Water quality					
Land availability					
Animal numbers					
Crop production/yield					
Health of children					
Food availability					

25 Are there any (good things) advantages in not having a permanent home?

26 Are there any (bad things) disadvantages in not having a permanent home?

27 Are there any (good things) advantages in having a permanent home?

28 Are there any (bad things) disadvantages in having a permanent home?

29 Does your family farm any land <u>now</u>?

IF YES - Do you own/partly own your land OR is it rented, borrowed, in exchange for produce, other...? (DESCRIBE) → please read me)

- Do you help in farming this land at any time in the year?

IF YES - What work do you help with?

- When do you do this?

30 <u>Before the very dry year</u>, did your family farm any land?

IF YES - Did you own/partly own your land OR was it rented, borrowed, in exchange for produce, other...? (DESCRIBE)

- Did you help in farming this land at any time in the year then?

IF YES - What work did you help with?

- When did you do this?

31 Does your family own any animals <u>now</u>?

IF YES - Do you help with the animals?

IF YES - What work do you do to help?

- When do you do this?

- Where?

32 <u>Before the very dry year</u>, did you own any animals?

IF YES - Did you help with the animals then?

IF YES - What work did you do to help?

- When did you do this?

- Where?

33 <u>This year</u> have you done OR will you be doing <u>any</u> work from which you derive earnings (include <u>all</u> wage labour, crafts sold etc)? For <u>each</u> please state:

eg money, goods..

What? work	When?	Where? is it done	Form of payment?	How were earnings used? (eg food, clothes, bizrode, travelling)

34 ~~could~~ would the ~~household have survived~~ people who live here with you have had enough food/clothes <u>this year</u> if you had not done this work? Please explain.

35 **Before the very dry year** did you do any work from which you derived earnings (include all wage labour, crafts sold etc)? For each please state:

What? work	When?	Where?	Form of payment?	How were earnings used?

36 Would the ~~household have survived~~ people who live here with you have had enough food/clothes at that time if you had not done this work? Please explain. alt (How important was this work for your family's survival?)

37 What standard of schooling have you completed?

IF NOT DONE PRIMARY - Can you read and write a letter?

38 What is the highest standard you think boys from your community should complete (if they have both the ability and can afford it)?

39 What is the highest standard you think girls from your community should complete (if they have both the ability and can afford it)?

40 What do you feel are the main (good things) advantages of schooling for boys?

41 What do you feel are the main (good things) advantages of schooling for girls?

42 What do you feel are the main (bad things) disadvantages of schooling for boys?

43 What do you feel are the main (bad things) disadvantages of schooling for girls?

44 Some people feel that schooling for girls is not nearly as important as it is for boys, whist other people feel that education for girls is as important, if not more important. What do you think?

45 Why do you feel this way?

46 What types of work would you like your sons to do? (DISCUSS)

47 What types of work would you like your daughters to do? (DISCUSS)

WATER USER HABITS AND PRACTICES

48 Could you tell me all the water sources which people in this village use, even if only for part of the year? For each please state:

Source	How far away*	Direction	Present cost

* If distance is measured in 'time', please state whether on foot, by donkey...

49 If costs vary through the year, please describe.

50 Please describe seasonal variations in water availablity.

51 Please describe (in detail) how the availability of water has changed over the last few years.

52 Please could you tell me all the water sources where your household gets water from in:

wet season .... dry season ....
....
....
....
PROMPT: Is that all? PROMPT: Is that all?

53 Please complete the following tables?

during the rainy (Autumn)
~~WET~~ SEASON

Rank by vol	Type	WHERE USE	Why use	Tins/ day	Cost/ tin	Trips/ day	Who brings	How carried	Tins/ trip
1									
2									
WET 3									
4									

list sources in order of most used ~~while~~ the most dry season
~~DRY SEASON~~

Rank by vol	Type (where use)	Why use (clean, near ...)	Tins/ day	Cost/ tin	Trips/ day	Who brings	How carried (donkey, head)	Tins/ trip
most used								
next 2								
DRY 3								
4								

54 Where do you get water from for the following purposes? Please complete tables.

during the rainy ~~WET~~ SEASON (Autumn)

	Source	Why use (near, cleaner ...)	Where use (home, ...)	Tins/ day	Who goes	How collect
drinking						
washing clothes						
wash hands/feet						
bathing						
washing utensils						
watering animals						

~~when~~ in the most dry season (   )
~~DRY SEASON~~

	Source	Why use	Where use	Tins/ day	Who goes	How collect
drinking						
washing clothes						
wash hands/feet						
bathing						
washing utensils						
watering animals						

55 How many tins of water does your family consume in one day in:
a) dry season........... b) wet season..........

56 How long does it take per day to collect water and bring it back to the house?
a) dry season........... b) wet season...........

57 Before the very dry year did men from this household ever collect water?

IF YES - For what purposes?

- How did they collect it?

58 Are there times when you have not used your normal sources for some reason?

IF YES	When?	Why?
For drinking	....	....
For washing clothes	....	....
For washing hands and feet	....	....
For bathing	....	....
For washing ~~utensils~~ plates, dishes, pots, knives...	....	....
For watering animals	....	....

59 If there is a ~~borehole~~ (donkey) or large hafir which is used by your family, when did you begin to use it and why?

60 Do you ever use methods of water purification here? to make water clean

IF YES - Could you please describe what methods you use?

- From which sources is the water you use purified?

- Why is it necessary to purify the water?

- For what purposes do you use purified water?

61 Do you know of any religious teachings concerning water?

IF YES - Could you tell me what these say?

- How do they affect you/your household?

62 Do you know of any folklore or tribal sayings concerning water?

IF YES - Could you tell me what these say?

- How do they affect you/your household?

63 Is it more difficult to obtain water now than last year?

IF YES - Why?

64 Is it more difficult to obtain water now than before the very dry year ?

IF YES - Why?

65 How much money does your family ~~currently~~ spend on water now?

66 In comparison with last year do you now spend on water? **(Please Tick)**

More ( ) Less ( ) About the same ( )

67 How much money would be necessary each day to purchase the water of the volume and type you prefer?

68 If you ~~controlled~~ had all the ~~finance~~ money which your household has, how much money would you ~~allocate to~~ spend on water purchasing each day?

69 Which households have most problems obtaining water? (DESCRIBE)

WATER STORES: TEBELDIS AND WATER-MELONS

83 Do you know how to hollow a tebeldi?

IF YES - How did you learn?

- When did you learn? Why?

84 Does your household use tebeldis for water storage here now?

IF YES - How many and who owns them/it?

- Did your household hollow them/it?

- Do you remember a time when you did not use tebeldis for water storage? When and why?

IF NO - Do you remember a time when you did use tebeldis for water storage? When, where and why?

