WETLANDS IN DRYLANDS:
THE AGROECOLOGY OF SAVANNA SYSTEMS IN AFRICA

PART 3c:
Wadis of north Kordofan, Sudan - present roles and prospects for development

by Mohammed Osman El Sammani

IIED
INTERNATIONAL INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT

DRYLANDS PROGRAMME

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Edited by Ian Scoones, Drylands Programme, IIED, London.
January 1991

This review project was supported by the Swedish Agency for Research Cooperation with Developing countries (SAREC) and was coordinated by IIED, London. The review is a collaborative effort, drawing on the wide experience of researchers based in Europe and Africa.

The review is in three parts and is aimed at providing a broad overview of the role of 'valley bottomland' wetlands in savanna agroecosystems in Africa. The role of spatial heterogeneity and farmers' and pastoralists' responses to patchiness is often ignored by researchers, planners and extensionists. The review aims to map out the key issues and suggests a new way of interpreting savanna agroecosystems with important implications for future directions in agricultural and pastoral development in drylands areas.

Part 1 by Ian Scoones: Overview - ecological, economic and social issues.

The overview provides an introduction to the case studies (part 3) and the detailed assessment of biophysical aspects (part 2). It attempts to highlight key issues that run through all analyses of patch use within dryland agroecosystems. Bottomland agriculture and pastoral systems are investigated with a series of case studies. Questions of environmental degradation, land tenure and appropriate economic analysis are also explored. Part 1 concludes with a discussion of the implications for agricultural and pastoral development.

Part 2 by Julie Ingram: Soil and water processes

The review of soil and water processes examines the literature on soil processes by looking at interactions between topland and bottomland in soil formation and movement. Bottomland wetland areas are placed in a landscape context by reviewing catchment level processes. In situ soil and hydrological factors are also examined. Part 2 concludes with an assessment of the potential impact of land use change on patchy wetland areas.

Part 3: Case studies

Part 3a by Are Kolawole: Economics and management of fadama in Nigeria.

Part 3b by Folkert Hottinga, Henk Peters and Sjoerd Zanen: Potentials of bas-fonds in agropastoral development in Sanmatenga, Burkina Faso.

Part 3c by Mohammed Osman El Samanni: Wadis of North Kordofan - present roles and prospects for development.

Part 3d by Zeremariam Fre: Khor Baraka - a key resource in Eastern Sudan and Eritrea.

Part 3e by Misael Kokwe: The role of dambos in agricultural development in Zambia.

Part 3f by Ian Scoones and Ben Cousins: Key resources for agriculture and grazing: the struggle for control over dambo resources in Zimbabwe.

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PART 3c: WADIS OF NORTH KORDOFAN: PRESENT ROLES AND PROSPECTS OF DEVELOPMENT

Mohammed Osman El Sammani

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WADIS OF NORTH KORDOFAN: PRESENT ROLES AND PROSPECTS OF DEVELOPMENT

1. INTRODUCTION

This case study investigates the current status of wadi (seasonal watercourse) utilisation in the northern semi-arid belt of the Kordofan Region of the Sudan. The prospects of enhancing present wadi roles for improving agro-pastoral production systems are also explored. Wadi ecology, resource utilisation, prevalent agrarian economics, human use, organisation and management are considered.

The case study is based on research during repeated visits prior, during and after the 1984 drought, combined with secondary data analysing processes of wadi utilisation.

Northern Kordofan is characterised by the existence of a drought-prone population, with a sizeable number still displaced, under a vulnerable ecosystem, where wadi potentialities could be explored for the development of more sustainable economies.

Although much of the case study is specific to North Kordofan, pertinent experiences and data from other wadi cases shall be referred to. It is believed that these broader comparisons are possible, since wadis have specific physical characteristics, and tend to reveal similar human uses. This comparative study contributes to understanding the role of wadi areas within dryland systems.

Physical Features

In Sudan seasonal water courses are referred to as wadis and khors. Both originate from the direct rains; they flow during the rainy season and are dry for the rest of the year. Wadis refer loosely to water courses that run in the northern desert and semi-desert lands of the country, approximately down to latitude 11° N, mostly associated with sandy topographies and camel pastoralism cultures. Khors refer to water courses of the savannah, middle and southern parts of the country, rising on clay soils associated with the cattle raising belt and the more stable rain-fed farming economies. However, there are some exceptions: Khor Arbaat flows into the Red Sea in the locality of Port Sudan, which is of semi-arid conditions, while wadi Salih and wadi Azum in South Darfur both flow from the highlands of Jebel Marra southwards into the rich savanna cattle country.

2. WADIS OF NORTH KORDOFAN

Study Area

North Kordofan refers to Sodiri District or Dar Kababish, engulfing the country between the eastern and western boundaries of Kordofan Region down to Latitude 14° 00′ N (Figure 1). The basic bio-physical features of the district are highlighted in Box 1 (Associated Consultants 1981: p1-12).

Land Use

Dar Kababish had an approximate total population of 405,872 persons in 1983. Of this figure, 109,585 were rural settled, 292,228 rural nomadic, and 4,059 urban. The geographic distribution of the population is very much related to the prevalent types of land use in the area.

