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ENVIRONMENTAL INDICATORS AND TRENDS IN TFGALI DISTRICT:
A CASE STUDY OF A TROPICAL MONTANE

BASE - LINE SURVEY
(1984)

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INTRODUCTION:

This work introduces some aspects of the physical and non-physical environment in Togali District an area known as 'Eastern Jebels' of the Nuba Mountains. It is essentially, a base-line survey whose prime objective is to review the environmental conditions in the past 30-40 years as well as reviewing the present situation.

Acquiring information on the past and present, changes and trends can be detected and assessed. Environmental stimuli and human response(s) can also be investigated. Furthermore, tasks of monitoring preventive and curative measures would be founded on some understanding of environmental problems. Expectedly, gaps in the literature are found and the present work has taken the task to fill in some gaps.

This base-line survey, however, is an acomplishment of the first stage of an ETMA programme concerning Togali District. Of the regions under E.T.M.A investigations, Togali District stands out for its montane environment as well as its rather unique historical, cultural and political backgrounds.

There, rather rapid changes in the socio-economic life have taken place. Accordingly, it is hypothesized that those rather rapid changes have their impacts on the natural resources and population dynamics.

Based on the above hypothesis, the district was selected for ETMA programme with focus on changes, trends and monitoring. Members of the Study group, however, came from different academic backgrounds which include geology, ecology and forestry, climatology, population geography, agricultural geography and environmental hazards.

THE STUDY AREA: LOCATION AND BACKGROUND

Tegali District forms about one third of the area of Southern Kordofan Province. It extends in the eastern of part of the province and lies in the south eastern corner of the mother province Kordofan, fig (1). The latitudinal extension of the district is between about 9^{0} 36' N and 12^{0} 18' N. Longitudinally, it extends from about 30^{0} E to 33^{0} E,.

The area is hilly and high enough to induce the moist south westerly wind orogrophically. The relief factor there makes all the Nuba Mountains

of which Tegali District forms the eastern part) anomalous in the isohyetal map of the Sudan. The average annual rainfall varies from about 500 mm in the north to about 800 mm in the western slopes of the southern parts of the District, Fig (3).

In Tegali pastoral nomads and the sedentary agriculturist co-exist. For a long time in history, however, the area was not open to the outside world and thus the natives lived in isolation. In recent history, admittance to the Nuba hills was like the South restricted by the British during the Colonial period. During the period of isolation when demands and aspirations were very simple, a natural ecological balance was thought to have been maintained.

Afterwards and recently the whole of the Nuba region of which Tegali District forms a great part has witnessed some rapid changes toward's modernization. Now, the subsistence economy inherited and passed to generations is quickly giving place to cash economy with new techniques, tools and larger farms. Of paramount importance, however, are the new aspirations and attitudes in which profit maximization overwhelms other interests of environmental conservation.

METHODOLOGY:

As stated earlier members of this study group come from different academic disciplines. In several meetings the task and some outlines of this research were discussed. According to interest sections of the report were undertaken by group members.

The immediate task was to collect readily available information on the district. Some data were compiled and previous works along this line of environmental resources were reviewed. Areal photographs in the case of relief were interpreted. Meteorological data were collected and manipulated for some rather detailed agroclimatological parameter to indicate agricultural potentials of the district. Similarly population data were analysed to fill in some gaps. Human activities was reviewed and data on water supply were compiled. In these aspects of socio-economic relevance some hypotheses emerged and future field work, will consider those hypotheses of which the rapid commercialization in the region is thought to have some negative impacts on the quality of land.

In the case of soil information are very meagre and a member of the group is planning shortly some soil pitting and then analyses. Regarding natural vegetation, thorough investigations were carried out long ago by Andrew in 1948, in Cathill, (1948). Later in 1956 Jackson and Harrison made an ecological classification of the vegetation of the Sudan. Based on these two works, flora of the Sudan is reviewed, but changes and trends must wait field investigation planned by the present study group, using a transel method.

PART I.

PHYSICAL AND BIOLOGICAL INDICATORS.

GEOLOGY, GEOMORPHOLOGY AND SOILS:

GEOLOGY:

The whole district is underlain by Basement Complex (B.C) rocks which can be broadly divided into three major groups which are: (i) The older granites (ii) The gneisses and granite gneisses (iii) The Metasediments.

The older granite, however, occur principally in a broad belt of North-South trend. It extends from Rashad to the North upto latitude 12°:15' N. Although the greisses constitute most of the area they outcrop mainly in the Rashad-El-Abbasiya area where, together with the metasediments give rise to the Tegali Plateau, Fig (2). Also in a broad belt are the Metasediments (B.C) (Marbles, Schists graphite and QuartzitesSchist, formations flank the plateau from the east and continue to the south under Abu Gubeiha and further south to about latitude 11°:00' N (the latitude of Kadugli in the Southern Jebels).

GEOMORPHOLOGY AND SOILS:

(i) GEOMORPHOLOGY

Tegali District can be sub-divided into:

(a) The East Nuba Mountain Country

(b) Tegali Plateau (c) The pediment

(d) The inselbergen

(e) The eastern plain

(f) The Southern and Western plains, fig (2)

(a) The East Nuba Mountain Country:

The mountains are semicircular or horse-shoe like mass of highly dissected hills rising for more than 400 m above the plain and extending primcipally from north and east of El-Abbasiya to Rashad in the west and El-Biteira in the east. The country, there, is characterized by the prevalence of domed land forms in the Rashad area and by linear hill ranges in the east. Land forms are dissected by numerous gorges often controlled by a remarkably parallel series of factors which are mostly of east-west orientation, fig(2).

(b) Tegali Plateau:

This refers to the square land confined within the horse-shoe extending latitudinaly between 12° to 11°:37' N. It starts from Rashad mountain range and flat wooded land surface of only 4 square kilometres area occurs in the plateau. This represents a very

ancient erosion surface. The rest of the plateau is a surface of gentle north-to-south slope, dissected by a rectangular network of shallow seasonal streams. The soil here is mainly deeply weathered of coarse texture.

It is lightly wooded but with considerable gallery forest along the major streams. The plateau is a favourable resting place for nomads.

(c) <u>The pediment</u>: It flanks the mountain country from north, west and east. The pediment is now largely weathered to a clay-loam. The slope, however, is clearly indicated by the attitude of the numerous streams draining it. It is thought that during the period of desiccation which is responsible for the Kez sands formation (werren the Nuba mountains at large suffered some semi-desert conditions which resulted in the formation of allvial fan deposits. Later, and under more humid conditions, the formations were subjected to weathering <u>in situ</u>. By-and-large, the soil formed there, supports cultivation of groundnuts durra and other crops. This is the so-called gardoud type of cultivation.

(d) The inselbergs:

The eastern fringe of the area where the metasediments occur, is a zone of numerous elongate inselbergs surrounded by sediments dumped from the hill sides. The manner of formation of the inselbergen is apparently due to erosion of beds of contrasting hardness, again under desert or semi-desert conditions. The dumping of sediments from the more resistant beds has resulted in the formation of a series of small elongate inselbergen smothened by coarse sediments. Later, the sediments were again weathered in-situ to give a clay loamy soil fig(2). To the south this layer of sediment may be absent for various reasons and in this case the metasediments in the intermontane spaces are weathered in-situ to give ferroginous and more cracking clays.

(e) The eastern plain:

This is a broad plain apparently underlain by sediments of Umm Ruwaba Series dumped by the numerous khors draining the Nuba Mountains. This plain, however, is outside the present focus. It is just beyond the Study area.

(f) The Southern and eastern plains:

These probably represent an old erosion surface possibly the one underlying the Nubian formation. It is noteworthy that contrary to previously held opinion, the irregularity in Nuba Mountains topography is a product of differential uplift of various blocks rather than scarp retreat. This can be, well illustrated with reference to numerous phenomena of neotectonic movements, both around the raised blocks and the plains. There, the clay soil was formed in-situ by weathering of the gneissic rocks of the plains. Thickness of clays range from 1-2 m, to more than 5 m. In areas of uplift, the clay layer of the level blocks may be destroyed partially or completely. In such cases the gneissic rock is exposed with only patches of clay surviving between the individual streams. In extreme cases, however, only bare rocky outcrops are evident, fig(2).

CLIMATE OF THE AREA:

INTRODUCTION:

Climate has always been the prime factor in shaping the mode of life in traditional communities. On the normal climate, human activities are founded. Deviations from the norm, if great may result in some hazards or catastrophe. Climatic extremes, however, shake the economy of traditional societies. The shaken economy, in turn shakes the population of the area and affects many aspects of distribution, attitude and behaviour, but these have their great impact on the environment, due to how natural resources are tapped.

BASIC CLIMATIC FEATURES:

Using Thornthwaite's system of 1948, all parts of Tegali District fall within the Arid Zone, with soil moisture indices as follows:

TABLE 1
Soil Moisture Indices: After Thornthwaite(1948)

Locations	Latitude	Longitude	Soil Moisture Indices
Talodi	10°;37' N	30°;24' E	34
Kologi	10 ;52	30 ;59	39
Heiban	11 ;12	30 ;32	39
Abu Gubeiha	11 ;25	31 ;15	42
Umm Bermbeita	11 ;50	30 ;40	43
Rashad	12 ;43	30 ;39	38
El-Abbasiya	12 ;10	31 ;19	43

Source: Awadalla,S.A. (1981)

A modified version of Thornthwaite's system (1948) incorporating Penman Potential evapotranspiration and UNESCO definitions of the arid regions, by Awadalla (1981) classifies Tegali District as 'SEMI ARID' Mean annual rainfall over the district varies from about 500 mm in the north to 800 mm or more in the south, fig (3). Mean annual potential evapotranspiration (Penman P.E.) is at 2000 mm or just over that in almost all parts of Tegali District. Ratios of rainfall to potential evapotransipiration (max. atmospheric evaporative demand) on annual basis is about 35%. Relative Humidity is at maximum in July, September when mean monthly values are 60-70%. The atmosphere has cloud almost all the year round, but in winter the coverage is normally less than one third of the sky. In Summer the normal coverage is 5/8 th or more. The peak of which is in the period of July-August.

The North Easterly winds prevail from November to April after which period the moist South Westerlies dominate at mean velocity of 6-7 M.P.H.

Temperature records gauged at Rashad show the daily average mean max. for the whole year as 32.9°C and

the mean minimum for the 12 months is 20.3°C. At the same station, the mean monthly temperature for January conditions (representing winter) is 24.7°C when the mean maximum is 31.5°C and the mean minimum is 17.9°C. The highest January temperature ever recorded within the period 1951-1980 was 40°C in 1967. On the other hand the lowest ever recorded January temperature was 9.0°C in 1974. May is perhaps the hottest month in Rashad when the mean maximum is 36.0°C. In this month conditions of lower than 21°C have never been recorded within the whole period of 1951-1980.