85 Do other people in this village use tebeldis for water storage?

IF YES - What sorts of people use tebeldis for water storage? (DESCRIBE)

- Did these people hollow them themselves?

- Do they own them?

86 Have any hollowed tebeldis died or become unusable for some reason? (DESCRIBE)

87 Does your household plant water-melons?

IF YES - How do you grow them? (describe: how intercropping, where....)

- Could you tell me what you use water-melons for?

- Do you remember a time when you did not plant them? When and why?

IF NO - Have you ever thought of growing them?

- Do you remember a time when you did plant them? When, where and why?

88 Do other people in this village plant water-melons?

IF YES - What sorts of people plant water-melons as a source of water?

- Why do they grow them?

YOUR NAME

WERE OTHER PEOPLE PRESENT IN ADDITION TO ~~INTERVIEWEE~~ person you were questioning AT ANY TIME WHILE YOU WERE CONDUCTING THE INTERVIEW? (**Please TICK**)
Men ( ) Women ( ) Older Children ( ) Young Children ( )

DESCRIBE IF ANY OF THE ABOVE PEOPLE ~~PARTICIPATED~~ assisted IN THE INTERVIEW

WAS THE INTERVIEWEE CO-OPERATIVE? IF NOT, EXPLAIN WHY.

OVERALL INTERVIEW EVALUATION - eg good, bad etc.

MANAGEMENT OF WATER: FORMAL AND INFORMAL

donkey | Hafir dug with machines

70 If an improved source has been constructed, were any traditional sources filled in after it was constructed?

IF YES - Do you know why these traditional sources were filled in ?

71 To your knowledge have any of the following happened here? and when?

	TICK if happened	When?
a) Lining wells	....	....
b) Building up hafir banks	....	....
c) Building up earth dams	....	....
d) Deepening existing wells	....	....
e) Digging new wells	....	....

72 Has anything else been done to improve traditional sources that exist here? (DESCRIBE)

73 Do some people in the community still use traditional sources for purposes/uses which you now get ~~obtain from boreholes~~ donkey/large hafirs?

IF YES - How many households? (many, some, a few...)
- For what purposes do they use the water from these traditional sources?

- Why do they use the traditional sources instead of the modern sources?

- Do they tend to be from certain groups within the community? (DESCRIBE)

74 Since you have been using the modern sources have you ever gone back ~~reverted~~ to using traditional sources?

IF YES - How often?
- When?
- Why?

go back to using

75 Would you ~~revert~~ to traditional sources now if: (TICK)

a) There was insufficient (not enough) water available at the modern source. .....
b) Crowding made queues very long (rows standing in line) at the modern source? .....
c) Costs increase further (become more expensive) at the modern source? .....
d) There was a plentiful supply of water in the traditional sources because of good rains? .....

76 Are there any other reasons which would make you decide to use traditional sources instead of modern sources?

77 Do you think any of these things will happen in the next year?

IF YES - Which?

- Why?

78 What groups of people are the poorest in this village (immigrants, woman-headed households, small families, families with no animals, no land, no money-earnings...)? (DESCRIBE) → tell me which.

79 Do the sheikh and his family have any responsibilities toward the poorer people here?

IF YES - What?

80 Does your household own by itself or with other people, a well or any other water sources? (DESCRIBE). For each please answer the following:

IF YES - What water source?

- Where is it? (distance and direction)

- How was it obtained?

- Why was it obtained?

- Who owns it?

- How long have you owned it?

- How deep is it?

- Describe variations in water levels between years.

- Describe variations in water levels between seasons.

- Describe any problems with it (Why?).

quarrels
81 Have there ever been any major disputes concerning water in this area?

IF YES - Why did they occur?

- Can you describe what happened?

- What year?
- What season?
- Where?

82 If the rains failed and the water failed here this year how would you obtain enough water?

IF WOULD MOVE - Where would you go to?

- Why would you go there?

- Who would go with you?

- Who would not go with you? WHY?

- Would you sell animals? WHY?

APPENDIX B

OUTLINE SEMI-STRUCTURED INTERVIEW

APPENDIX C

STRUCTURED INTERVIEW SHEET: SHEIKHS

RECONNAISSANCE TRIP and MAIN TRIP: details checked and added to as possible

VILLAGE TOUR IF POSSIBLE TO SEE LOCAL WATER POINTS, MARKET ETC (as appropriate)

Number of families in village-proper

Number of people in village-proper

Number of married women with husbands working away from the village

In the Very Dry Year:

- number of people/families which have moved away

  (where to; characteristics? have they returned?)

- number of people/families which have moved into the village

  (where from?)

Since the Very Dry Year:

- number of people/families which have moved away

  (where to; characteristics? have they returned? NB DAMMERING)

- number of people/families which have moved into the village

  (where from?)

Discuss number of people: this year compared to:

- last year
- before the Very Dry Year

Discuss number of livestock: this year compared to:

- last year
- before the Very Dry Year

When rains last as good as this (nb time of year when asked)

Facilities:

- school (standard)
- police station
- mosque (type)
- health facility (type)
- veterinary facility (type)
- *caros* in the village ... etc

Village Organisations:

- VWC (if appropriate)
- VC
- Women Group
- Youth Association ... etc

Communications

Water sources available (for each season):

- types (check other types)
- names (check others of the type)
- orientations
- distances by donkey
- descriptions/details (where appropriate)
- frequency of any water deliveries by lorry
- ownerships as appropriate
- problems associated
- date constructed (if appropriate)
- disputes

Water purification:

- describe methods used; sources of water purified; and its uses

Watermelons:

- uses
- sale

Tebeldis:

- number (hollowed/unhollowed; good/bad)
- used for storage? (when)
- who uses?

Which families have the most problems obtaining water? (characteristics)

Religious or tribal sayings about water

Other (general/specific)

REFERENCES

REFERENCES

Abdalla, A.A.R. (1985), ***Cost Recovery from Rural Water Supply Services - a Case Study from South Darfur, Sudan***, report submitted as a contribution to an M.Sc. in Agricultural Economics, (University of London, Wye), 38pp.

Abdalla, A.H. (1986), "Water Supply Factors in Sudan", in A.B. Zahlan and W.Y. Majar (eds), ***The Agricultural Sector of Sudan***, Ithaca Press (London), pp.301-31.

Abu Kumbal, S.A., Abdalla, A.J., Abu Diek, A.G.A., Ubaid Ala, A.M.A. and Abdalla, J.J. (1985), ***A Proposed Land Use Model for Kordofan Region***, paper produced for Kordofan Regional Governorate.

Adamson, D.A., Gasse, F., Street, F.A. and Williams, M.A.J. (1980), "Late Quaternary History of the Nile", ***Nature***, Vol.288, pp.50-5.