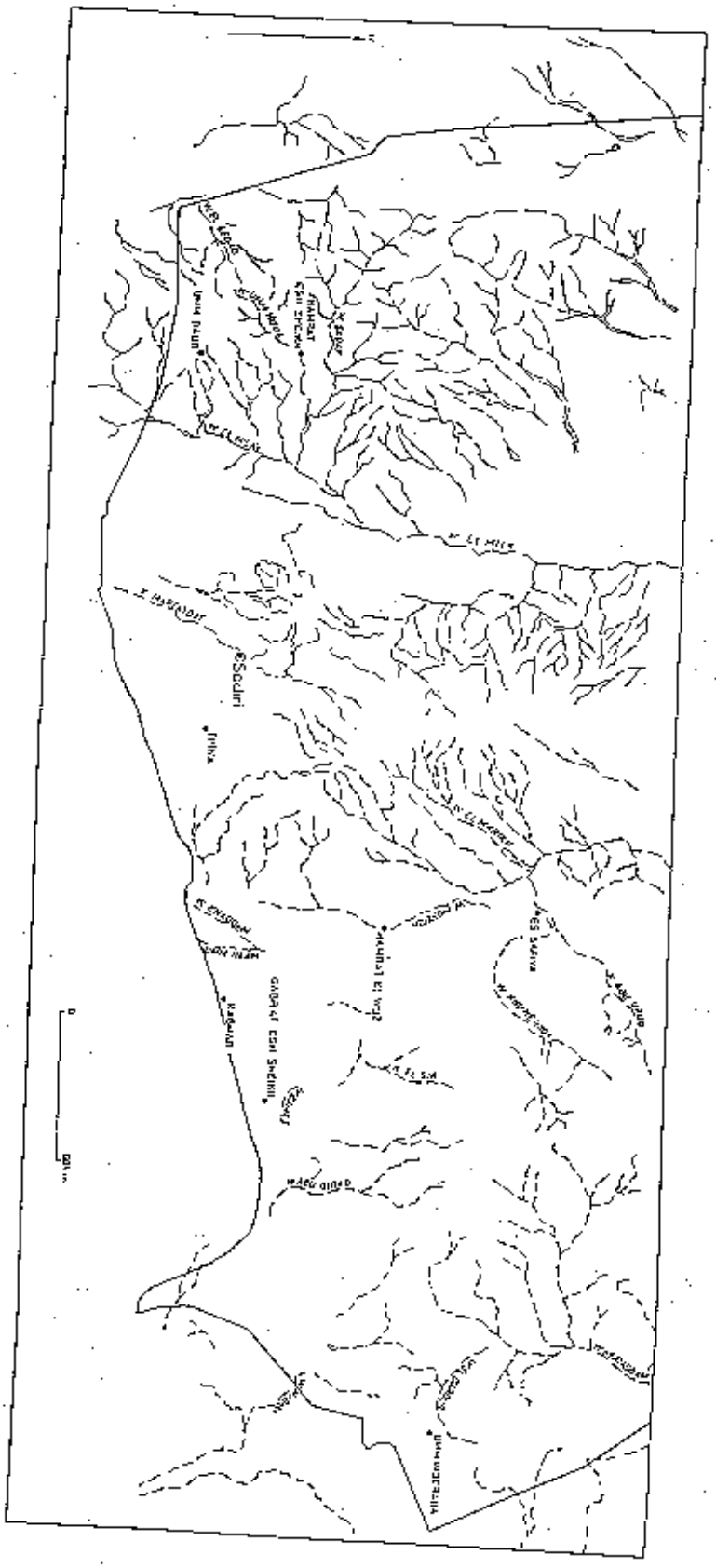
Two main types of land use are to be found: livestock raising and, to a lesser degree, shifting cultivation. Livestock raising is practised as a form of pastoral nomadism. The main animals raised in order of importance are: sheep, camels, cattle and goats. Five main population groups are involved in this economy: the Kababish, the Kawahla, the Hawawir, the Beni Gerar and Diweih. The pastoral life of all five groups is controlled and directed by the alternating seasonal availability of pastures and water supplies.

Agriculture, in the form of shifting cultivation, is the main occupation of the settled population, who keep small herds as well. It is also practised by the nomads, but to a lesser degree. The main crop is dukhun (millet; Pennisetum spp), plus other minor crops such as water melons and occasionally sesame. Judged on yield levels and the uncertainty of harvests due to the unreliability of rains, agricultural production is of limited potential in this area.

Indicators of Environmental Change

Dar Kababish has been witnessing large scale environmental changes. The indicators of change include: large scale removal of vegetation; decline in sheep reproduction rates; shifts in type of animal raised; reduction in amounts of milk produced by herds; scarcity of clarified butter; decline of game; lowering of crop yields; increase in conflict incidence; diversification of the rural employment base; and collapse of small business centres (El Sammani et al, 1984).

Figure 1: Wadis and main centres of Sodiri District (Dar Kababish), Kordofan Province, Sudan.



Box 1: Biophysical features of North Kordofan

Climate: The study area is generally too dry for non-irrigated agriculture. It falls within the belt which receives 200 mm rainfall and less as one goes northwards. Rainfall is received during the period July to September with the maximum attained in August. In this semi-arid region, rainfall is not only essential for the growth of annual and perennial grasses that constitute the fodder for the nomads' herds, but is also the source of water that fills the seasonal water courses, and replenishes the well centres, around which humans and livestock concentrate.