ANNUAL RAINFALL: AMOUNT, VARIABILITY AND RELIABILITY:

Rainfall over Tegali exhibits some anomalies in the isolivetal map of the Sudan. There, amounts are higher that what is expected at these latitudes, due to the significant topographic effect. Moreover, topography there has resulted on some shadowing effect in the eastern parts of Tegali where significantly less amounts are received. Accordingly the isoliyets tend to take a meredionial trend rather than the expected latitudinal one,(fig.3). This easto-to-west decrease in annual rainfall can be demonstrated

by comparing rainfall over Rashad (at elevated western shapes) with records of El-Abbasiya or Abu Gubeiha, both a few miles North East and South South East respectively. There, Rashad's annual rainfall exceeds that of El-Abbasiya by more than 200 mm on the average. Abu Gubeiha, though further south of Rashad, but with an easterly component of location, its mean annual rainfall is exceeded by more than 100 mm which amounts to about 20% of its annual, (figs. 4,5).

Temporal variability, however, can be indicated by several methods, including the range, the mean deviation, the standard deviation or the coefficient of variation. Furthermore, analyses of variability can consider the average deviation from the mean or can consider the average deviation between any two consecutive years. Of these measures, the range exaggerates variability, because of considering the extreme values. Nevertheless, in Tegali places like Rashad show relatively low ranges, where at Rashad the highest annual rainfall ever recorded from 1916 to 1980 is 1065.5 mm (1934) compared to the lowest value of 539.5 (1927) and central tendency

of about 760 mm.

Of the above mentioned methods, the interannual variability which is based on the year-to year variations is a simple and useful indicator. Indexing variability on interannual basis, Tegali shows modest values. On the average, the expected fluctuations from one year to the next are in the range of ± 5 to 10%. Tegali and all parts of the Nuba Mountains are comparable with locations further South in the Southern Region.

Considering variability from the mean and using the coefficient of variation, deviations from the norm in different parts of Tegali range from about 16% in the western slopes to 23% or more in the east. Again rainfall distribution favours the western slopes not only in terms of amount, but also in terms of variability, compose the 16% coefficient of variation in the case of Rashad with 23% at Abu Nuwara or the 22% at Jebel Ettiri further south, but meridionially to the east. However, variability indicates reliability which can be quantified by some probability analysis considering critical threshalds related yield of subsistence crops for instance.

SEASONAL RAINFALL AND THE WITHIN-SEASON DISTRIBUTION.

In fact what matters most in this aspect is not the annual total, but the seasonal amount and how distributed. Investigations along this line requires, primarily, delineation of the wet season on basis of clearly defined onset and termination. For the control zone of the Sudan which includes Tegali District, Awadalla(1981) defines the onset of the wet season on pentadly basis (5-day period) and moisture conditions assumed to satisfy germination and early growth of sorghum. The definition seeks the first three consecutive pentads each of which satisfies not less than 80% of the young plant evaporative demand. The first of the three pentads marks the onset of the wet season. The approach for this definition is essentially agrochimatological based on manipulation of meteorological data using known values of crop Water Requirement at different stages of growth (Adam and Farbrother 1976). On basis of depleted soil moisture in the first three consecutive pentads, the termination of the season is defined.

Accordingly, the average time for the onset of the wet season in Tegali is found to vary from late

May to late June as the following table shows.

TABLE 2

Average Time of Onset of The Wet Season

Location	Average Time of onset	Average Time of termination
Talodi	25th May	13th November
Kologi	31st May	8th November
Heiban	5th June	3rd November
Umm Bermbeita	15th June	25th October
Abu Gubeiha	10th June	29th October
El-Abbasiya	20th June	14th October

Based on the above definition of the wet season, the soil continues to be wet until the dates shown in table (2) above. Needless to emphasise that the wet season defined on basis of soil moisture continues well after termination of the rainy season because of soil moisture storage which afterwards depletes gradually when actual evaportranspiration is below the potential. It is an established fact that soil moisture below the saturation level is not readily available for evapotranspiration, because of the gravitational force exerted on the moisture between soil particles.

Accepting the above definition of Awadalla (1981), rainfall received within the first 110 onset, (a period which is required for growth of medium-term sorghum) is not less than 400 mm and in the southern parts of the district 500 mm may be exceeded. Values for Taloli, Abu Gubeiha and Heiban are 507, 455 and 476 mm respectively, (figs. 6,7).

Data on rainfall, received within the growing season would have more value if compared with the Crop Water Requirement (C.W.R). In these localities, however the Maximim Crop Water Requirement (MCWR) varies, by far less than seasonal rainfall, table 3 and fig (8).

TABLE 3

Maximum Crop Water Requirements and Seasonal Rainfall

Location	C.W.R (mm)	Growing Season Rainfall as % of M.C.W.R.
Taloli	569	91
Kologi	583	86
Heiban	588	84
Umm Barmbeita	620	80
Abu Gubeiha	601	69
El-Abbasiya	632	73

Variations in the above values of MCWR is primarily a function of the atmospheric evaporative demand which is a conservative parameter. Estimated potential evopetranspiration (Penman P.E.) based on interpolated meteorological data, Awadalla (1977) shows equal annual P.E. at Abu Gubeiha and Heiban, each of which score 2141 mm. Annual P.E. at Talodi and Kologi is 2114 and 2119 mm respectively.

One of the aspects of the distribution of seasonal rainfall to be ivestigated is the seasonal march of moisture whether, peaky, very peaky or not peaky. Concentration of rainfall is required, but over concentration in cases of twoo peaky distribution can be hazardous to the environment. Too wet conditions can seriously affect road passability, human health and agricultural operations. Soil erosion, logging and compaction can result from too conditions. Crop yield in the same year or other years to come can be negatively affected by too wet conditions for prolonged periods.

The peakyness however can be indicated and expressed mathematically by Fourier Time Series which investigate harmonics of different orders. Considering

the first harmonic (which shows the primary peak) 71% of the total variance is accounted for at El-Abbasiya, 60%, 49%, 52% and 50% at Abu Gubeiha, Heiban, Kologi and Talodi, respectively. Elsewhere at similar latitudes to the west, at Nyala and Geneina the first harmonic accounts for 91% and 98% respectively. Obviously at this aspect of distribution, Tegali District is one of the best regions in the Sudan. This is the norm, but individual years may deviate significantly.

Times of soil moisture peaks are of great interest in agricultural climatology, because according to these dates planting dates can be recommended. Generally, over Tegali the mean time of the primary peak of soil moisture occurs after about 60 days from the onset of the season as the table (4) and (fig.9) show.

TABLE 4

Mean Time of Primary Soil Moisture Peak

Location	Mean Time From Onset (Days)
Talodi	81
Kologi	75
Heiban	73
Umm Barmbeita	62
Abu Gubeiha	66
El-Abbasiya	56

SOWING DATES: BASED ON CLIMATOLOGICAL ANALYSIS:

If the above definition of Awadalla (1981) is accepted and accordingly sorghum seeds are sown, the discrepancy in time between max soil moisture and the time of maximum crop demand is minimal in Tagali. The maximum discrepancy on the average would be only 16 days at Tagali, 10 and 8 days at Kologi and Heiban respectively. Surprisingly, in the, case of El-Abbasiya the above definition brings perfect coincidence between the time of maximum crop water requirement. There the time lag is nil days, (fig.10).

Vegetation of the Nuba Mountains.

Introduction :

Here it is attempted to describe the state of vegetation of the Nuba Mountains about 30 years ago; and to indicate what has happened to it now (1983) with reasons for the change. This section therefore draws largely from the works of Andrews (1948) as a floristic account, Harrison and Jackson (1958) as ecological account and Smith (1949) where an emphasis was made on the distribution of tree species in relation to rainfall and soil type. Trees being perennial plants, long lived there and presence or absence has its influence on both soil and the associate flora.

The treatment aims at identifying the most obvious indicators of desertification as reflected by present day vegetation when compared with that recorded by the authorities cited above.

Flora of the Nuba Mountains :

As topography, or land-forms play an important role in the distribution of flora in the Nuba Mountains, it is worthwhile listing the characteristics flora of each landform :

1. Valleys; and inter-hill depressions; are covered with cracking clay soils. Tree-vegetation is predominated by thorny *Acacia seyal*, *Acacia fistula*, *Balanites aegyptiaca*, with *Borassus aethiopium* and *Hyphaene thebaica* on silty sites.

2. Mountains : These carry a special flora, quite different from the surrounding area ; e.g. Jebel Daier has Oxytenanthera abyssinica (Bamboo), Steganotaenia araliacea, Croton gratissimus, Vitex cooeata and Allophyllus rubifolium.

3. On the rocky shallow soils surrounding this mountain, species like Commiphora africana, Commiphora pedunculata and Adenium honghel, are found.

4. On light soils, members of the germs Combretum dominate e.g. Combretum heratmanianum and Anogeissus liocarpus as well as members of the community Acacia short grass". In addition Dombeya quinqueseta were found. Pseudocedrela kotschyi, Sclerocaria birrea and Fiscus sp. e.g. Fiscus plathyphylla and F. populifolia associated with Adansonia digitata.

5. On the sandy edges of (Khors) rannels ebony Diospyros mespilliformis was found and Celtis integrifolia.

6. The heavy cracking clays or heavier soils represent the greater part of the area. They are characterized by the thorney community and grasses. The tree flora consists of : A. seyal, A. campylacantha, Dichrostachys cinerea, A.seberiana, Zizyphos spinachristi, Balanites aegyptiaca, Albizia coricocephala and Euphorbia calycina.

The grasses are numerous but the main ones are Hyparrhenia sp., Brachiaria mullissima and Setaria incressata, Sorghum purpurad-sericeum and Cymbopogon nervatus. These are all tall grasses. Short grasses were also represented in this seemingly flat terrain, but local topographic pockets carry short grasses.

Human Impact on Vegetation and the Main Indicators of Degradation :

The list of species given for each landform is by no means exhaustive. Factors of topography, soils and rainfall combine to give the Nuba Mountains this complex flora. The factor of topography has also made human impact most impressive by dictating where roads and settlements should be. In fact in an area of about five square kilometers or so all land forms will be represented. So all of them will be accessible to human activity. The settlement on slightly sloping ground overlooking a valley beyond which stretches a plain. The human activity on the mountain can be traced by erosion, lack of trees and the unmaintained old terraces. The vallys lost their characteristic trees especially Borassus and Hyphreon both of them being replaced by orchards or horticultural activity. So loss of species is an indicator on this land form.

The lighter soils also have a characteristic flora whose loss by human activity is another indicator.

As for the sandy edges of Khors, these carry trees which are always in demand for buildings because of durability (Celtis) or carving and decoration timber e.g. ebony (Diospyros). So their absence or rarity is an indicator. Also bank erosion is another indicator.

The flat terrain vegetation suffered more than any of the above types. This is for several reasons :

a) It covers a great area.

b) It contains species of several or multiple ones.

c) Their soils are suitable for the important agricultural crops e.g. sorghum and sessame, cotton.

d) They constitute the free-range grazing areas.

e) They constitute the main fuel source.

f) Their tall grass community and a long dry season make them extremely vulnerable to fire.