Ahfad University (undated), ***Research Proposal: Women and their Role in Water Supply and Sanitation in Ajery Villages, Kordofan, Sudan***, Ahfad University for Women (Omdurman, Sudan) and the International Development Research Centre (Ottawa, Canada), 39pp.

Ahmed, E.A.E.A.H. (1982), ***The Impact of Improved Rural Water Supply on Peasant Farmers and Nomads in Eastern Kordofan District***, Unpublished M.A. Thesis, University of Khartoum, 224pp.

Ahmed, M.B. (1988), "Primary Export Crop Production and the Origins of the Ecological Crisis in Kordofan: the Case of Dar Hamar", in D.H. Johnson and D.M. Anderson (eds), ***The Ecology of Survival: Studies from Northeast African History***, Lester Crook (London), pp.115-134.

Al-Awad, A.A., Mohammed, Y.A. and El-Tayeb, S.A. (1985), "The Impact of Improved Rural Water Supplies on the Environment: the Case of East Kordofan District", in H.R.J. Davies (ed), ***Natural Resources and Rural Development in Arid Lands: Case Studies from Sudan***, United Nations University (Tokyo), pp.16-29.

Al Teraifi, A.A.A. (1986), ***Decentralization Policies in the Sudan: an Assessment of the Regional Government Act of 1980***, paper presented at the PVOs Workshop, Khartoum, Jan 5-6 (1986), 26pp.

Ali, A.D. and Mustafa, H. (1985), ***Sudan Experience on Rehabilitation of Rangeland in the Vicinity of Perennial Watering Stations***, pre-released paper presented at the PVOs Workshop, Khartoum, Jan 5-6 (1986), 9pp.

Andrew, G. (1948), "Geology of the Sudan", in J.D. Tothill (ed), ***Agriculture in the Sudan***, Oxford University Press (London), pp.84-128.

Anker, R. (1981), ***Research on Women's Roles and Demographic Change: Survey Questionnaires for Households, Women, Men and Communities with Background Explanations***, World Employment Programme Research: Population and Labour Policies Programme, ILO (Geneva), 224pp.

Anon (1985), ***Water in Kordofan Region***, paper prepared for the El Obeid Water Workshop, Mar 25 (1985), 2 parts.

Anon (1986), ***Regional Finance and Planning Project Planned Implementation***, paper presented at the PVOs Workshop, Khartoum, Jan 5-6 (1986), 7pp.

Anon (1987), ***Rural Water Problems in Kordofan***, paper presented at the National Conference on Drinking Water, Khartoum, Oct 10-13 (1987), 8pp.

Arlosoroff, S. (1983), "World Bank's Handpumps Testing Programme", ***Waterlines***, Vol.1 (3), p.28.

Arlosoroff, S. (1987), "Rural Water Supply Projects", in J. Pickford (ed), ***Developing World Water***, Grosvenor Press International (Hong Kong), pp.59-62.

Asad, T. (1964), "The Seasonal Movement of the Kababish Arabs of Northern Kordofan", ***Sudan Notes and Records***, Vol.45, pp.48-58.

Badri, A.E., Shabo, M.K.A., El Nujumi, E., El Obeid, M.A., and Hassan, M.M. (1981), "Income Generating Projects for Women: a Village Case Study", in D. Baxter (ed), ***Women and the Environment Papers Presented at the Workshop on Women and the Environment***, Institute of Environmental Studies: Environmental Research Papers Series No 2, University of Khartoum, pp.30-5.

Bakhtiari, Q.A. (1987), "Community Management for Sanitation: a Case Study of the UNICEF-Sponsored Baldia Soakpit Project", in J. Pickford (ed), ***Developing World Water***, Grosvenor Press International (Hong Kong), pp.40-2.

Barbour, K.M. (1961), ***The Republic of the Sudan***, University of London Press, 292pp.

Baxter, D. "Women and the Environment: a Downward Spiral", in D. Baxter (ed) (1981), ***Women and the Environment Papers Presented at the Workshop on Women and the Environment***, Institute of

Environmental Studies: Environmental Research Papers Series No 2, University of Khartoum, pp.1-7.

Baxter, D. (ed) (1981), ***Women and the Environment Papers Presented at the Workshop on Women and the Environment***, Institute of Environmental Studies: Environmental Research Papers Series No 2, University of Khartoum, 141pp.

Bayoumi, A.R. (1963), ***Special Fund Project of Land and Water Use Survey of Kordofan Province***, lecture delivered at the Philosophical Society of the Sudan, Jan 23, 7pp.

Beech, C. (1985), ***Rural Domestic Water Resources Availability and Cost in Four Districts in North Kordofan***, CARE Sudan, 10pp+. (some pages missing on manuscript consulted).

Bein, F.L. (1981), "Domestic Water Resource Use in Rural Sudan", ***Ekistics***, Vol.48, pp.430-3.

Beshir, M.O.B. (ed) (1984), ***The Nile Valley Countries: Continuity and Change***, (Vol.1), Sudanese Library Studies No.12, Institute of African and Asian Studies (Khartoum), 176pp.

Bjornson, B. (1985), ***North Kordofan Water Supply Project (internal evaluation)***, CARE Sudan, 41pp.

Blackett-Ord and Nash, H. (1990), ***Water Survey in Tendelti-Kosti and Dinder Areas, Sudan***, Report for CONCERN, 42pp.

Bland, G.C. (1981), ***Planning for Rural Water Supply: the Case of Sudan***, Unpublished M.Phil. Thesis, University of Edinburgh.

Blunt, H.S. (1923), "Tebeldis", ***Sudan Notes and Records***, Vol.6, pp.114-7.

Bowyer, A. (1985), ***The Socio-Economic Status of Women in Central Sudan***, Unpublished M.A. Thesis, University of Durham.

Briggs, J.A. (1975), "Some Thoughts on the Problems Facing Geography Field Workers in Africa", ***Swansea Geographer***, Vol.13, pp.18-21.

Brown, A. (1989), "UNDP Assesses Accomplishments", ***INSTRAW News***, Vol.13, p.6.

Bulmer, M. and Warwick, D. (eds) (1983), ***Social Research in Developing Countries: Surveys and Consensuses in the Third World***, Wiley (Chichester), 383pp.

Burgess, R.G. (ed) (1982), ***Field Research: A Sourcebook and Field Manual***, George Allen and Unwin (London).

Burgess, R.G. (1984), ***In the Field: An Introduction to Field Research***, George Allen and Unwin (London), 254pp.

Butzer, K.W. (1961), "Climatic Change in Arid Regions Since the Pliocene", ***Arid Zone Research - UNESCO***, Vol.17, pp.31-56.

Butzer, K.W. (1983), "Palaeo-Environmental Perspectives on the Sahel Drought of 1968-73", ***Geojournal***, Vol.7 (4), pp.369-74.