Geology: Two main geological formations prevail in Sodiri District: the dominant Basement Complex and the Nubian Sandstone. The Basement Complex is poor in ground water. Human habitation in the area is thus very much dependent on sub-surface water, building up in depressions, fed by wadis, and reached by means of permanent and annually hand-dug wells.

Topography: The topography of the study area is characterised by three types of land surfaces: aeolian sand mantle (sand sheets, longitudinal dunes and transverse dune systems), planated land surface (plateau and inselberg formations), and stretches of pediplain surfaces and depressions of variable clay composition, often originating from plateau and inselberg formations.

Drainage Systems: Drainage systems shape the sub-surface hydrology and water availability in the area. These are: seasonal water courses, wadis, inselbergs and plateau catchment areas, and extensive pediplain surfaces.

Soils: There is a close link between the topographic and geomorphologic units and the soil types. Two main soil associations prevail: the aeolian sand soils are categorised as a steppe soil, associated with sand sheet and dune formations; and the pediplain reddish to grey soils are categorised as semi-desertic soils, and associated with Jebel and pediment surfaces.

Vegetation: Vegetation formations follow soil associations and types. On the steppe soils the dominant formation is a pseudo-steppe, which also prevails on the semi-desertic soils, but with little or no trees. The pseudo-steppe vegetation corresponds with Harrison and Jackson's (1958) sub-division: semi-grassland on sand, with the vegetation being an Aristida grassland association. The main grasses are: Aristida species, Crotalaria sp, and Eragrostis sp. The main tree vegetation includes: Acacia raddiana, Leptadenia spratiuni, with some Acacia melliferia - Commiphora, and Balanites aegyptiaca. Most of the grass species are to be found again on the semi-desertic soils with a sparse occurrence of the same tree species.

Wadi centres

The wadis investigated in this study are best presented in relation to the settlement centres that have sprung up around them, and are dependent on their resources (Table 1).

Table 1: Wadis and settlement centres

Centre	Wadi(s)
Umm Inderaba	W. El QarQur
Gabrat Es Sheikh	W. Damas
El Safiya	K. Abu Uruq
Hamrat El Wuz	W. Mgheigh
Timma	W. Katul
Sodiri	W. Sodiri
Hamrat Esh Sheikh	W. Umm Hayaya
Umm Badr	W. Umm Badr (a branch of W. El Milk)

(For Centres and wadis locations, See Figure 1)

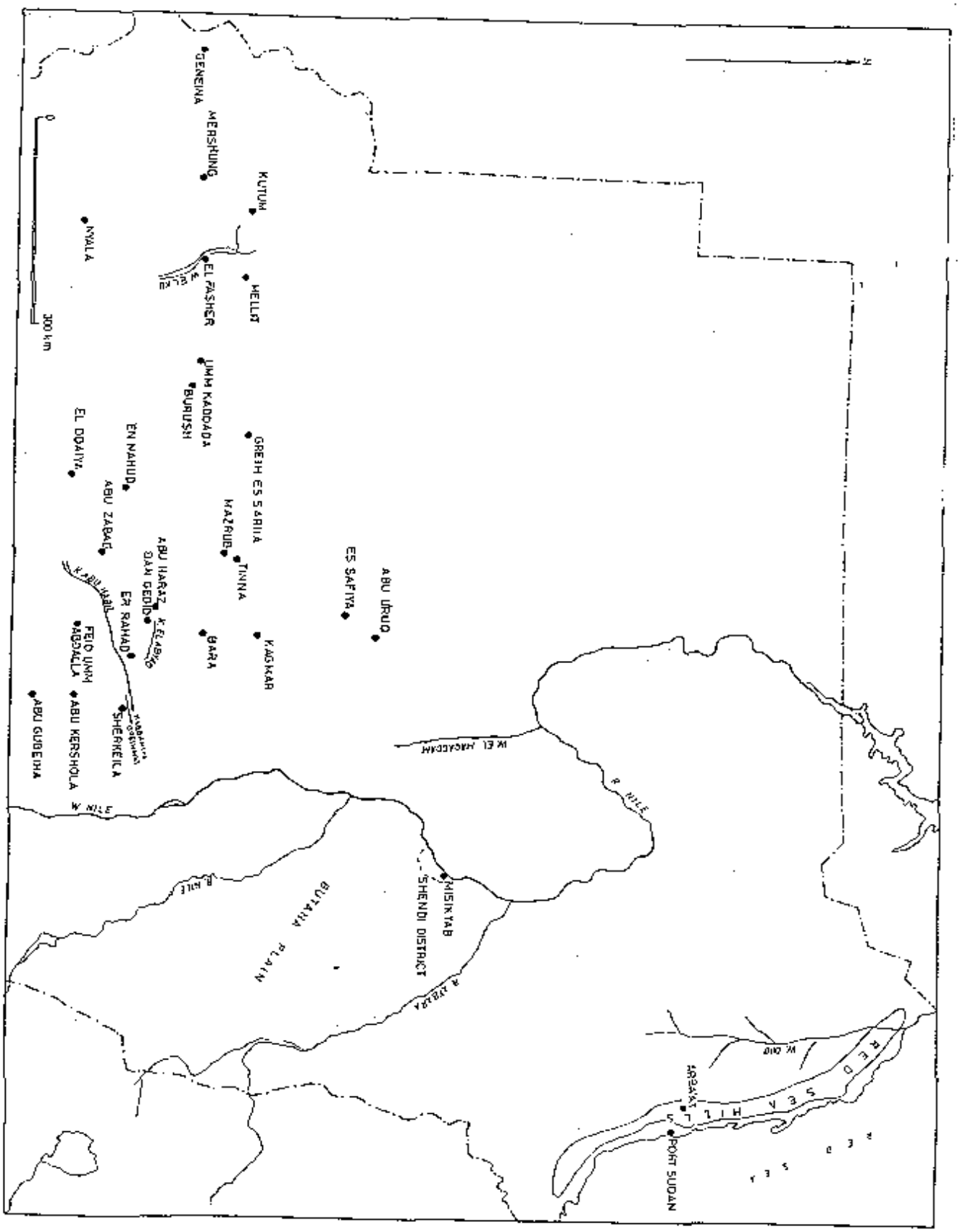
Wadis of the first three centres drain the eastern parts of the district, while those of the last five centres drain the western parts of the district, with wadi El Milk originating in between the two.