So these dark cracking clay flats may suffer :

i) over cultivation and soil exhaustion.
ii) Over cutting and become tree-less.
iii) Over grazing.
iv) Damage by fire.

Once degraded of their vegetation cover, these soils become very sensitive to erosion by water. Because they crack when dry, they become very wet at crack-depth and move in masses forming rill and gully erosion.

So the indicators here are many :

a) Loss of tree species - selectively or whole sale.

b) Loss of fertility.

c) Damage by erosion.

d) Change of vegetation to a less economic one.

Interaction with Other factors :

The indicators cited above can be generated by the local use i.e. use of the local population or they can be triggered by demand outside the area. The study area has :

a) a soil type that can produce good crops for sale outside the area (Cotton, sorghum, sesame, etc.). Therefore more areas can be cleared for such crops if demand is great.

b) The area contains tree species suitable for charcoal (A. sayal), Building Poles (Anogeissus leiocarpus), Fibre (Lonchocarpus and Hyphaene), furniture (Balanites), (Cordia abyssinica) etc.. If there is demand or a good market outside the area these species can be exterminated. Also the rich pasture can draw animals from outside the area to degrade these range lands.

These factors and their adverse effect can be augmented by : (i) good roads, (ii) water supply and (iii) mis-use of the resource.

Summary :

The vegetation of the study area was described by Andrew (1948) who gave a floristic composition of the Nuba Mountains. Harrison and Jackson (1958) gave an ecological classification of the vegetation of the Sudan placing the study area under Hill catenas (*Acacia seyal* Balanites - Savannah). Also Smith (1949) studied the distribution of tree species in relation to rainfall and soil type. In this paper the vegetation types on six landforms, as recorded by the above cited authorities will be compared by present day (1984) studies of vegetation on an agreed on transect. The indications in mind such as erosion of soils, change of species and loss of fertility will be evaluated by a field trip to the area.

PART II.

DEMOGRAPHIC AND SOCIO-ECONOMIC INDICATORS.

POPULATION DYNAMICS

1- Introduction: theme and literature review

1.1. Theme:

Population dynamics constitute a central point in environmental evolution, monitoring and planning. This is manifested in its two-fold role in a) degrading the environment b) improving it. This role is explainable in cultural medium, practices, perception strategies and behaviour as well as the demographic mechanism of the population. Therefore such role can be traced in population structure, trends of growth rate mobility,(whether spatial or in the socio-economic ladder and spatial distribution.

Tegali district as part of the Nuba Hills eco-system and a cross road for population mobility along the Central, Belt, presents a unique area of population dynamics and cultural interaction processes.

The main currents and streams of population mobility, superimposed on the sedinlary Nuba population are:-

1. The west-east mobility of Western Sudanese and West Africans. (2) The nomadic north-south reciprocal movement which is of seasonal rythmic and

highly flexible in both direction, timing and intensity. (3) The east-west mobility of the riverine population which is responsible for the introduction of cash economy and urbanization in the district (4) The trarisient movement of casual labour from the Southern Region. (5) Out-migration from the Nuba population and other sedinlary population.

In spite of the traditional uniformity of the economic base (agriculture and nomadism); yet population parameters differ considerabley and reflect variations in background, exposure and response to external forces of change and resultant attitude, preference and behaviour.

In fact the problem to be investigated is how far population through internal mechanism interact with the physical environment to attain a favourable harmony of the environment and the well-being of the population. To attain this objective it is appropriate to provide a population inventory and the trend of change of population components as a pre-requisite for a sound monitoring and planning of the environment suggested in the second phase of this research project.

1.2. Literature review:

There are three principal sources of data about Tegali District at different levels of adequacy, reliability and orientation.

a) Unpublished government reports and files since the British time. Such reports, though helpfull in giving background information, yet few of them are available for consultation. Others are improperly kept, fragmented and inaccessible. When available are very valuable in tracing administrative development, legislation related to land use, settlement of tribal conflict and organization of nomadic movement etc. They are defecient in questions related to either population or the environment.

b) Published materials are dominated by social anthropologists who are basically interested in origin, culture and social network of the Nuba as a district African ethnic group. They are less help in the current population dynamics and the population/ environment interaction process as such. There are few published problem-oriented works concerned with issues of water supply (Mansour 1957) and Mechanized Crop Production (MCP).

c) The two national census of 1955/56 and 1973, probably constitute the major source of population raw data used in this inventory.

The main limitations of the available sources of data are:-

a) The improper orientation as stated earlier towards phancy writing about the Huba culture social network and beliefs. Little or almost none is oriented towards population analysis or the environment in the present context, see bibiliography.

b) Results of the two censuses which constitute the major source of the raw materials of this baseline report, provide sielent statistics of demog demographic variables only. Still they provide the basis of comparison and trend analysis of population dynamics in the inter-censual period at a reasonable level of reliability.

2- Historical background

It is not the purpose of this Study, at least in the present stage to go into the detailed history of the district. Still it is appropriate to point to some historical developments that are essential for the understanding of the population dynamism and trends of changes.

The origin of the Nuba, the original settlers of the district is one of the most contravertial issues in the Study of ethnic history in the country. One of the mostly accepted ideas, is that they are purely an indegnous African Community. Another idea associate them with the Nubiyans stock and attached from the Nile area for quite a long time. They constitute a sedintary agricultural stock with a more African Culture who for quite a long time were confined to the hilly area known as the Nuba Hills. Togali District constitutes its eastern part and forms a buffer zone between the riverine population to the east and the proper Nuba hills to the west. The Nuba have a distinct physical and cultural features that had resulted from a long period of isolation. They have all characteristics of all hilly people i.e. ethnic purity, cultural homogenity and resistance to change.

Beside the Nuba there is a wide range of ethnic groups that move into the district in series of waves of migration over a lengthy period up to the present. These include the nomadic and settled Arab Stock, Western Sudanese and West Africans.

Such groups are confined to the plains and seasonal water courses while the Nuba were confined to the hills and only recently they descended into the foot hills and plains (Fig.1). The first population census of 1955/56 gave (for the first time) the number, demographic characteristics and distribution of the ethnic groups constituting the district population (Table 5).

Recent population trends of change can be traced in political and economic developments during the Colonial days and the independence period up to the present.

During the Colonial period the Nuba hills were closed under the law of Isolation of primitive societies which was applied also to the South and Ingassana hills. The result of this law is a complete isolation of the whole Nuba hills and a slow process of change initiated by the merchants from the riverine areas.

After independence the Nuba hills were openned to free movement of population, investment, provision of services etc. In fact Tegali District being a contact zone between the riverine areas and the proper

Table 5(a)(b).

Table 5 (a).

Ethnic Composition of Tegali District, 1955/56.

a) Major Ethnic Groups.

Ethnic Group	TOTAL		TEGALI NORTH		TEGALI SOUTH	
	Total No.	% of Total	Total No.	% of Total	Total No.	% of Total
1. Arabs.	68,647	42.7	24,372	30	44,275	54.4
2. Nuba	56,439	34.7	34,979	43.0	21,451	26.4
3. Easterners	15,675	9.7	8,450	10.4	7,225	5.4
4. Foreigners with Sudanese Status	11,499	7.1	11,309	13.9	190	0.2
5. B. Southerners (Sudanic).	4,465	2.7	34	0.0	4,431	5.4
6. Beja	3,262	2.0	49	0.1	3,213	3.9
7. Foreigners with no Sudanese Status.	1,769	1.1	1,769	2.2	--	--
8. C. Southerners (Nilotic).	573	0.4	180	0.2	393	0.5
9. Nubians	253	0.2	144	0.2	109	0.1
10. Miscellaneous	106	0.1	11	0.0	95	0.1
11. C. Southerners (Hamitic)	26	0.0	21	0.0	5	0.0
Total	162,705	100	81,318	100	81,387	100

Table 5(b)

Break down of the Major Ethnic Groups.

Tribal Group	TEG LI NORTH		TEG LI SOUTH	
	Total	%	Total	%
a) ARABS	24,372	20.2	44,218	
1. Baggara	8,235	6.8	16,086	
2. Dar Hamid	735	0.6	--	
3. Gawama'a+Badyria	3,095	2.6	212	
4. Other Arabs				
a) Central	196	0.2	27	
b) Northern	6,944	5.8	13,469	
c) Eastern	37	0.03	20	
d) Western	5	--	5,125	
e) N. Eastern	5	--	1	
5. Shukriya	528	0.4	-	
6. Ga'alyin	1,530	1.3	504	
7. Guhayna	2,941	2.4	14,815	
b) Nuba	34,979	29.0	21,451	
1. North East	2,178	1.8		
2. " West	2,675	2.2		
3. South West	94	0.07		
4. South East	18,772	15.6		
5. Others	2,068	1.7		
c) Nuba-Messriya	254	2.1		
d) Beja	49	0.04		
e) E. Southerners.	21	0.02		
f) W. Southerners.	34	0.03		
g) Westerners	8,450	7.0	7,225	
Total	120,484	100	98,722	

Source: Dept. of Statistics, 1st. Population Census, 1955/56, Khartoum, 1958, Vol.3.

Nuba hills had been subjected to migration of population and cultural diffusion from the east reaching its climax by the rise of the Islamic Kingdom of Tegali.

After independence further development in socio-economic services, improvement in administration linkage and expansion in mechanized crop production and freedom of population mobility has broken the district isolation and increased its ethnic complexity, and population dynamism.

The district had been subjected to administrative changes during the British rule, that had considerable importance in population increase composition and distribution. In 1930 two Omodiyas of the nomadic tribes of Kenana and Kawahla of (2,300 persons) were added (Stevenson 1940). In 1933 Tajwak & Tagai Nuba were included (3,300 persons) and in 1935 Rashad Mekship of (7,800 persons) was added plus the nomadic tribes of Awlad Heimaid Kenana and the Kawahla of Kadogli (13,200 persons). Other groups of Baggara Gawama'a were added afterward and the district population was estimated in 1940 to be about 47,000 persons, (Kornek 1948).

3- Population dynamics: Size and growth

The first reliable estimates of the size of the district population was given by the 1st national census of 1955/56, in which the district was divided into two census areas Tegali North and Tegali South. The total population was estimated as 162,705 persons of whom 81,318 were reported in Tegali North and 81,387 in Tegali South. The average natural increase reported was ranging between 2.5-3%.

The second census of 1973 gave a total population of 264,963 for the whole district which was taken as one census area. The intercensual increase was 101,963 persons amounting to 62.7% of 1955/56 census estimates. When applying a simple interest techniques the approximate the annual growth rate (natural increase + net migration) will be in the vicinity of 3.4%. This indicates a high level of growth rate even by Sudan Standard, but can be explained in the high rate of population influx from the north as a result of the severe desertification processes and from the south in search of work beside the constant flow of migration along the central belt.

Using the same crude simple interest techniques the population of the district in 1983 to be 273,932 persons. At the present rate of increase the population will double itself every 25 years in the average, to reach about ½ million by the year 2000.