Butzer, K.W. and Twidale, C.R. (1969), "Deserts in the Past", in E.S. Hills (ed), ***Arid Lands: a Geographical Appraisal***, Methuen (London), pp.127-44.

Carr, M. (1978), ***Appropriate Technology for African Women***, The African Training and Research Centre for Women of the Economic Commission for Africa, United Nations, 90pp.

CARE (1987), ***Regional Finance and Planning Project: En Nahud District, Kordofan Region***, Project Proposal, CARE Sudan, 90pp.

CARE (1988), ***Kordofan Monitoring Support Project: Kordofan Socio-Economic Conditions - August 1988***, CARE Sudan, 23pp.

Cater, N. (1986), ***Sudan: the Roots of Famine***, Oxfam (Oxford), 36pp.

Cembrowicz, R.G. (1982), "Technically, Socially and Economically Appropriate Technologies for Drinking Water Supply in Small Communities", ***Applied Geography and Development***, Vol.22, pp.74-93.

Chambers, R. (1983), ***Rural Development: Putting the Last First***, Longmans (London), 246pp.

Clarke, J.I., Curson, P., Kayastha, S.L. and Nag, P. (eds) (1989), ***Population and Disaster***, Blackwells (Oxford), 292pp.

Clarke, J.I., Khogali, M. and Kosinski, L.A. (eds) (1985), ***Population and Development Projects in Africa***, Cambridge University Press, 329pp.

Collins, R.O. (1990), ***The Waters of the Nile: Hydropolitics and the Jonglei Canal, 1900-1988***, Clarendon Press (Oxford), 441pp.

Coughenour, C.M., Frankenberger, T. and Skartvedt, E. (1985) "Women Farmers in Rural Settlements in North Kordofan, Sudan", ***The Ahfad Journal***, Vol.2 (2), pp.9-22.

Craig, G.M. (ed) (1991), ***The Agriculture of the Sudan***, Oxford University Press, 468pp.

Culwick, G.M. (1954), "Some Problems of Social Survey in the Sudan", ***Sudan Notes and Records***, Vol.35, pp.110-31.

Davies, H.R.J. (ed) (1985), ***Natural Resources and Rural Development in Arid Lands: Case Studies from Sudan***, United Nations University (Tokyo), 84pp.

Davies, H.R.J. (ed) (1986), ***Rural Development in White Nile Province, Sudan***, United Nations University (Tokyo), 142pp.

Ddirar, H.A. (1978), "The Art and Science of Merissa Fermentation", ***Sudan Notes and Records***, Vol.57, pp.115-29.

De Waal, A. (1987), ***Famine that Kills: Darfur 1984-5***, SCF (London), 151pp.; later published in (1989) under the same title by Clarendon Press (Oxford).

De Waal, A. (1988), "Famine Early Warning Systems and the Use of Socio-Economic Data", ***Disasters***, Vol.12 (1), pp.81-91.

Dempsey, J. (1955), ***Mission on the Nile***, Burns and Oates (London).

Dixon, C. and Leach, B. (1978), "Survey Research in Underdeveloped Countries", ***Catmog***, 35.

Doxiades Associates (undated), "Experimental Yard - El Obeid Water Conservation Techniques: Prototype No.6" in ***Land and Water Use Survey in Kordofan Province of the Republic of the Sudan***.

Economist Intelligence Unit (1989), ***Sudan: Country Profile 1989-90 - Annual Survey of Political and Economic Background***, Economist Intelligence Unit (London), 44pp.

El-Bushra, E.S. (1967), "The Factors Affecting Settlement Distribution in the Sudan", ***Geografiska Annaler B***, Vol.49, pp.10-24.

El-Bushra, E.S. and El Sammani, M.O. (1977), "Urban and Rural Water Supplies in the Sudan", ***Ekistics***, Vol.254, pp.37-42.

El-Khalifa, M.D., Awadalla, S.A. and El Sammani, M.O. (1985), "Pattern and Impact of Drought in the Sudan", in ***Symopsium on Drought in Africa***, Proceedings and Summary Report of a Symposium held in Ottawa (Canada), International Development Research Centre - Report MR119e, pp.37-50.

El Nasri, A.R. (1980), ***Guide to Sudan Notes and Records Vols 1-55; 1918-74***, University of Khartoum, 139pp.

El Sammani, M.O. (1978), "Gaps in the Water Provision Map of Sudan", ***Sudan Notes and Records***, Vol.59, pp.99-106.

El Sammani, M.O. (1981), "The Impact of Water-Supply Centres on Ecosystems with a Suggested Strategy for Action", ***Sudan Notes and Records***, Vol.62, pp.123-46.

El Sammani, M.O. (ed) (1985a), ***Kordofan Resource Inventory and Development Prospective by Rural Council***, Ministry of Finance and Economic Planning (Khartoum), 304pp.

El Sammani, M.O. (ed) (1985b), ***El Khuwei-Mazroub-Tinna Study Area, North Central Kordofan and Messeriya Study Area, Southern Kordofan: Final Report***, Institute of Environmental Studies (Khartoum), 272pp.

El Sammani, M.O. (1986), ***Kordofan Rehabilitation Development Strategy (2 Vols)***, Ministry of Finance and Economic Planning and the UNDP (Khartoum), 247pp. + 283pp.

El Sammani, M.O. (undated), "Pressure on Water Resources in Rural Areas", in IES, ***Preassessment of Natural Resource Issues in Sudan***, joint publication of the Institute of Environmental Sciences (Khartoum) and the Program for International Development (Clark University, USA), pp.47-80.

El Sammani, M.O. and Abdel Nour, H.O. (eds) (1986), ***Northern Kordofan: a Collection of Papers on Desertification, Drought-Impact and Related Issues***, Institute of Environmental Studies (Khartoum), 367pp.

El-Singaby, T. (1987), ***La Republique Democratique du Soudan Bilan des Recherches en France et en R.F.A. Bibliographie Selective: 1900-86***, Traveaux et Documents de l'I.R.E.M.A.M. No.4 (Aix-en-Provence), 139pp.

El Tom, M.A. (1972), "The Reliability of Rainfall over the Sudan", ***Geografiska Annaler A***, Vol.54, pp.28-31.

El Tom, M.A. (1975), ***The Rains of the Sudan: Mechanism and Distribution***, Khartoum University Press, 89pp.

Eldredge, E., Khalil, S.E.S., Salter, C., Nicholds, N., Abdalla, A.A. and Rydjeski, D. (1987), ***Changing Rainfall Patterns in Western Sudan***, loose paper Ref. DRN, DC13SP86.

Farah, A.A. and Preston, S.H. (1982), "Child Mortality Differentials in Sudan", ***Population and Development Review***, Vol.8 (2), pp.365-83.