3. THE ROLE OF WADIS IN THE AGROECOSYSTEM

A look at the history of settlement in Dar Kababish, and in the other parts of the country, away from the Nile, reveals a pattern of growth of settlements on wadi sites. Population association with wadis may also be of a seasonal nature; moving out during the rainy season for pastoral and agricultural activities, and back to wadis at the start of the dry season, where a secure supply of water could be obtained.

This major role is well demonstrated by the siting of the main towns of Western Sudan on wadis: Er Rahad, El Obeid, Dilling, Abu Zabad, En Nahud, Sodiri, Umm Keddada, El Fasher, Nyala, etc (Figure 2).

Figure 2: Location of places mentioned in the text, northern Sudan.



Watering Places

Water can be obtained as surface flow in the form of pools, lakes, or stored in hafirs that are linked by feeder canals to wadis and Khors. Ground water may also be reached through well-digging.

The pastoralist grazing cycles in most parts of the country are influenced by wadi location, utilising their grazing resources and dependent on the water supplies. Table 2 shows the well-fields found on the wadis under study.

Table 2: Wells

Settlement	Number	Depth (m)
Umm Inderaba	800	8
Gabrat Esh Sheikh	130	6
Es Safiya	200	12
Hamrat El Wuz	80	8
Tinna	300	12
Sodiri	150	12
Hamrat Esh Sheikh	5	18
Umm Badr	600	5

Except for Hamrat Esh Sheikh, whose 5 wells are lined, in the rest of the sites the great majority of wells are temporary; dug afresh, or mended after wadi flooding is over.

Dependency on wadis for water supply is not only limited to the sedentary communities residing there, or the pastoralists visiting, but extends to distant settlements which carry water on animal back, or even truck it by lorry. A striking example in Dar Kababish is Tinna settlement, where 20 lorries operate daily from the well-field to Mazroub and its surrounding villages, where the selling of water is a flourishing commercial activity. Buyers are not only sedentary cultivators, but include sheep raisers who prefer holding their flocks at good grazing sites and securing water for them at commercial prices, to keeping the animals on depleted pastures adjacent to watering places.

Tinna was a poor water site up to 1962. But following the construction of some earth works on the wadi, this replenished its well-field, raised the water table and changed the site into a dependable water source. Many other examples of well-fields outside Dar Kababish with large population and livestock dependency could be cited in Kordofan and Darfur: Sherkeila, Er Rahad, Abu Haraz, Ban Gadeid, Abu Zabad, El Odiya, En Nahud, in Kordofan; Umm Kaddadah, Burush, Mellit, El Fasher, in Darfur (figure 2).

Grazing Axes

Wadis act as contact axes between the different seasonal grazing areas. Under a balanced cycle of seasonal movements (a matter of the past) the Kababish pastoralists used to go for wet season grazing (July-September) into lands north of the wadi zones, spent the cool period of October-January in the wadi areas, and the dry period, February-June to the south of the wadi zone. Similarly, the Habbaniya and Direihmat cattle pastoralists of Sherkeila area of Eastern Kordofan District, for example, followed Khor Abu Habil, on their migration between wet and dry season grazing localities, spending the cool period on its banks.

Both the rangelands of Dar Kababish and the grazing movements of the pastoral groups living there have witnessed drastic changes in the last 20 years or so. Wadis have changed from their previous role, as intermediate locations between wet and dry season grazing belts, into permanent grazing sites for the herds. A picture of the past, at places like Gabrat Esh Sheikh and Hamrat El Wuz, as gathered from interviews with two merchants who entered the area in 1935, reflects how ecology and life looked at that time (Box 2).