This high rate of growth embodied a wide range of variation according to ethnic complexity and mode of life and availability of basic health and educational services. For example the lowest natural growth rate was recorded among the nomadic population in the district compared with the rural sedintary and the urban population.

In spite of the generally high natural growth rate characterizing similar population in the early stage of the Demographic transition, yet imigration into the district is consistanty contributing to the overall growth rate.

3.2. Population Composition

3.2.1. Ethnic Composition

Although the ethnic composition is quite complex; yet it is dominated by two major groups. The Arab stock accounting for 42% of total population with

heavy consentration in Tegali North where they constitute 54%, compared with 30% in Tegali South according to 1955/56 census. Then the Nuba who constitute about 35% of total population (43% and 26% of total population of Tegali North and South respectively, (Table 5(a). The third largest group is the Westerners-with 9.6% of total district population and 10.4% of Tegali North and 8.9% of Tegali South. The breakdown of the major ethnic groups can be assessed from Table 5(b). The Arabs of Kordofan Province constitute the major group-of among the Arabs in the district, while the south eastern Nuba sub-group account for the majority in both district sub-divisions.

The district is in fact characterized by a high degree of ethnic pluralism compared with the rest of the Nuba hills, where the sharp isolation is a major cause of ethnic "purity". This relatively high ethnic complexity is due to the Arab infileration into the district. The descent of the Nuba from the hills brought them into more contact with other ethnic groups and has resulted in differsion of land use practices which complicated the population environment relationships.

The abolitionof the native administration and the "Tribal Dar" has accelerated the integration of the ethnic groups, fluidity of population distribution, hence impredictable population and environment relations.

Ethnic composition of population influence on the environment can be traced in (a) land use practices associated with each ethnic group (b) Diffusionof land use practices within ethnic groups- (c) perception attitude and land attatchment or lack of attatchment variation, especially between the Arabs also are predomintely nomads and the Nuba who are predominantely cultivators and sedintary. (d) conflicts and land use disputes resulting from the difference in interests and needs.

3.2. Sex-age composition

It is difficult to give a detailed analysis of sex-age composition because of inadequacy of data available. From analysis of the broad sex-age groups adopted in 1955/56 (1-5, 5 yrs-pubaty' and over pubaty) The district population exhibt the characteristics of the stable population in the 1st stage of the demographic transition, with a balanced sex composition and higher percentage of population

in the lower age group and a low level of life expectancy (47-54 yrs) reducing the ratio of old people. This pattern is disturbed when out-migration rate is high or infant mortality is high especially among the nomads and isolated sedentary population.

Sex ratio and masculanity for 1955/56 and 1973 can be traced in table 6, a,b,c,d. Analysis of these tables indicates the following major characteristics:-

(a) The variation in sex ratio reflects trends of fertility and mortality which is associated with mode of life and trends of out-and in-migration.

(b) Sex-ratio is in favour of males in urban areas compared to nomads and sedintary population reflecting trend of in-migration and out-migration respectively.

(c) The lack of restriction on female economic participation and migration particularly among the Nuba may be an explansion for the increase in sex-ratio reported in 1955/56. In fact urban centres are unable to absorb farm leavers and they constitute centres of out-migration into the Nile axis.

(d) The disparity in sex ratio (1973) between urban and sedintary population from one side and nomads is a clear evidence in the trend of out-migration among the sedintary and urban population (Table 6).

Table 6(a),(b),(c),(d).

Table 6(a)

Distribution by Omodia and Masculinity Ratio 1955/56.

Town	Both Sexes.	Male	Female	Masculinity Ratio
1. Umm Berembita	13,488	7,029	6,459	109
2. Rashad	13,968	7,198	6,770	108
3. El Abbasiya	53,862	27,895	25,967	107
4. Abu Gubeiha	26,134	13,414	12,720	105
5. Talodi	16,584	8,656	7,928	109
6. Kalogi	21,940	11,302	10,638	106
7. El Liri	16,729	8,621	8,108	106
Total	162,705	84,115	78,590	109

Table 6(b)

Urban Population - 1955/56.

Town	Both Sexes		Male		Female		Masculinity Ratio	
	De Jure	De Facto	De Jure	De Facto	De Jure	De Facto	De Jure	De Facto
Rashad	1683	1802	817	892	866	910	94	98
Talodi	2736	3529	1327	1729	1409	1800	94	96
El Abbasiya.	2816	2914	1400	1397	1446	1517	97	92
Total								

Table 6(c).

Sex Ratio by Mode of Life.

Mode of Life	Both Sexes	Male	Female	Masculinity Ratio
Nomadic + Semi-nomadic	13,488	7,029	6,459	109
Sedentary Rural	59,147	30,702	28,445	108
Rashad Town	1,683	817	866	94
El Abbassiya Town	2,846	1,400	1,446	97
Abu Karsholla	4,154	2,174	1,980	110

Table 6(d).

Sex Composition by Mode of Life 1973.

Mode of Life	Both Sexes		Male		Female		Sex Ratio
	Total		Total	%	Total	%	
Urban	30897	100	15207	49.2	15690	50.8	97
Rural Sedintary	159448	100	78347	49.1	81101	50.9	97
Rural Nomadic	74323	100	38888	52.0	35435	48.3	110
Total & Average	264668	100	132442	50.0	132226	50.0	100.2

Source: Department of Statistics, 1st. Population Census 1955/56 Khartoum, 1958 and 2nd. Population Census 1973, Khartoum, 1975 (Preliminary Results).

Sex-age composition relevance to the environmental question can be traced in (a) The volume and replacement rate of manpower (b) The trend of fertility and natural growth rate and population resource relationship. (c) As an index of migration processes in seasonal or permenant measure of resource carrying capacity and population. (d) The trend in dependency rate and population basic needs which must be extracted from the resources at the present level of technology.

3- Occupational Composition

The majority of the population are concentrated in the primary activities. In 1955/56 census 89% of the economically active population were enggaged in agriculture and pastoral nomadism. According to 1973 almost 88% were enggaged in such activity of which 46.6% were cultivators, 28% nomadic and 11.7 were enggaged in urban-based activities of trade and services. Occupational composition show a limited spectruim with a low percentage in professional and skilled workers (Table 7).

Table 7.

Occupational Composition 1955/56.

Sub-District	Total	Nomadic Animal Owner	Sed. Animal Owner	Cultivators.	Unskilled in Rural Areas	Skilled in Rural Areas.	Unskilled in Urban Areas.	Skilled in Urban Areas	Management & Professional.
Tegali North	81,318	310	53	71,575	3,115	2,853	1,049	2,336	27.
Tegali South	81,383	1,827	549	70,253	2,285	4,658	554	1,262	--

Source: Department of Statistics, First Population Census, 1955/56, Khartoum, 1958.

Occupational composition shows the following broad characteristics:-

(a) Full dependence of the population on the natural resources on traditional basis of resource use through a flexible shift between agriculture and animal keeping under extensive nomadism semi-nomadism and semi-sedintary modes of life. It is this dependence that presents the most critical situation of population/environment relationship. This is coupled by the limited chances of occupation in modern agriculture or industry.

(b) The distinction between paying and non-paying occupation is not clear. At the same time occupation burdaries within the traditional sector(between cultivation, animal keeping and seasonally paid jobs) are by no means clear. This is, in fact a ferm of strategy of adjustment to environmental conditions which are generally unpredictable.

As indication of high level of concentration in the primary sector is the low level of school attendance.

Occupation/environt relationship can be traced in (a) The full dependence on the physical environment

with an increasing tendency towards the law of diminishing returns especially in heavy settled area. Occupation within the primary sector is characterized by self-generated adjustment within the changing environmental conditions.

(b) The uniformity in occupation and mode of living lead to heavy competition on the same resources of agricultural land, water supply, range and space. Under the present land tenure system the present occupation structure and attitude is leading to practices that have increasing rate of the environment degrading instead of improving it.

3.4. Population: Spatial distribution

Distribution of population in Tegali District is a function of the natural resource base and its carrying capacity in relation to agriculture, pastures and water supply. It is also related to the degree of isolation and accessibility and provision of basic services. The distribution is closely related to the seasonal and annual and cyclic rainfall variability and its role in pasture capacity and yields from cultivation.

Analysis of 1955/56 and 1973 census shows a clear tendency of concentration of population in Tegali North along certain axis in Tegali South especially Abu Gabisha axis (Fig.2&3). There is also a tendancy towards urban concentration indicating rural out-migration.

Beside the general tendancy of concentration in the relatively marginal area of Tegali North, an area of population contact constituting part of the "central Sudan Sedintary Belt,"distribution is characterized by the following features:-

1- Seasonality and fluidity of distribution and concentration in the dry season and dispersal in the wet season especially in the case of nomads.

2- A tendancy of northwards shift in the wet season and to the south in the dry season.

3- A tendancy towards relative stability among the Nuba population and other sedintory groups .

4- Spatial concentration is along certain axes, and drainge courses of arable land and water supply centres are also places of concentration, (Fig.

The most important consequence of such pattern of distribution in relation to resource use and environmental aspects are:-

1- The high fluidity in distribution from one side and relative stability from the other generate serious problems in a high degree of resource use intensity.

2- The concentration of population along certain axis has resulted in an imbalanced use of natural resources and environmental degradation at varying speeds.

3- Although the seasonal shift of population has produced a sound mechanism of adjustment to resource distribution, yet has produced a fluid and an unpredictable population pattern of distribution.

4- Although the northern part of the region accommodates the larger part of population per unit area there is a recent trend of shift southwards along Abu Gubeiha axis.

3.5. Migration

Spatial mobility is probabley the most important mechanism of adjustment to the unevenly distributed natural resources. The magnitude of migration in its three forms: nomadism, seasonal and permenant mobility,

can be detected in the number of people annually moving and fluidity of distribution. The magnitude of internal mobility was very considerable as recorded in 1955/56 census (Table 8). This trend continues at higher rate afterward as a result of several factors of which some are ecological while others are purely economical.

We encounter the following types population mobility that have special relevance to the environmental questions.

1- The rythmic, horizontal, flexible and reciprocal pattern of mobility along a north-south axis or east-west axis from the hills into White Nile area.

2- The early starting down-hill mobility of the Nuba into the plains water courses and urban centres and eastwards feeding the constant stream of population mobility into the Nile axis.

3- Seasonal and reciprocal movement into the mechnized crop production area within the district or elsewhere.

4- The traditional shifting cultivation with or without change of residence.

Table 8.

Trends of Internal Migration 1955/56.

Sub-District	Sex	Total	Born in Place of Residence.	Total Born outside place of Residence.	% of Born outside place of Residence.
Tugali North + " South	Both Sex	162,705	27.5	44,825	72.5
	Males	83,420	26.3	21,962	73.7
	Females	78,590	28.9	22,715	71.1
Tugali North	Both Sex	81,367	22.1	17.9	77.9
	Males	42,122	19.8	81,325	75.8
	Females	39,196	24.2	9,469	75.8
Tugali South	Both Sex	81,369	33.0	26,831	67.0
	Males	41,298	33.0	13,637	67.0
	Females	39,394	33.6	13,244	66.4

5- The semi-transicut and recent movement from the southern region.