Feachem, R.G., McGarry, M. and Mara, D. (eds) (1977), ***Water, Wastes and Health in Hot Climates***, Wiley (London).

Furfey, R. and Dearth, C. (undated), ***Regional Finance and Planning Project: En Nahud District, North Kordofan - Life of Project Work Plan***, report submitted to En Nahud District Council.

Glantz, M.H. (ed) (1976), ***The Politics of Natural Disaster: the Case of the Sahel Drought***, Praeger (London), 340pp.

Glennie, C. (1983), ***Village Water Supply in the Decade: Lessons from Field Experience***, Wiley (Chichester), 152pp.

Gould, J. (1984), "Rainwater Catchment Systems in Botswana: Present, Past and Future", ***Waterlines***, Vol.2 (4), pp.14-9.

Grabham, G.W. (1909), "Wells of the North-Eastern Sudan", ***Geological Magazine***, Vol.5, pp.265-71 and pp.311-8.

Graham, A.M.S. (1969), "Man-Water Relations in the East Central Sudan", in M.F. Thomas and G.W. Whittington (eds), ***Environment and Land Use in Africa***, Methuen (London), pp.409-45.

Graham, A.M.S. (1973) "Adapting to Water Shortage in a Year of Poor Rains: a Case Study from the Sudan", ***Savanna***, Vol.2 (2), pp.121-5.

Grainger, A. (1982), ***Desertification: How People Make Deserts, How People Can Stop and Why They Don't***, Earthscan (London), 94pp.

Gurdon, C. (1987), "Current Affairs in Sudan", ***Sudan Studies***, Vol.3, pp.21-25.

Hall, M. and Ismail, B.A. (1981), ***Sisters Under the Sun***, Longmans (London), 264pp.

Hamdouk, A.A., Bashir, I. and Abudiek, A.A.G.A. (1985), ***Agricultural Credit for Small Farmers in Al Nahud Area***, Ministry of Finance and Economy for Kordofan Region (Sudan): Department of Planning and Economy, 24pp.

Harrell-Bond, B.E. (1986), ***Imposing Aid - Emergency Assistance to Refugees***, Oxford University Press.

Hassan, A.R.M. (1986), ***Regional Finance and Planning Project (RFPP)***, paper presented at the PVOs Workshop, Khartoum, Jan 5-6 (1986), 4pp.

Hawkins, A. (1987), "The Durability of GRP Storage Tanks in Middle East Countries", in J. Pickford (ed), ***Developing World Water***, Grosvenor Press International (Hong Kong), pp.394-400.

Henderson, K.D.D. (1935), ***History of the Hamar Tribe***, collection of articles.

Hills, E.S. (ed) (1969), ***Arid Lands: a Geographical Appraisal***, Methuen (London).

Hoagland, E. (1982), ***African Calliope: A Journey to the Sudan***, Penguin (Harmondsworth), 272pp.

Holy, L. (1980), "Drought and Change in a Tribal Economy: the Berti of Northern Darfur", ***Disasters***, Vol.4 (1), pp.65-71.

Howell, P. (1988), "The Genesis of the Jonglei Canal", in P. Howell., M. Lock, and S. Cobb (eds), ***The Jonglei Canal: Impact and Opportunity***, Cambridge University Press, pp.21-46.

Howell, P., Lock, M. and Cobb, S. (eds), ***The Jonglei Canal: Impact and Opportunity***, Cambridge University Press, 537pp.

Hulme, M. (1985), ***Secular Climatic and Hydrological Change in Central Sudan***, Unpublished Ph.D. Thesis, University of Wales (Swansea).

Hulme, M. (1986), "The Adaptability of a Rural Water Supply System to Extreme Rainfall Anomalies in Central Sudan", ***Applied Geography***, Vol.6, pp.89-105.

Hulme, M. (1987), ***An Annotated Bibliography of the Climate of Sudan***, Cambridge African Occasional Paper 5, 56pp.

Hulme, M. (1989), "Recent Rainfall in Perspective", ***Sudan Studies***, Vol.6, p.9.

Hulme, M. and Trilsbach, A. (1989), "The August 1988 Storm over Khartoum: Its Climatology and Impact", ***Weather***, Vol.44 (2), pp.82-90.

Hulme, M. and Trilsbach, A. (1991), "Rainfall Trends and Rural Changes in Sudan Since Nimieri: Some Thoughts on the Relationship between Environmental Changes and Political Control", in P. Woodward (ed), ***Sudan After Nimieri***, Routledge (London), pp.1-17.

Hulme, M. and Walsh, R.P.D. (1983), ***Hydrological Consequences of Recent Climatic Change in the West-Central Sudan and Some Suggestions for Future Monitoring and Assessment***, paper presented at the Workshop on Monitoring and Controlling Desertification in the Sudan, Khartoum, February (1983),18pp.

Hurst, H.E. (1952), ***The Nile***, Constable (London), 326pp.

Ibrahim, F.N. (1978), ***The Problem of Desertification in the Republic of the Sudan with Special Reference to Northern Darfur Province***, Development Studies and Research Centre Monograph No.8, Khartoum, 54pp.

Ibrahim, F.N. (1984), ***Ecological Imbalance in the Republic of the Sudan - with Reference to Desertification in Darfur***, Bayreuther Geowissenschaftliche Arbeiten (Bayreuth), 215pp.

Ibrahim, F.N. (1991), "The Third Famine Disaster in the Sudan within Two Decades - a Case Study of the Situation in the Village of Burush, Darfur", in SSSUK, ***Proceedings of the Second International Sudan Studies Conference - Sudan: Environment and People***, Durham, Apr 8-11 (1991), pp.338-46.

Idris, H.A. (1960), ***White Nile Pump Schemes***, Unpublished B.A. Dissertation, University of Khartoum, 36pp.

INSTRAW (1988), ***Women, Water Supply and Sanitation - a National Training Seminar - Proceedings of the Kadugli Workshop***, Kadugli, Jan 16-21 (1988), 51pp.

IES (undated), ***Preassessment of Natural Resource Issues in Sudan***, joint publication of the Institute of Environmental Sciences (Khartoum) and the Program for International Development (Clark University, USA).

Iskander, W. (1986a), "Water Resources of Northern Kordofan", in M.O. El Sammani and H.O. Abdel Nour (eds), ***Northern Kordofan: a Collection of Papers on Desertification, Drought-Impact and Related Issues***, Institute of Environmental Studies (Khartoum), pp.81-125.

Iskander, W. (1986b), ***Role of Rural Water in the Development of Kordofan and Darfur Regions***, paper presented at the PVOs Workshop, Khartoum, Jan 5-6 (1986), 40pp.