The change from this picture of the production system was gradual and reported to have intensified in the last 20 years. This has been due to the interplay of a diversity of factors: increases in human population, livestock numbers and settlements; expansion of cultivated land; wood cutting for various needs; decline in range capability; and rains failure. The drop in productivity has culminated in a flight of the pastoral groups based on these wadis, and with the occurrence of the 1984 drought, tribes like the Hawawir, based on Es Safiya and Abu Urug, have completely disintegrated into smaller groups that have dispersed widely into Merowe District and around El Obeid and Er Rahad in Central Kordofan.

Box 2: The changing agroecosystem of North Kordofan

- Up to 1935 only a few herdsmen reached Kagmar, south of the latitude of El Safiya and Abu Uruq, for dry season grazing, while the greater majority of pastoralists spent the dry season north of wadi sites up to Debba (on wadi El Muggadam corridor). Gizu grazing was also extensive north of El Safiya and Abu Uruq, and used to hold livestock up to April; with the pastoralists spending only the two months of May and June to the south of the wadi sites.

- There existed a richer ecology of varied trees and grasses of a wide range of palatable types.

- Both human and livestock numbers were small and herd movement was confined to tribal territorial boundaries.

- Game was abundant too: gazelle and guinea fowl were often brought to the market for sale.

- Agriculture was practised mostly by sedentary groups, raising dukhun (millet) and sesame.

- There were only two shops in the area (presently 20) and no service facilities at the sites. The numbers of livestock sold were small, and business boomed only during the winter period, when pastoralists' presence intensified near the wadi in preparation for the southward movement.

(Source: Interview with two merchants, North Kordofan)

Wadi cropping

The people of Dar Kababish do not practise rainfed crop farming on wadi floods as extensively as in other parts of the country. However, some examples are still present, such as in wadi El Milk and wadi El Mahbas, plus in some dispersed localities between Tinna and Sodiri. The sites chosen are clay to loamy patches, usually well drained, locally referred to as Seisa (clay soils). These contrast with the extensive surrounding Goz, or sandy soils.

In Dar Kababish this type of cultivation is mainly practised by sedentary villagers, and rarely by pastoralists. Reviewing the situation in other areas outside Dar Kababish reflects varied experiences. While, for example, in the Red Sea Hills area and the Butana plain, wadi cultivated patches of land provide the main source of sorghum for the pastoral groups (see Part 3d), they are less relied upon in North Kordofan and North Darfur by the same groups. The reasons relate to:

i) The pastoralists are not basically cultivators; crop raising is a subsidiary activity to their dependency on livestock; when they engage in farming out of necessity they choose sandy soils. These are abundant, not tied to a specific location, accessible to migration routes and easy to till.

ii) Sandy soils are better suited to the production of dukhun (pearl millet), as compared to Seisa soils, which are more suited to dura (sorghum). The former is the preferred diet of the camel pastoralists of Northern Kordofan.

iii) Flood irrigated patches are not annually reliable land, as they might not receive adequate water, hence a cultivator would lose a production season. In places outside Dar Kababish, where this form of farming is practised, the cultivation of wadi patches is combined with other forms of agriculture: permanent irrigation from the Nile, as in South Shendi District; rain-fed farming on Goz, as in Khor Abu Habi (North Kordofan) and wadi El Ku area (North Darfur); or with livestock raising in the Butana and the wadis off the eastern bank of the Nile, north of Khartoum.

iv) Wadi use for farming requires close monitoring of the time when the soil is well drained and suited for starting cultivation. This is more feasible for a sedentary villager than a mobile pastoralist.

v) Access to patchy irrigable land on water courses by pastoralists is often limited. By contrast, sedentarists have a continued presence and a closer association with this type of farming. In the Red Sea Hills area, where the tenure status is clear, with tribal groups owning specific lands on wadi courses, cultivable land is only owned by the early settlers among the group, usually sedentary cultivators.

vi) Pastoralists of North Kordofan, and to a greater degree in other areas (Rufaa El Hoi of South Blue Nile, the Hawazma of South Kordofan, the Beni Halba of South Darfur, etc) generally do not encourage the expansion of cultivation, especially by outsider groups (other pastoral groups and sedentarists) in their areas, particularly close to watering sites, as it obstructs herd movement and becomes a continual source of conflict. In Dar Kababish disputes are centred around the expansion of cultivation at the masharai (watering sites) and the digging of wells in traditionally open grazing areas. This has been raised in a number of tribal conferences.

Crop farming on wadis, under natural conditions, has a high degree of vulnerability. For instance, crop production in wadi El Muggadam depends on rainfall which rarely sustains a crop to maturity. In the past, the wadi ran more frequently, flooding certain areas for days during the rainy season.

Loamy wadi soils, with high water holding capacity, would then have enough moisture to produce a quick maturing crop of sorghum or millet. Small holdings of about two hectares were cultivated for family subsistence with the straw used for animals. Due to recent droughts, crop failures have been continuous for the last 10 to 15 years; rain-fed crop production is a memory of the past (IES, 1987:54). The exceptional rains of 1988, which flooded large areas of the lowlands of Northern Sudan, resulted in a successful crop in wadi El Muggadam in that year. When the next successful flood will be, nobody can tell.