6- The movement of the riverine people responsible for introducing the cash economy accelerating urbanization process.

The most observable consequence of migration process, although varies from one area, yet can be summarized in the following:-

1. A highly fluid population spatial distribution, ethnic friction, land use conflict, and unpredictable intensity and imbalanced use of resources and environmental consequences.

2. A contrast between a stable population distribution among the Nuba and other settled community and a highly fluid distribution in case of nomads and semi-nomads.

3. Out-migration although released population pressure in particular areas, yet presents a serious problem of human resource allocation because absorbing the most productive and enterprising element of the population. The insignificance of the counter-stream of returnes migrant makes out-migration problem increasingly serious.

4. The influx of population from the northern part of the province is getting increasingly serious in the district especially in areas already settled.

5. The variation in "locality attachment" between the nomads and Nuba who have shown high level of land attachment present an important element in resource and environment assessment and monitoring.

6. There are three phases of migration process (a) an early phase of internal mobility and a current of mobility of riverine and nomadic population into the district (pre-colonization and early colonization period, (b) A second phase of down-hill, nomadic mobility and trend of out-migration and riverine people mobility (late colonial and early independence) (c) A third phase of active migration in all types (late independence to present).

Conclusion

Summary and Indicators

This section is an attempt to outline the general trend of the population components as well as showing the present situation condition according

to the available meagre and inadequate literature relevent to population and environmental interaction process.

Besides the introduction in which the theme of Study, objective and literature review are attempted, the population components were considered with the objective of presenting a base line for the second phase of this research project.

From this discussion and brief review of population dynamics it is possible to arrive at broad indicators that may be helpful in the second phase of detailed Study of the District. Such indicators are summarized below and in Table 9 where their environmental relevance is tentatively outlined.

1- Population Growth

a) Natural growth rate - Fertility and Mortality trends

b) Due to net migration gain(+) or loss (-)

2- Population Composition

a) Sex-age

b) Ethnic, culture, beliefs and perception

c) Occupation

3- Mechanism of migration

a) Types, causes and pattern

b) Migration results

c) In-and out-migration

4- Spatial distribution

a) disparity,fluidity and trends of concentration

b) Assessment of density and land attachment

c) rural settled, nomadic and urban pattern of distribution

d) Distribution in relation to the economic base and natural resource distribution carrying capacity measures.

Table 9.

Population Indicators Relevant to the Environment Monitering and Planning in Tegali District.

Indicator-Status in Tegali District.	Relevance to Environment.
1. High rate of natural increase.	Higher annual increment and population pressure.
1. High flucuating flexibility rate and mortality rate	Changing pressure and unpredictable relation with carrying capacity.
2. Increasing net migration.	" " " "
3. Sex-age composition a general sex ration in favour of females.	Productivity and over-use of immediate resources from female capabilities, replacement of population and change of residence
4. Ethnic composition with a high degree of pluralism.	Perception variation, land use practices, conflicts and friction, etc..
5. Occupational Composition mostly primary activity.	Needs and wants and coompetition on resource use of the uniform natural economic base.
6. Migration : High rate of : a) Internal migration	Balance or lack of balance in pressure and intensity of use.
b) Into the district migration.	Increase in population pressure.
c) Out-migration.	Loss of productive and over-pressing element of population.
7. Spatial distribution a) Fluidity b) Concentration trends toward certain axis. c) Trend of shift (southwards.)	Seasonal and permanent. Variation in resource use between nomads and settlers. Inbalanced use of resources and severity of environmental problems. Release of pressure in the north and increase in intensity and problems of over-use. Southwards is the axis of Abu Gubeiha.

WATER SUPPLY : SOURCES AND DEVELOPMENT OF SOURCES

WATER SOURCES:

Availability of water for both man and beast has always been an important factor in distribution and re-distribution of the population of the Sudan as elsewhere. Over large areas of the Sudan the short duration of the rainy season necessitates tapping ground water from varying depths. Undoubtedly, provision of water plays a great role in the social and economic development of an area. Generally in the Nuba Mountains, the prevailence of solid rocks of the Basement Complex limits the chances of reliable supplies of ground water. However, efforts in water provision resulted in some success of tapping ground-water in some towns like El-Abbasiya and some villages as well. By-and-large, water sources fall into two groups A) sources of water related to hill masses; B) sources related to the clay plains.

A) SOURCES OF WATER RELATED TO HILL MASSES:

(i) Sarafs and Springs:

This type was widespread in the hill masses where rain water fill the cracks and seeps down by gravity. A saraf is observed when the seepage re-

appears somewhere on the surface like a spring but of a lateral flow. Such sources used to be of limited value, because of drying up quickly. In recent years, such springs have disappeared and other sources were sought.

(ii) Wells dug in the Coarse shallow soils:

This formsthe second source associated with hill masses. The hill masses are normally surrounded by a well developed zone of coarse shallow soils which offer favourable conditions for sub-surface storage of rain water. When such zones rest on solid rocks or on the impervious older clays, they get saturated with water and can produce ample supplies through shallow wells. This type is the most wide-spread source. In some cases shallow wells may be dug away from the hill masses in areas where rock outcrops have been completely wetheared to residual soils featuring sandy areas. However, such patchy sand zones are of limited occurance, but where they exist yielding shallow wells are indicated.

B) SOURCES RELATED TO CLAY PLAINS:

These include (i) Sandy'Khor' beds (ii) hafirs, (iii) earth dams and (iv) boreholes.

(i) Sandy Khor beds:

In the clay plains, sandy khor beds provide suitable places for digging shallow wells. There, the sub-surface storage performed by rich sandy beds depends on the areal extension of the bed and its porosity. In some cases over some places the flow of water may exceed the storage capacity of sandy beds in which situations surface-flow may occur for some time even during the dry season. There, water may be tapped through Jamams.

(ii) Hafirs:

Hafirs form a very important source of water during the dry season in the clay plains. Development of hafirs in the area started in the 1940s as a result of the concern for soil conservation and later to provide water along the planned cattle route to Kosti beef canning factory. The factory seized to exist and the cattle route has not been in function, but the hafirs have played a great role in opening the area for commercial activities as well as attracting the slope dwellers down hill and along the routes to establish new settlements in the clay plains.

There, in Tegali hafirs were excavated in areas of heavy clay to minimize deep seepage and to ensure good catchment areas on the foot-hills to replenish the reservoirs.

(iii) Earth dams:

Earth dams are embarkments constructed across khors for interception of the stream flow in semi natural reservoirs the most important of which is that of Rashad town. It forms the only source of water for the whole town.

Although favourable locations for these embarkments are numerous in the area, yet dams other than that of Rashad are small in size and limited in number, perhaps because of the perceived high cost of construction.

(iv) Boreholes:

Away from the sandy khor beds and surface water bodies, tapping groundwater in the clay plains seems to be a remote possibility. The rather thick impervious of clay does not permit any down-flow of water to the highly weathered basement zone. Despite this fact, some boreholes were drilled to provide

permenant water sources in places like El-Abbasiya, El-Terter Wakara etc. Generally, the rate of failure is very high considering well yield and quality of water with regard to salinity. However, UNICEF indicates that abstraction from Basement can be successful if a high level of technical know-how is applied. However, the distribution of boreholes and wells is shown in fig (12).

HISTORY OF WATER DEVELOPMENT:

Traditionally the natives used to depend for their water supplies on surface or sub-surface sources, in the form of shallow wells. Dependance on these sources had limited the economic activities to areas where favourable conditions existed which were mainly near the hills or Wadi beds.

However it was realized that vast areas of fertile clay plains continued to be underdeveloped, because of lack of water for human needs. In 1948 the government began an extensive programme of water provision tied to efforts for soil conservation. The possibility of developing water sources through construction of hafirs in the clay plains was conceived.

The new sources were sought to bring a number of benifits such as :-

a) induce down-hill migration

b) open new areas for cultivation

c) attract cotton cultivators to settle around the new hafirs.

To achieve these objectives without degrading resources, it was decided to construct small scattered hafirs rather than having few large one. Large ones attract concentration of livestock, the consequences of which include spread of animal diseases, soil compaction and ultimately creation of local deserts. However, to settle cotton growers hafirs were excavated near the existing ginneries.

This policy has resulted in creation and growth of new settlements as the Nuba and Tegali people moved down-hill. Social and economic changes have been shown by the new settlers. Cash crops were grown and the pattern of land use was significantly changed from. There, intensive terrace cultivation gave place to a more extensive form of land use in the plain in which cash cropping became not uncommon.

During this period early settlements were located near the hills, but as the population of the original settlement grew, small satellites were established further in the plains resulting in further clearance of land for cultivation.

However, these developments have both positive and negative results. Positive results were shown in the form of increased production and diversification of the local economy. Surveys made in the area showed a significant increase in yields of cotton, immediately after the fist phase of hafir programme had finished.

As mentioned earlier, most of the water development programme concentrated on hafirs as the main source in the clay plains. Despite the economic benifits, these hafirs were neglected and consequently silted up. Most of the hafirs for various reasons lost more than 50% of their storage capacity. At present UNICEF (1982) estimates the average storage at 40% of their design capacity. Moreover, most of the hafirs are unprotected and therefore exposed to fecal pollution. UNICEF also estimates

the population served by boreholes and hafirs at only 30% of the total population, the rest depend on traditional sources.

Hafir siltation, however, reflects the degree of deterioration in the catchment areas. Large scale clearance of forest whether to open areas for mechanized farming or traditional peasantary farming has contributed significantly to this degradation, but the most direct cause of siltation is the bad management and lack of maintenance.

HUMAN ACTIVITIES:

The use of land in this area is quite varied, but the two main activities are rainfed farming and animal raising.

Prior to 1925, rainfed farming was confined to hill slopes on the terraced lands. During that period, terraces were well maintained and fairly good yields were achieved. The clay plains, and other low land areas were left under forest or range land. After 1925 cotton was introduced to the area as a cash crop, El-Hassan (1961). The general policy then, was to create suitable conditions for the Nuba

to move down hill to plains and valleys. The new policy and the new crop have brought some changes and farming expanded to the clay plains and to the valleys.

At present, farming can be classified into (i) traditional and (ii) rainfed mechanized farming.

TRADITIONAL FARMING:

This is the most wide-spread type and dominated by subsistance orientation with food crops occupying most of the area under cultivation. It is a household enterprise. Surveys in Tegali and other parts of the Nuba Mountains have shown that a family usually has two type of farms (i) a house farm; at the back--yard called Jubraka and (ii) a distant farm of Bildat type. The two types are different not only in terms of location and distance, but also in size, crops grown and the degree of intensification, nursing and devotion.

In the Jubraka a simple farm of rotation is practiced. Also, and in order to maintain soil fertility animal dung is applied as manure. Crop selection for Jubraka focuses primarily on quick maturing varieties of crop and on vegetables. Jubraka

provides limited, but important food supplement during the rainy season when grain stores dry up. Abdel-Bagi (1983) has found that the well kept Jubrakas are those owned by old people, because old people cannot walk long distance and thus devoted for the backyard farm, Jubraka.