Ismail, E.T. (1981), ***Social Environment and Daily Routine of Sudanese Women: a Case Study of Urban, Middle Class Housewives***, Dietrich Reimer Verlag (Berlin), 200pp.

Jefferson, J.H.K. (1949), "A Short Description of Harig and Mahal Methods of Cultivation", ***Sudan Notes and Records***, Vol.30, pp.276-80.

Jefferson, J.H.K. (1952), "A Note Based on Field Experience on Planning Hafir Excavation Programmes", ***Sudan Notes and Records***, Vol.33, pp.224-44.

Johnson, D. and Anderson, D. (eds), (1988), ***The Ecology of Survival: Studies from Northeast African History***, Lester Crook (London), 399pp.

KAEP (CARE) (1986), "KAEP Site Selection Questionnaire for Surveyed Village" (Khammas Hajar).

KAEP (CARE) (1987), "KAEP Site Selection Survey 1987" (Khammas Halab).

Khogali, M.M. (1979), "Should Pastoral Nomads be Settled?", ***Swansea Geographer***, Vol.17, pp.66-9.

Khogali, M.M. (1980), ***Sedentarism of Nomadic Tribes in the North and Central Sudan***, Unpublished Ph.D. Thesis, University of Khartoum, 432pp.

Khogali, M.M. (1986), "The Changing Nature of Nomadism in the Northern White Nile Region", in H.R.J. Davies (ed), ***Rural Development in White Nile Province, Sudan***, United Nations University (Tokyo), pp.65-72.

Khogali, M.M. and El Sammani, M.O. (1986), "Resources, Population and Mobility in Marginal Drylands - the Case of Northern Kordofan Province, Sudan, in in M.O. El Sammani and H.O. Abdel Nour (eds), ***Northern Kordofan: a Collection of Papers on Desertification, Drought-Impact and Related Issues***, Institute of Environmental Studies (Khartoum), pp.154-86.

Lado, C. (1985), ***Environment, Knowledge and Change: a Case Study of Peasant Farming in Maridi District, Southern Sudan***, Unpublished Ph.D. Thesis, University of Durham, 515pp.

Lawless, R.I. (ed) (1987), ***The Middle Eastern Village***, Croom Helm (London).

Lebon, J.G. (1956), ***Land Use in Sudan***, World Land Use Survey: Regional Monograph No.4, Geographical Publications Ltd (London).

Lebon, J.H.G. (1968), "The Land and Water Use Survey of North-Central Kordofan (1961-66)", ***Geographical Journal***, Vol.134, pp.546-9.

Lowes, P. (1987), "Half Time in the Decade", in J. Pickford (ed), ***Developing World Water***, Grosvenor Press International (Hong Kong), pp.16-7.

Mabogunje, A.L. (1970), "Systems Approach to a Theory of Rural-Urban Migration", ***Geographical Analysis***, Vol.2, pp.1-18.

MacMichael, H.A. (1920), "The Kheiran", ***Sudan Notes and Records***, Vol.3, pp.231-44.

Maloiy, G.M.O., Heglund, N.C., Prager, L.M., Cavagna, G.A. and Taylor, C.R. (1986), "Energetic Costs of Carrying Loads: Have African Women Discovered an Economic Way?", ***Nature***, Vol.319, pp.668-9.

McDowell, J. and Hazzard, V. (1976), "Village Technology and Women's Work in Eastern Africa", ***Assignment Children***, Vol.36.

McGowan R. and. Burns, K. (1987), ***Evaluation of CARE Sudan Interim Water Supply and Management Project***, Dec, Khartoum, 83pp.

McLean, M. (1985a), ***Nutritional Surveillance and Drought Monitoring Project: A Report on the Nutritional Status of 1,888 Children in Kordofan Region in February/March 1985***, Submitted to OXFAM, UNICEF and the Kordofan Regional Government, 30pp.

McLean, M. (1985b), ***Nutritional Surveillance and Drought Monitoring Project: A Report on the Nutritional Status of 4,836 Children in Kordofan Region in May/June 1985***, Submitted to OXFAM, UNICEF and the Kordofan Regional Government, 21pp.

McLean, M. (1985c), ***Nutritional Surveillance and Drought Monitoring Project: A Report on the Nutritional Status of 4,575 Children in Kordofan Region in September/October 1985***, Submitted to OXFAM, UNICEF and the Kordofan Regional Government, 28pp.

McNally, J. (1986), "An Overview of the Western Programme, El Obeid Diocese", in R. Rees, ***Final Reports on Activities and Programmes Implemented in the Period July 1985 to January 1986***, CAFOD (London), (Annex 1).

Mohamed, Y.A. (1975), ***Some Spatial Aspects of Rural Change in Western Sudan: the Case of Eastern Kordofan and El Fasher Districts***, Unpublished Ph.D. Thesis, University of Liverpool, 455pp.

Mohamed, Y.A. and Abu Sin, E.H. (1985), "Rural Population and Water Supplies in the Sudan", in J. Clarke et al., (eds), ***Population and Development Projects in Africa***, Cambridge University Press, pp.254-64.

Mohamed, Y.A., Abu Sin, E.H. and El Tayeb, M.E.H. (1986), ***Social and Managerial Aspects of Rural Water Supplies in the Sudan***, University of Khartoum, Faculty of Arts, Department of Geography Occasional Paper No.1, 225pp.

Mohamed, Y.A., El Sammani, M.O. and Shadad, M.Z. (1982), ***The North Kordofan Rural Water Baseline Survey***, prepared for CARE Sudan, Institute of Environmental Studies (Khartoum), 152pp.

Montagu, J. (1987), "Soak the Poor", in J. Pickford (ed), ***Developing World Water***, Grosvenor Press International (Hong Kong), pp.78-81.

Morton, J. (1986), "Report on a Visit to En Nahud District", - Appendix II in SUDANAID (1986a), pp.76-80.

Moser, C.A. and Kalton, G. (1971), ***Survey Methods in Social Investigation***, Heinemann (London).

Muktar, A.R. and Bushara, E.T.Y. (1987), ***Technologies in Rural Drinking Water***, paper presented at the National Conference on Drinking Water, Khartoum, Oct 10-13 (1987), 8pp.

Mustafa, A. (1981), "Women and Water in Western Sudan", in D. Baxter (ed), ***Women and the Environment Papers Presented at the Workshop on Women and the Environment***, Institute of Environmental Studies: Environment Research Papers Series No 2, University of Khartoum, pp.67-9.

Mustafa, M.I. (1982), ***The Development of Rural Water Supply Systems, with Particular Reference to the Sudan***, Unpublished M.Sc Thesis, University of Strathclyde.

Nash, H. (1991), "Water Supply in a Rural Area of White Nile Province", in SSSUK, ***Proceedings of the Second International Sudan Studies Conference - Sudan: Environment and People***, Durham, Apr 8-11 (1991), pp.307-14.