Despite this high vulnerability, sorghum produced through wadi cultivation fills an important gap in the grain needs and fodder requirements of the populations dependent on this type of farming. Randell (1973:8,23) notes:

> "The communities along the Nile (its eastern bank north of Khartoum to Atbara) are supported by three main types of agriculture. In order of importance these are: irrigated agriculture, pastoralism and wadi cultivation (in years of good rain wadi cultivation may yield a higher return than livestock in Shendi District). The relative importance of each varies a great deal from one village to another. Wadi cultivation is undertaken by a relatively small number of inhabitants, since the lands are distant from the river and their cropping requires expeditions into the interior of the Butana"
>
> "Rainland cropping is more significant than the environment or the number of persons engaged in it would suggest. All villages obtain some of their dura supply this way. In Misiktab village about one third of the inhabitants have rain-fed cultivation, most of which are in wadis or mayas (flooded pans) in the interior of the Butana."

Data from the Red Sea Hills area validate further this role of wadi farming in supplying dura for the local population. In Diib wadi:

> "Sorghum production under the arid conditions (75 mm rainfall) of the project area depends on the seasonal flooding of the wadi Diib system. The occurrence of summer rains (July-October) and winter rains (October-February) makes the wadi carry 1-4 spates of flooding during the whole period. Two crops of sorghum may be raised annually on the winter and summer flood waters, all depending on the intensity of rains and the flow levels of the wadi. However, in most years only one cropping is practised." (IES, 1988: 38-9)

Horticultural Production

Horticultural production has grown in importance in association with wadi development in recent years, especially with the increase in urban population and the consequent growth of a market economy for horticultural crops. It usually starts with rainfed vegetables: tomatoes, cucumber, ladies fingers etc are produced in wadi beds and mayas. Depending on the availability of ground water, this form of seasonal production may turn into a permanent activity. It develops through a variety of irrigation systems: large diameter lined wells (mataras), tube wells, canalisation, automated pumps. A diversity of production types have emerged: sizeable orchards of mango, guava and citrus; vegetable gardens; fodder plots and, in some cases, dairy and poultry production. Examples can be cited throughout the semi-desert belt "region of wadis" and the wetter savannah belt "region of Khors" in Kordofan and Darfur: Sherkeila, Er Rahad, Bara, Ban Gadied, Khor El Abyad, El Odiya, Abu Kershola, Feid Umm Abdalla, Abu Gubeiha in the former; Burush, Millet, Kutum, Mersheng, Gineina, Nyala in the latter (figure 2).

In Dar Kababish this form of production is at its start, and being practised at the following sites (Table 3).

Table 3: Wadi garden production

Site	Nº of Gardens	Status
Gabrat Es Sheikh	2	Permanently irrigated
Hamrat El Wuz	5	Permanently irrigated
Sodiri	1	Seasonally cropped on Hafir overspill water
Tinna	40	5 under permanent irrigation, rest only seasonally cropped
Umm Badr	2	Permanently irrigated, sorghum attempted on wadi flood during drought time

Except at one site, Umm Badr, where some sorghum fodder plots were attempted during the 1984 drought, the activity is oriented towards vegetable production for the small market of semi-urban consumers residing at these places. In the Sodiri case, the development is founded on the overspill water from the town hafirs (water storage sites), supplemented by

irrigation from a hand-dug well at the inlet of the hafirs. The activity was initiated by the District Council Executive Officer, mainly to supply government officials with vegetables.

At some of the sites the activity has risen, as an immediate response to the drought, either for fodder production (eg Umm Badr) or for income generation. At one site, in Gabrat Es Sheikh, Zaribas, enclosures previously used for keeping livestock, were transformed into vegetable production plots irrigated by hand from nearby wells and manured by material collected from the well-field. Tinna is the site with the most numerous gardens (40 of 200 m^2 each). This is a recent development, originating with a dyke constructed for increasing the recharge of wells.

Ownership of gardens is predominantly by merchants and government officials, with only a few traditional sedentary households having access to plots. Here, tenure right is not tied to specific families, as in the case of the Red Sea Hills wadis. It is vested in the hands of tribal chiefs; this facilitates access to land by richer and influential groups.

Sustaining environmental refugee populations

Wadis serve as temporary or permanent sites for people displaced due to environmental change. They possess the highest ecological potential in terms of vegetation and water supply as compared to the surrounding open range. They also house settlements that have government presence, service facilities and marketing infrastructure, where stressed groups may find care and support for their basic needs.

These wadi centres are resorted to during times of drought, as during the three years preceding 1984. With the continued depletion of the rangelands of Dar Kababish, livestock raisers concentrated at the main centres on the wadis and adopted management systems that met the requirements of the various types of animals. Camels would still roam the rangeland, browsing trees, again basically on wadi beds, while sheep and goats were held at camps at settlement sites.

For sheep, zero grazing was practised on purchased hay, transported on camel back, again from wadi sites that were 3-5 days journey from settlements. This was supplemented by cakes and dura bought from the local markets or Omdurman. Goats, being browsers, were sustained on the tree vegetation in the vicinity of settlements.

For three successive years pastoralists sold some sheep to spend on maintaining the rest of the flock in anticipation that the next years rains would produce good pastures and enable the animals to move out of the settlement into the open range. By 1984 the real drought occurred, resulting in the majority of livestock owners either selling at depressed prices, or in animals perishing at the wadi sites. A look at

the mortality figures during the drought reveals that sheep loss was up to 80%, while camel and goat mortality was in the region of 20%.