On the other hand, distance farms are bigger than the house farms. They are found in the clay plains 5-15 km. away from the village. However, farm size depends on factors such as available family labour and available technology. Abdel-Bagi estimates the average size as 5-10 feddans (a feddan is 4200 m^2), but local leaders and traders who have access to some facilities and better technology may farm 50-100 feddans.

Land tenure and land ownership is communal. The land belongs to the village or the tribe and members of the community have the right of use which is acquired by clearing. Once acquired can be inherited, sold or rented. There, the system of land ownership can be described as owner-like possession. The local community as well as the village administration

recognize this form of ownership. But legally and according to 1971 Act of Unregistered Land, all unregistered lands in the Sudan are deemed as registered to the government. Then the government, regional or central may use this power to take any land from local use and put under another use e.g. mechanized farming.

With regard to distant farms shifting cultivation is practiced as a strategy to maintain soil fertility. In such heavy clay soils, however, farming operations require much labour. Alternatively, weeds and bushes are cleared by setting fire, a practice known as Hariqua cultivation.

Depending on soil fertility and growth of weeds the period of continuous cultivation varies between 5-10 years before the land is left fallow. In recent years and as a result of population growth and introduction of commercial farming the fallow period has shrinked significantly.

In distant farms the main food crops are grown as well as cash crops where sorghum (dura), sesame and short staple cotton are dominant. Food crops

occupy more than 80% of the land under cultivation, Abdel-Bagi (1983). This fact again reflects the degree of subsistance orientation among traditional farmers there. Unlike local farmers, the so-called Jallaba traders play a significant role in the change towards commercialization. This trend however was initated by growing cotton. Other crops for cash like Sesame were also grown and the presence of Jallaba traders there has made marketing possible and accelerated the change.

Deductively, the distant farm provides the bulk of consumption and cash needs. To assure returns fragmented plots located at different direction are cultivated. The demerit of this practice of fragmentation is the lack of concentration of efforts but it reflects good understanding of the natives to the localized rains in the tropics at large. It is a traditional strategy for catching early rains in one of the plots.

RAINFED MECHANIZED FARMING:

This is a new type of farming in the area which started in 1968 with the main aim of increasing dura

production to supply the needs of western and southern Sudan. The programme started in Habila to cover an area of about 200,000 feddans. Generally mechanized schemes are of three types (i) Private (ii) State farms (iii) directed and co-operatives. In the case of private schemes, rich merchants living in towns, operate and manage about 53% of the total cropped area. The vast majority come from outside the region and manage schemes through resident agents.

The directed schemes represent an attempt to involve the local active farmers through extended loans for purchasing tractors, clearing the land and other inputs. The area of each scheme is about 1,500 feddans with one third fallow. The Co-operative sector is also encouraged in the area by extended loans and priority.

Exactly, the area under mechanized farming tends to fluctuate according to rainfall, labour availability and lack of spare parts or fuel. The main crops grown are dura, sesame and cotton for commercial purposes. There, some form of simple rotation is practiced whereby 50% of the area is devoted for dura, 25% for cotton, leaving 25% fallow,

Abdel-Bagi (1983). In fact, many scheme owners do not observe this system of rotation, the logical result of which is misuse, overcultivation and rapid degradation.

Mechanized farming, however, is criticized as the most destructive agent to forest resources. Land preparation involves felling of all trees and burning all the vegetative cover to get rid of the weeds and facilitate the use of tractors. Of the different trees the most affected species is the Acacia level which dominates area of good black cracking clay soils preferred for mechanized farming. This tree type is also preferred by the local inhabitants for fuel wood and charcoal. Abdel Bagi (1983) estimates that 98,500,000 trees have been lost through mechanized farming in Southern Kordofan Province of which Tegali District forms a great part. Furthermore, the loss in trees is estimated as a loss of 25,000,000 m^3 of solid wood which could have been annually yielded.

As mentioned earlier, mechanized farms are owned by rich merchants mainly coming from outside the area. In an attempt to involve the local inhabitants

and to modernize traditional agriculture, a form of what is called modernized schemes was introduced. This system involves a programme of grouping the small dispersed peasant farmers into bigger groups of economical units in order to facilitate use of machines and to provide loans and credits. In such schemes a farmer is alloted 15 feddans to grow cotton and dura while a portion is left fallow.

IMPACTS OF AGRICULTURAL SYSTEMS ON THE ECOSYSTEM:

Both traditional cultivation and modern mechanized farming have contributed effectively to the degradation of natural resources especially forest resources in the area. At present the area faces problems of soil erosion, gully erosion, removal of vegetative cover and some signs of desertification. Causes of land degradation include bad management and mispractices in both modern and traditional sectors. There the environment is injured by soil erosion, and damage of range land and forests. Examples of bad management and mispractices include :-

(i) Cultivation of slopes without terracing them properly.
(ii) Clearance of watersheds for cultivation
(iii) Setting fires for Harique cultivation
(iv) Bad management at the farm scale.

Undoubtedly the problem is getting serious along both the horizontal scale and the vertical one. Stoppage and remedy is now easier and a programme for action is to be devised.

ANIMALS:

Water, together with grazing is the critical resource for animal owners. Without water in the area fodder goes unutilized. In the Sudan reasonably water conditions normalize movements in time and space. Provision of water induces and/or reflect changes in settlement patterns, growth. Changes also relate to intensity of land use, human well being and environmental quality, Johnson and Samzuni (1982). In Tegali District the rapid growth of Abu Gubeiha is thought to stem from the adequacy of water for both man and his beast, Figs (11,12).

In fact Tegali District is unique in assessing the impacts of the development in groundwater technology and provision of the resource upon livestock and environmental conditions in general. The physiographic feature as discussed earlier forms a challenge against development of groundwater supplies.

Conditions of limited number of water points result in large concentrations of population and livestock. The concentration leads to erosion, compaction and eventually rings of local desert around settlement and water points. This fact was recognized in the Sudan as early as 1939 and a Soil Conservation Board was formed in 1945. The activities of the board have played a major role in water provision through hafirs in the Nuba Mountains. The hafir programme stimulated cotton production and helped animal owners to utilize new grazing areas.

To serve Kosti cattle route a series of hafirs were excavated across the Nuba Mountains at about 15 miles internal. Hafirs were designed for a capacity of 25,000 m^3 each so as to serve animals other than those going to Kosti Beef Canning Factory.

The new hafirs however, have attracted new agricultural settlements and local animal owners as well as pastoral nomads. Water availability there in addition to new grazing lands and the provision of vetrinary services have encouraged the permanent settlement of sedintary agriculturalist and stablization of some pastoral nomads, both of whom have

have inclined towards keeping more cattle, sheep and goats.

Two distinct types of grazing are apparent in the area. The first type is cattle grazing within the area though out the year, which is the case of Sedentary population. The second type of grazing is linked with the nomadic tribes who visit the area during the dry season or part of the rainy season.

Traditionally Tugali District is roamed by Baggara grazers like Kennana, Hawazma, Habbaniya, Awlad-Hamed and Kawahla. Few camel grazers, Abbala have been seen in the area. These include camel nomads from the north such as Shanabla as well some Ahamda and Kawahla. It goes without saying that the appearance of the camel nomads (Abbala) should be interpreted as a sign of environmental degradation.

Some years ago, animals were kept for subsistence and security against bad years. With more involvement in cash economy more animals have been seen marketed. Accordingly animal markets evolved and some of them like El-Abbasiya and Abu Gabeiha have gained fame.

Unfortunately, data concerning livestock within the district boundaries are not made available, because of atleast two reasons.

(i) The district boundaries are porous for nomadic movement

(ii) Perhaps because of the above problem of enumeration and other reasons, the available information is in the form of estimates for the whole old province of Kordofan or the new Southern Kordofan.

However, indications hint that a large portion of Kordofan's livestock are found in Tegali District. These hints are given by records of market transactions, but better estimates or seasonal enumeration should be a major pre-requisite for proper planning and environmental monitoring.

HUMAN ACTIVITIES AND WATER SUPPLY: SUMMARY OF INDICATORS :

This trend analysis has outlined some of the changes taking place in Tegali District. It shows how the traditional system prevailed for a long time enabled the native to devise methods of adjustments and maintained an ecological balance. Terrace cultivation, crop rotation and use of manures were some of the devices employed to maintain the ecological balance.

Later, the introduction of cash crops and the spread of mechanized farming did upset the environmental balance. Moreover, development in the field of water supply has initiated a series of social and economic changes with serious environmental implication. Thus more work is needed to adequately monitor and explain present changes. Trends are to be assessed, changes are to be predicted so as to take the necessary preventive and remedial measures. In Tegali District, water points, watershed disturbance and mechanized farming are critical variables that require further analysis. The impacts of these developments on the environment are fist felt, by the local community although the cause may originate from forces working at regional, national or global scales. The expansion in cash crops is the result of demand by regional, national and international markets. Technology transferred from other parts of the world has improved the situation in water supply. The colonial interest in cotton was to meet the demand of British industry and other international markets. Thus forces may be local or external.

This base-line survey shows how provision of water (whether in the form of hafirs or borcholes) stimulated settlements and affected pastoral activities. The role of water in environmental change and the interaction between settlement pattern and environmental change are reviewed here with human responses to the perceived environmental changes.

Water and environmental change is one of the issues of focus. However, water development is found to be the main indicator of adverse environmental change. These negative results show themselves in overgrazed areas, deforestation and soil degradation as a result of population growth and misuse of natural resources.

To assess the impacts of water provision on the environment with the aim of arriving at indicators of environmental change, more information is needed on resource type, distribution, the national use and carrying capacity. In this respect indicators of change show themselves in the following forms :-

(i) Change in productivity and the situation of water supply

(ii) Changes in the pattern of grazing e.g. quality of the range lands.

(iii) Changes in maximum soil-moisture holding capacity (M.S.M.H.C.) associated with compaction brought by trampling animals.

(iv) Changes in traditional rights of water use

(v) Changes in nomadic routes or length of stay at a particular source.

(vi) Increase in deforestation adjacent to water points.

(vii) Changes in population distribution.

(viii) Changes in place of residence

(ix) Land use competition

Regarding watershed disturbance, it is directly related to the pattern of land use practiced in the area. Traditional farming (crop farming and animal raising) as well as the mechanized schemes are equally responsible for the disturbance that has taken place. Indicators of this disturbance, however, include :-

i) deforestation

ii) soil erosion - gully erosion

iii) hafir silting

iv) dust storms

v) changes in the indigenous tree species of the clay plains like Talh which has been competed against by other species.

vi) terrace abandonment is also one of the indicators.

TASKS AHEAD

This base-line survey clearly indicates the need for further work with specific aim of collecting more data on human impacts on the ecosystem and to assess indicators of environmental change in the district of Tegali. The complex physiographic and floristic divisions of the area present the problem of coverage during the field-work.