Newbold, D. (1924a), "More Notes on Tebeldis", ***Sudan Notes and Records***, Vol.7 (1), pp.135-7.

Newbold, D. (1924b), "Still More Notes on Tebeldis", ***Sudan Notes and Records***, Vol.7 (2), pp.120-3.

Newbold, D. (1929), "The Tebeldi Again", ***Sudan Notes and Records***, Vol.12, pp.111-2.

Nicholson, S.E. (1979), "Revised Rainfall Series for the West African Subtropics", ***Monthly Weather Review***, Vol.107, pp.620-3.

Nicholson, S.E. and Flohn, H. (1980), "African Environmental and Climatic Changes and the General Atmospheric Circulation in the Late Pleistocene and Holocene", ***Climatic Change***, Vol.2, pp.313-48.

Olsson, L. (1985), ***An Integrated Study of Desertification***, Published Doctoral Dissertation, Lund Studies in Geography Series C: General and Mathematical Geography No.13, 170pp.

Pallme, I. (1844), ***Travels in Kordofan***, J. Madden and Co (London), 356pp.

Parr, M.W. (1924), "Still More Notes on Tebeldis", ***Sudan Notes and Records***, Vol.7 (2), pp.117-9.

Pastizzi-Ferencic, D., Ahooja-Patel, K., Bulajich, B. and Meltzer, E. (1989), "Editorial", ***INSTRAW News***, Vol.13, pp.1-7.

Penn, A.E.D. (1927), "Note on Tegundi and Tebeldis", - Appendix G(i), in ***SUDANAID*** (1986a), pp.72-3.

Pickford, J. (ed) (1975), ***Water, Waste and Health in Hot Countries***, Proceedings of the Second International Conference on Environmental Health Engineering in Hot Climates and Developing Countries, Loughborough, Sep 21-24 (1975), 146pp.

Pickford, J. (ed) (1987), ***Developing World Water***, Grosvenor Press International (Hong Kong), 588pp.

Pocock, D.C.D. (1981), "Sight and Knowledge", ***Transactions of the Institute of British Geographers***, New Series Vol.6 (4), pp.385-93.

Poole, D.J. (1987), "Diesels - The Reliable Resource for Water Supply", in J. Pickford (ed), ***Developing World Water***, Grosvenor Press International (Hong Kong), pp.444-50.

Pumphrey, M.E.C. (1933), "A Note on Agricultural Methods in Dar Hamar", - Appendix G(ii), in ***SUDANAID*** (1986a), pp.74-81.

Rees, R. (1986), ***Sudan Emergency Relief and Rehabilitation Programme: Final Reports on Activities and Programmes Implemented in the Period July 1985 to January 1986***, CAFOD (London), 20pp.

Reeves, E.B. and Frankenberger, T. (1982), ***Farming Systems Research in North Kordofan, Sudan***, Instormil Report No.2, University of Kentucky.

Robertson, A.C. (1950), ***The Hafir - What, Why, Where and How?***, Ministry of Agriculture Bulletin No.1, Khartoum, 16pp.

Rodis, H.G. and Iskander, W. (1963), "Groundwater in the Nahud Outlier of the Nubian Series, Kordofan Province, Sudan", ***Geological Survey Research***, US Geological Survey Professional Paper 475-B (Article 49), pp.179-81.

Rodis, H.G., Hassan, A. and Wahadan, L. (1963), ***Availability of Ground Water in Kordofan Province, Sudan***, Ministry of Mineral Resources: Geological Survey Department Bulletin No.12, Khartoum, 16pp.

Rodis, H.G., Hassan, A. and Wahadan, L. (1968), ***Groundwater Geology of Kordofan Province, Sudan***, US Geological Survey Water-Supply Paper 1757-J, United States Government Printing Office (Washington D.C.), 48pp.

Saghayroun, A.A. and Van Kestern, J. (1985), ***Sudan Population Studies Bibliography***, Population Studies Centre, University of Gezira (Wad Medani).

Salih, H.A. (1986), ***Experience in Decentralization***, paper presented at the PVOs Workshop, Khartoum, Jan 5-6 (1986), 11pp.

SCF (1987), ***Umm Ruwaba Programme Overview***, internal report.

SCF (1988), ***Baseline Report: Umm Ruwaba District, North Kordofan Province, Sudan***, internal publication, 131pp.

Shakesby, R.A. (1986), "Geomorphology", in H.R.J. Davies (ed), ***Rural Development in White Nile Province, Sudan***, United Nations University (Tokyo), pp.6-20.

Shakesby, R.A. and Trilsbach, A. (1982), "Irrigation is the Desert's Secret Agent", ***Geographical Magazine***, Vol.54, pp.77-83.

Shepherd, A.W. (1984), "Water, Pastoralism and Agriculture Schemes: a case study of the Butana", in M.O. Beshir (ed), ***The Nile Valley Countries: Continuity and Change***, (Vol.1), Sudanese Library Series No.12, Institute of African and Asian Studies (Khartoum), pp.72-86.

Shepherd, A.W. (undated), ***The Rural Water Corporation and National Resource Planners: the Question of Organizational Relationships***, unpublished circular, 4pp.

Shepherd, A., Norris, M. and Watson, J. (1987), ***Water Planning in Arid Sudan***, Ithaca Press (London), 207pp.

Shohan, J. (1985), "Report of a Visit to Sudan: November 1984-5", ***Disasters***, Vol.9 (1), pp.12-4.

Siddhi, R.K. (1987), "Water Supply and Sanitation at Mid-Decade in Nepal", in J. Pickford (ed), ***Developing World Water***, Grosvenor Press International (Hong Kong), pp.22-3.

Soil Conservation Department (1987), ***Water Provision and Distribution by Tankers***, unpublished report, 6pp.

Stern, P.H. (1985), ***Draft Reconnaissance Report on the Water Supply Situation in Northern Kordofan with Outline Proposals for a UNICEF-Assisted Programme***, Report to the United Nations Children's Fund.

Sudan Government (1985), ***The Strategy of Kordofan Regional Government to Combat Desertification and Alleviate the Effects of Drought***, Ministry of Finance and Economy, Department of Planning and Economy, 6pp.

Sudan Studies Society of the United Kingdom (SSSUK) (1991), ***Proceedings of the Second International Sudan Studies Conference - Sudan: Environment and People***, Durham, Apr 8-11 (1991), 350pp.

SUDANAID (1986a), ***SUDANAID Emergency Relief and Rehabilitation Programme, July 1985-January 1986, Diocese of El Obeid, Sudan***, Report of the SUDANAID Rehabilitation Research Team on Dar Hamar (En Nahud District), North Kordofan Province, Sudan, CAFOD (London), 91pp.