The occurrence of losses during the drought, together with the effects of the long term processes of environmental change, have led to the emergence of marginalised groups that have been attracted to wadi settlement sites. For these groups the goat has become the main animal, dependent on browse vegetation, supplemented by purchased dura from the market and providing the household with milk and offspring to sell annually. For such marginalised groups income generation from outside the livestock economy is vital to household sustenance. The ability to gain access to employment opportunities, most probably away from wadis, to generate remittance income is seen as vital. The degree of flight of the male population from wadis may be taken as a good indicator of the degree of depletion that the wadi resource base has reached. With reductions in rainfall, wadis have been transformed from rich resources, as pictured previously under earlier conditions in Dar Kababish (see Box 2), to a situation where some wadis are only able to hold a marginalised population with a few goats. This stage is encroaching on the wadis of Dar Kababish, especially in the eastern half of the district, and is presently well exemplified by wadi El Muggadam and the wadis of the Red Sea Hills area.

Centres of Employment

The service infrastructure arising with wadi settlements employs groups of professionals on monthly salaries. The market places of the same settlements also incorporate other population segments, who draw their incomes from running businesses. There is also employment in herd related activities, and in agriculture, plus a diversity of off-farm jobs.

Water extraction from wells to supply herds and for nearby settlements offers dry season employment, drawing income from the sales of water. Where rainfed or irrigated agriculture is practised, wage labour is used for different agricultural operations providing additional employment, especially for the poorer segment of the population. Collection and selling of hay as fodder, for settlement based livestock, is a source of cash during the dry season for a needy sedentarist using his donkey or a pastoralist using his camel, bringing a load of hay to sell at the settlement. Fuelwood and wood for construction purposes is another source of cash generation.

Evidence from the last drought shows clearly that wood cutting for income generation, during these times of stress, leads to massive removal of trees from wadi beds. Drought afflicted groups, attracted to wadi settlements in anticipation of relief food, would head to nearby forests, cutting wood to sell for raising cash. This was the most readily available source of income generation (see Part 3d).

Brickmaking is one more activity practised at wadi sites, favoured by the availability of clay soils, adequate water, and an abundance of animal dung and woodfuel for brick firing.

Land Tenure Issues

Tenure systems organising wadi land use have evolved under different situations; these are dominated by traditional land rights and regulated by customary tenure transactions. These systems are highly adapted to local cultural, political and administration needs. Tribal hold over the land may be very strong. For instance, in the Red Sea Hills area outsiders are completely excluded from having access to wadi land, especially for cultivation. In other cases, people are allowed right of use or ownership with the consent of the owner or the local chiefs.

The handling of the land tenure issue is an important necessity in wadi development. Where the system is accepted by the people it should not be interfered with. Tenure systems should be judged on their efficiency in controlling the land and regulating its allocation, especially for the needy. Under other situations, where the tribal stronghold over wadi resources is weakening, mostly witnessed at sites accessible to towns, some measure of control needs to be applied. In the latter case experience has shown that traditional communities end up alien in their own land, with the land passing to the hands of the local merchants and outsiders. Even the groups of workers engaged in horticultural farming are often imported from outside the area as pastoralists, in particular, are not skilled in this kind of farming. Under such circumstances it is not only the land which shall be lost to the traditional user, but also the other accruing benefits; thus generating inequity and social conflict.

4. THE PROSPECTS FOR WADI DEVELOPMENT

The multiple use of wadis

Development of agriculture on wadis cannot be separated from other forms of use of wadi resources. Integrated planning needs to encompass all components.

Ideas of wadi development for various agricultural uses are not new to the rainfed lands of Sudan. They were part of the soil conservation mandate during the 1940s-50s. For instance, hafir construction has continued to harness part of the annual wadi and Khor flows, and conserve it in water reservoirs. Small agricultural schemes have been attempted at many sites (Bau in the Ingressana Hills, Miri Bara dam near Kadugli, Erawakeeb West of Omdurman, etc) by the Soil

Conservation Department and the National Water Corporation. In recent years the former has been carrying out small water harvesting and water spreading projects, on and outside water courses and *mayas* in Darfur, Kordofan and the Red Sea Hills areas. Developments in the Red Sea Hills clearly reveal the prospects of expansion of wadi agriculture under semi-arid conditions (see Table 4).

Table 4: Area of Sorghum Farming in the Red Sea Hills Wadis

Name of wadi	Previous time cultivated	Land potential feddans	Area cultivated 1986-87
Amur	1986	7,000	800
Agwampt	1986	6,000	1,200
Oko Kb.Gabatit	1986	5,000	1,200
Kiabiaf	1986	1,000	600
Obreg	1986	1,000	500
Amasa	1980	2,000	1,700
Oiy	1986	7,000	1,300
Mukban	1981	7,000	1,600
		31,000	7,900

Source IES (1988:71)

Development of agriculture on wadis and shallow ground water aquifers provides a good basis for improving the economies of small communities of graziers and sedentarists in semi-arid lands. This potential has not yet been fully tapped. The prospects of pursuing this form of development can be seen from different angles. The concerns of the resource planner and the user are considered here.