However, the group agreed that transect methodology has great appeal in meeting the needs and concerns of all group members with their varying interests. The transect is thought to be a broad zone which includes a number of environmental division.

In the proposed transect sites will be selected for intensive work. Different land systems of varying socio-economic units would be covered. By-and-large, sites tentatively selected include the following :-

1) Migeinis Mechanized Scheme
2) Abu Gubeiha Town and vicinity
3) Tertar village
4) El-Abbasiya Town and vicinity
5) En route to Rashad
6) Umm Abdalla village
7) Umm Lubia
8) Tosi and vicinity
9) Rashad Town and vicinity
10) Kalkada - Heiban area

However, for scientists of background on this area (of unique storey of development, complex socio-economic processes and which stands out of other study areas of ETMA in the Sudan for its montane environment) would appreciate the need for further anaysis, monitoring and intervension. This newly reformed study group has achieved writing this work within a few months, Lastly , all researchers in this group would like to see the area concerned of with ETMA or other bodies .There , potentials are great, but signs of degradation have just appeared, but at an increasing rate, suffice to mention seeing camels there !

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Fig. 1. Location of Tegali District

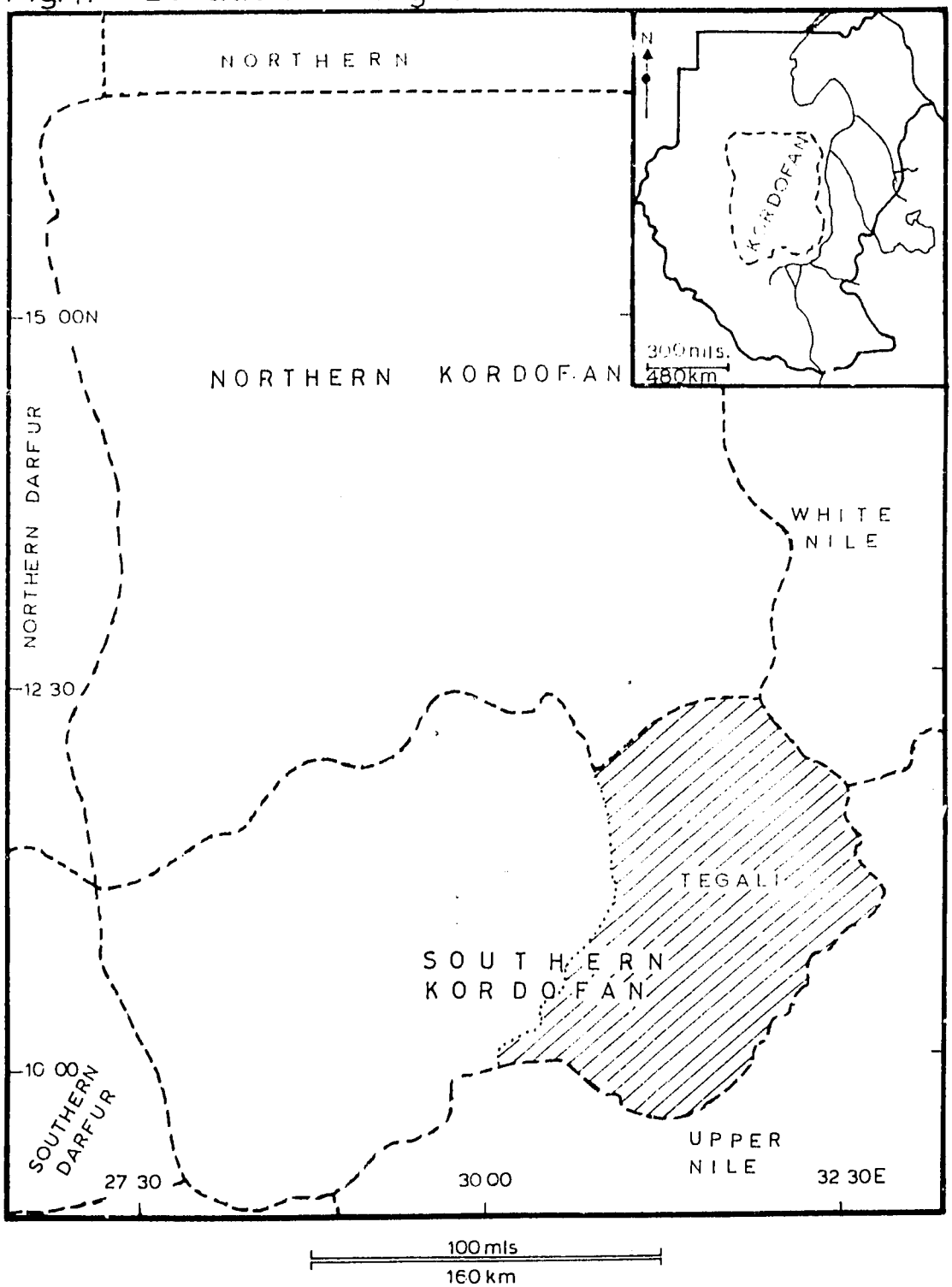


Fig. 2. Tegali: Landform, Soil and Drainage

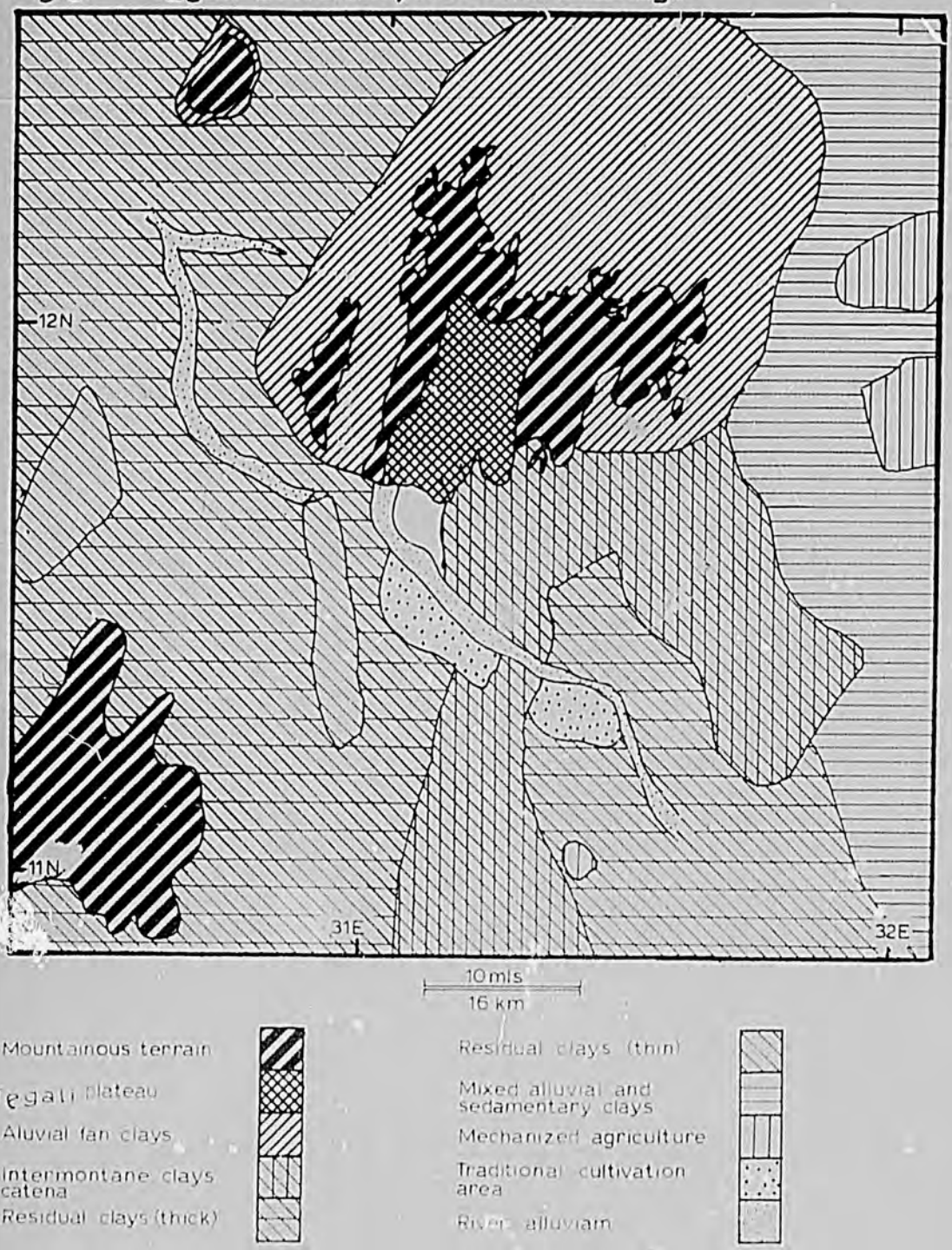


Fig. 3 Rainfall Over Tegali District in mm. (1951-80)

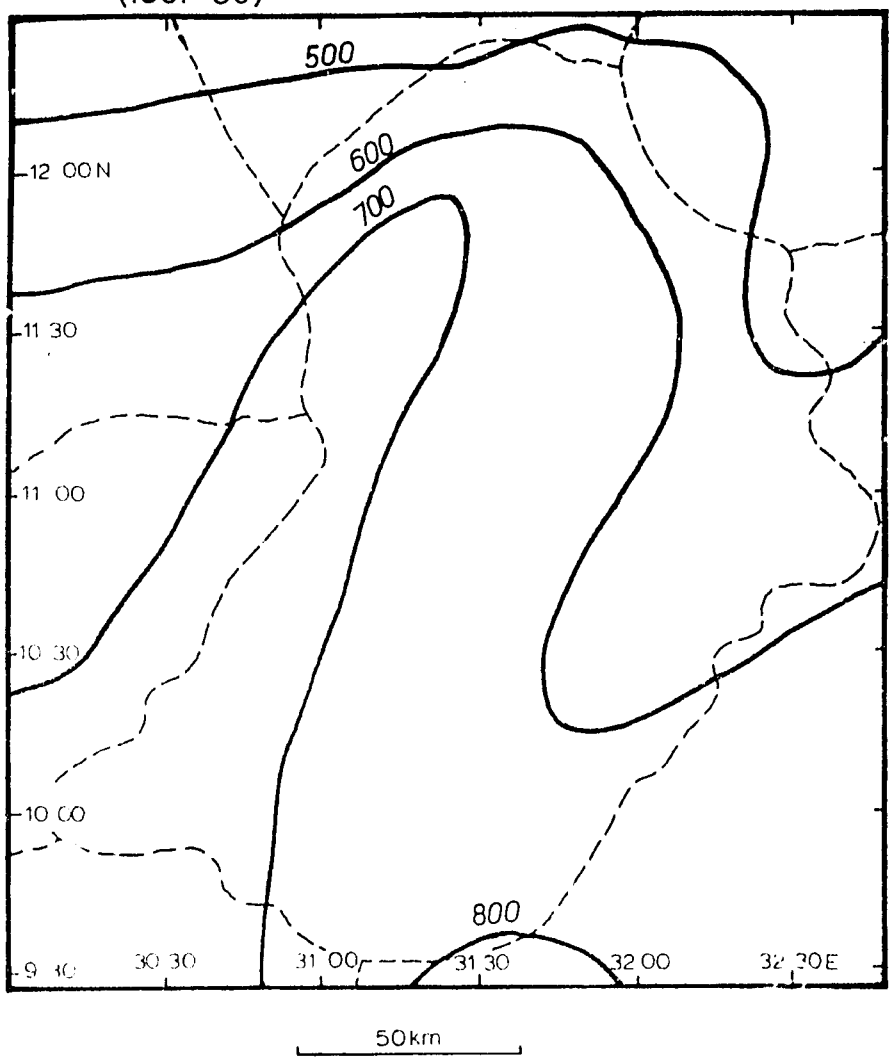


FIG.4. ANNUAL RAINFALL (1951 – 1980 In MM.)