SUDANAID (1986b), ***SUDANAID Emergency Relief and Rehabilitation Programme, July 1985-January 1986, Diocese of El Obeid, Sudan***, SUDANAID Reports on the Nutrition Intervention Programme in En Nahud, North Kordofan Province, Sudan, CAFOD (London), 34pp.

Thomas, M.F. and Whittington, G.W. (eds), ***Environment and Land Use in Africa***, Methuen (London).

Tinker, J. (1977), "Sudan Challenges the Sand-Dragon", ***New Scientist***, Vol.73, pp.448-50.

Tothill, J.D. (ed) (1948), ***Agriculture in the Sudan***, Oxford University Press (London), 974pp.

Tremblay, M.A. (1982), "The Key Informant Technique: A Non-Ethnographic Application", in R.G. Burgess (ed), ***Field Research: A Sourcebook and Field Manual***, George Allen and Unwin (London), pp.98-104.

Trilsbach, A. (1983a), ***Desertification and Rural Change in Central Sudan***, Unpublished Ph.D. Thesis, University of Wales (Swansea), 519pp.

Trilsbach, A. (1983b), "Hydrology and Water Supply in the White Nile Province of the Sudan: Modifications and Problems", ***Swansea Geographer***, Vol.20, pp.58-65.

Trilsbach, A. (1986), "Agriculture West of the White Nile", in H.R.J. Davies (ed), ***Rural Development in White Nile Province, Sudan***, United Nations University (Tokyo), pp.46-64.

Trilsbach, A. (1987), "Environmental Change and Village Societies West of the White Nile, Sudan", in R.I. Lawless (ed), ***The Middle Eastern Village***, Croom Helm (London), pp.13-50.

Trilsbach, A. (1989a), "The Indirect Effects of Famine on Population: Case Studies from the Republic of the Sudan", in J.I. Clarke et al., (eds), ***Population and Disaster***, Blackwells (Oxford), pp.128-36.

Trilsbach, A. (1989b), "It Never Rains Unless it Pours: a Personal Diary of the 1988 Rain and Flood Disaster in Sudan", ***Durham University Geographical Society Journal***, Vol.29, pp.19-24.

Trilsbach, A. (1991), "The Historical Development of Agriculture", in G.M. Craig (ed), ***The Agriculture of the Sudan***, Oxford University Press, pp.177-92.

Trilsbach, A. and Ahmed, M.M. (1986), ***The Aftermath of the 1984 Sudan Famine: Some Observations from North Kordofan in 1985***, report submitted to the University of Khartoum, 18pp.

Trilsbach, A. and Hulme, M. (1984), "Recent Rainfall Changes in Central Sudan and their Physical and Human Implications", ***Transactions of the Institute of British Geographers***, New Series Vol.9, pp.280-98.

Trilsbach, A. and Wood, S. (1986),"Livestock Markets and the Semi-Arid Environment: A Case Study from Sudan", ***Geografiska Annaler B***, Vol.68, pp.51-8.

Tully, D. (1988), ***Culture and Context in Sudan: the Process of Market Incorporation in Dar Masalit***, Albany State University Press, 306pp.

UNDP (undated), ***UNDP Proposal Document - Integrated Rural Development to Reverse Desertification in El Odaiya Area***, internal publication.

UNDP (1988), ***Brief on the Country Programme of UNDP in the Sudan (1988-91)***, internal publication, 33pp.

Vail, J.R. (1978), "Outline of the Geology and Mineral Deposits of the Democratic Republic of the Sudan and Adjacent Areas", ***Overseas Geology and Mineral Resources***, No.49, HMSO (London), 66pp.

Vail, J.R. (1988), ***Lexicon of Geological Terms for the Sudan***, Balkema (Rotterdam), 199pp.

Vail, J.R. and Duggua, J.P. (1986), ***Bibliography of Geological Sciences for the Republic of the Sudan, 1837-1985***, Centre Internationale Formation Echanges Geologique Paris: Occasional Publication, 173pp.

Wallace, I. (1987), "Appropriate Water Technology in Baringo, Kenya", in J. Pickford (ed), ***Developing World Water***, Grosvenor Press International (Hong Kong), pp.308-10.

Walsh, R.P.D. (1983), "Observation on Hydrological Problems of the Nuba Mountain Area of the Sudan", ***Swansea Geographer***, Vol.20, 16-25.

Walsh, R.P.D., Hulme, M. and Campbell, M.D. (1988), "Recent Rainfall Changes and their Impact on Hydrology and Water Supply in the Semi-Arid Zone of Sudan", ***Geographical Journal***, Vol.154, pp.181-97.

Warren, A. (1970), "Dune Trends and their Implications in the Central Sudan", ***Zeitschrift fur Geomorphologie***, Supplementary Vol.10, pp.154-80.

White, K. (1985), ***Women in Development: an Annotated Bibliography for the World Bank***, International Center for Research on Women (Washington DC).

White, G.F., Bradley, D.J. and White, A.U. (1972), ***Drawers of Water: Domestic Water Use in East Africa***, University of Chicago Press (Chicago and London), 306pp.

WHO (1977), ***International Workshop on Handpumps for Water Supply***, Bulletin No.8 of the International Workshop held in Voorburg (Netherlands), 12-16 July, 1976, 30pp.

Wickens, G.E. (1975), "Changes in the Climate and Vegetation of the Sudan since 20,000 BP", ***Boissera***, Vol.24, pp.43-65.

Wood, W.E. (1975), "Water Supply as a World Problem", in J. Pickford (ed), ***Water, Waste and Health in Hot Countries***, Proceedings of the Second International Conference on Environmental Health Engineering in Hot Climates and Developing Countries, Loughborough, Sep 21-24 (1975), pp.7-29.

Woodward, P. (ed) (1991), ***Sudan After Nimieri***, Routledge (London), 273pp.

World Water (Jan 1979), "Where Water is the Key to Survival", pp.33-6.

World Water (Aug 1979), "Dutch Team Favours Hand-Drilling for African Shallow Wells", pp.40-5.

World Water (Nov 1979), "Water Storage as the Temperature Climbs", pp.39-41.

World Water (Jul 1980), "Togo Lifts Water from Basement Complex", pp.12-4.

World Water (Nov 1980), "Can the UN Programme Halt a 'Permanent Disaster'", pp.23-31.

World Water (Dec 1980), "Water Decade is 'Sound Economics' - Waldheim", pp.13-7.

World Water (Jul 1981), "Location + Drilling + Long-term Maintenance = Borehole Success", pp.2-4.

York, S. (1985), "Report on a Pilot Project to set-up a Drought Information Network in Conjunction with the Red Crescent Society in Darfur", ***Disasters***, Vol.9, pp.173-8.