The agricultural production systems of semi-arid lands are highly vulnerable to rain shortage, leading to crop and pasture failure. Wadi development would assist in injecting a degree of stability in these economies, especially if the improvements envisaged aim at long term solutions of conserving and tapping the annual flow of wadis.

Both sedentarist and nomadic groups are utilizing wadi lands for crop production, realised through their indigenous technologies. It is vital to provide some bases for improvements that combine peoples skills, knowledge and organising abilities with outside packages, to effect more advanced use of the available agricultural resources.

Pastoralists have been practising supplementary feeding on sorghum stalks harvested from cultivated patches on wadis. The dependency on feed supplements (dura, hay and cakes) has noticeably increased as a result of the depletion of fodders obtained from the range. Hence, there is an inducement for expanding wadi farming, once harnessed for crop production.

The inhabitants of wadis have the perception of the kinds of development that could be effectively applied to tap wadis' land and water resources. In surveys carried out in Dar Kababish, Wad El Muggadam and Diib the communities there are suggesting irrigated agriculture based on mataras (big diameter irrigation wells) and the construction of dykes to check and spread wadi water for rainy season dura cultivation, and for the improvement of pastures. Permanent irrigation sites would act as small oases of stable agricultural production that would effectively integrate with the dry farming activities in the area, and provide support to the local communities.

In recent times, there have been noticeable improvements in the standards of living of both rural areas and towns. Vegetable consumption has increased tremendously in the last decades in areas away from the Nile. The daily supplies to markets are almost wholly met from gardens developed on wadis. With this trend growing, expanding horticultural production from wadis is socially and economically desirable.

Besides contributing their resources (land, customary tenure, acquired practices of land reclamation and water use) there is the possibility of both sedentarists and pastoralists contributing investment capital from sales of livestock in wadi development ventures, if they are seen to be economically rewarding. Under traditional rainfed economies there is an exchange of capital between livestock and crop cultivation; people invest surpluses from crops into livestock, and sell the latter to invest in farming.

Wadi development also provides an essential outlet for accommodating environmentally displaced groups. Such groups are currently congested within the semi-arid belt, are regarded as redundant populations, live under vulnerable conditions, and are subject to the deprivation of the small urban centres where they are presently to be found.

Planning wadi development

The current features of misuse of wadi land resources are part of the on-going processes of degradation occurring in semi-arid lands. Plans aimed at tapping the resources of wadis for agricultural and other purposes should benefit from the strategies developed for the rehabilitation of semi-arid lands in Sudan. The kind of planning principles that need to be considered are listed in Box 3.

Box 3: Planning principles for wadi development

- Balanced use of resources through applying integrated planning.
- Release of population pressure by moving out excess population and accommodation of displaced groups.
- Securing local peoples' interest through their involvement and full utilization of their organisational capabilities.
- Range improvements, coupled with management of livestock numbers and concentration on ecologically suited types of land-use.
- Checking expansion of settlements and cultivation in marginal lands.
- Rejuvenation of local economies through diversification and expansion of agrarian activities by harvesting the wadi potentials, through the application of more efficient water use and farming development technologies.

An important concept in wadi planning is the need for examining wadi function in a wider context, that integrates specific wadi uses, to wider aspects of resource utilisation. Much of the ecological degradation of wadi lands witnessed at present is a result of intensive use, triggered by grazing and cultivation imbalances in the wider territorial context. Wadis have formed the last resort, where users concentrate after the depletion of the topland production bases.

Development which is based on a wadi course is best attained by adopting a "river system approach" as wadis are serving different roles and benefiting many communities along their courses, dictating that the needs of various users need to be catered for to minimise conflict.

Wadis may not successfully flow in every year. This is built in in peoples perception of wadi development. For example, in the Red Sea Hills area people may end up in some years without a sorghum harvest. To minimise such adverse effects on the population, alternative means of sustenance need to be maximised through effective planning, integration of other sources of livelihood, employment in and outside wadi areas, reduction of the human and animal loads on the land, improvement of the livestock production bases and storage of dura from good years.

Measures for ecological conservation need to be applied to guarantee the sustainability of the wadi agroecosystem. For instance, monitoring of the tree vegetation cover along wadi courses should be accorded a high priority. The ongoing trend of productivity losses of the grazing resources of semi-arid lands will send more population into wadi sites, intensifying further the current heavy use levels. Conservation measures should aim at both renewing the tree cover along wadis and preventing cutting of trees, especially for commercial fuelwood supplies to distant populations.

Resource conservation also needs to look into applying adjustment measures that would regain potentials lost to wadis due to past misuses. Changes have lead to movement in wadi courses, loss of agricultural land, reduced well-field recharging capacities and devastation of settlement sites.

The systems developed by local people, their skills and acquired technologies in handling wadi resources provide a good start for enhanced utilisation. However, their technological solutions are short of tapping the full potentials available to them. Gaps between peoples' resources and more advanced solutions in areas of essential technologies, investment and capital need to be bridged.

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- **Support to local organisations and researchers to encourage sharing of experience and ideas, capacity building and establishing collaborative links.**

- **Action-oriented research in the practice and policy of sustainable development in Africa's drylands, focusing on the variability of resources and incomes on which populations depend, development-oriented research methodologies, and natural resource management systems.**

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