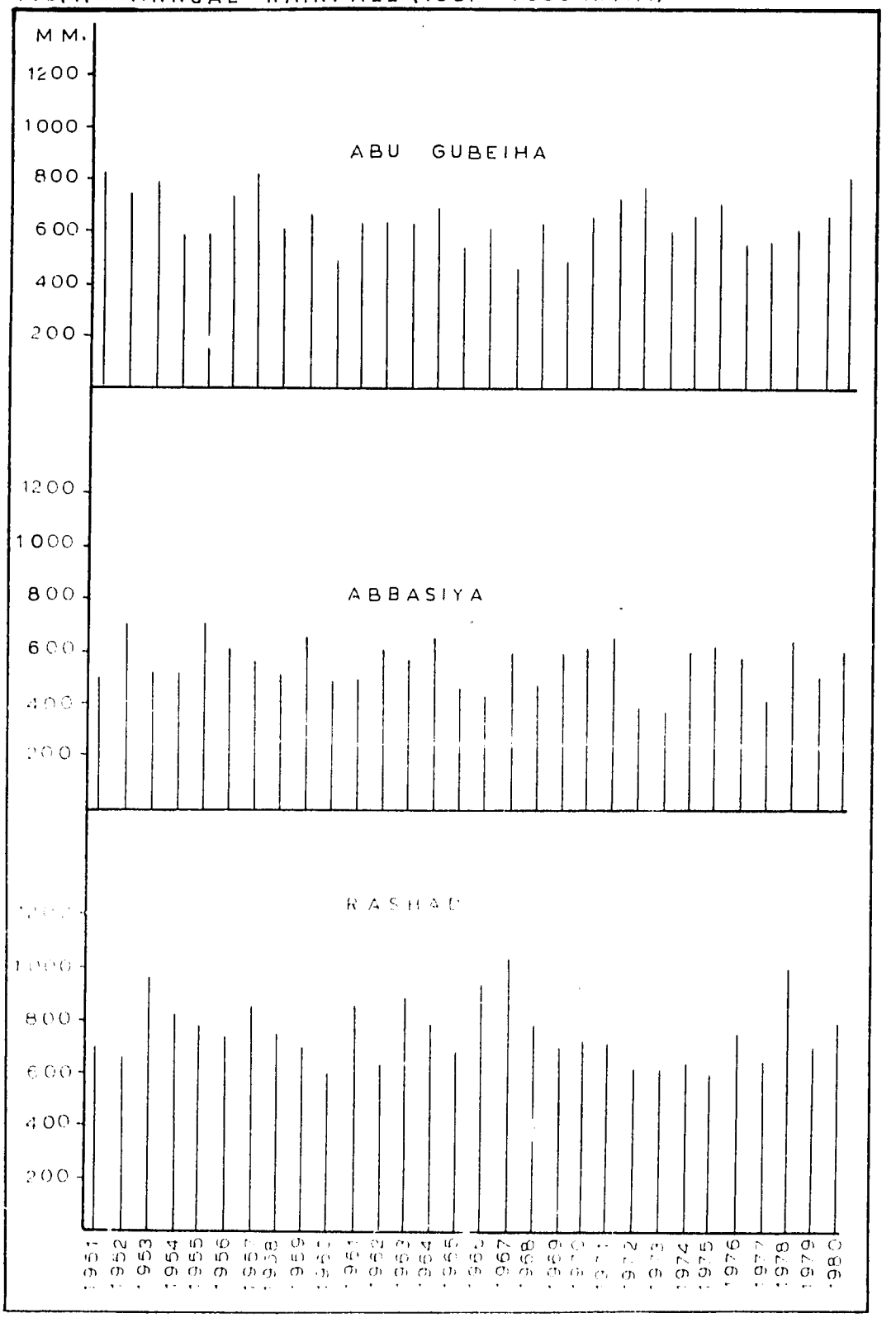


FIG. 5. MEAN MONTHLY RAINFALL OVER SELECTED LOCATIONS IN TAGALI DISTRICT (1951 - 1980)

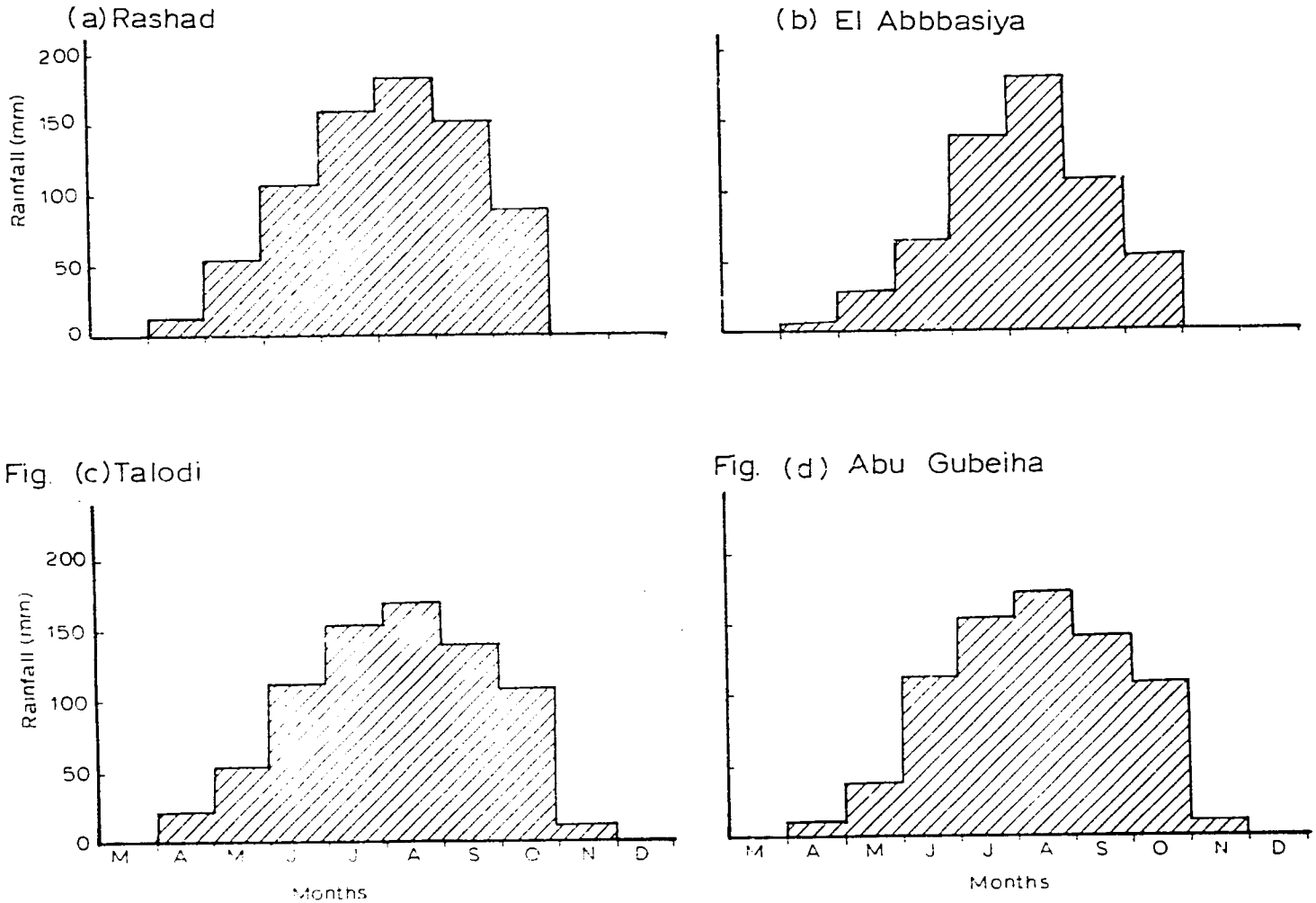


FIG.6. PERCENTAGE OF SEASONAL RAINFALL TO SEASONAL CROP WATER REQUIREMENT.

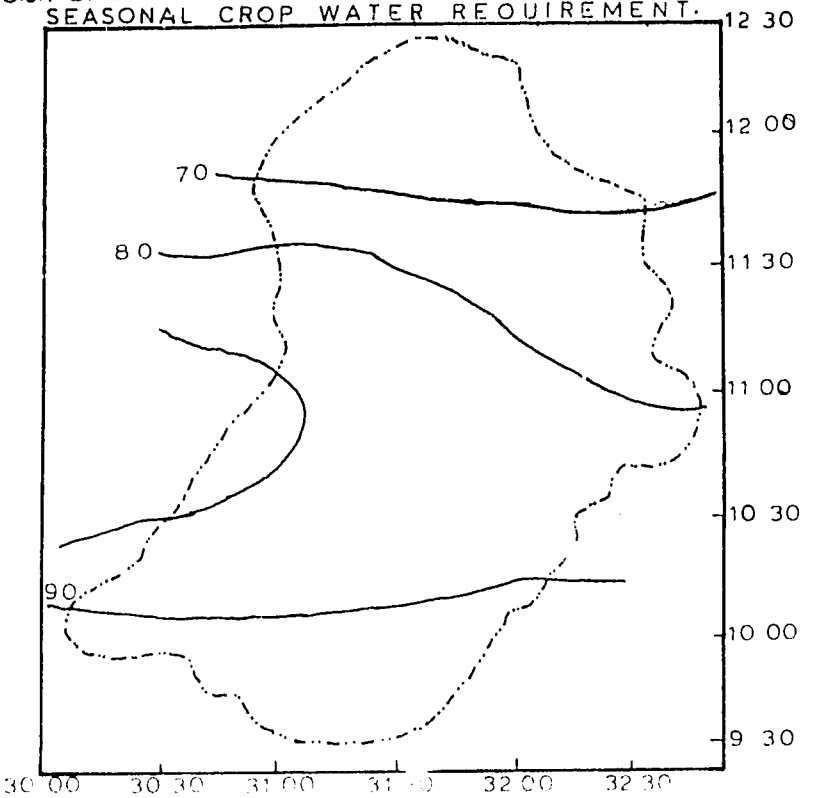


FIG.7 RAINFALL WITHIN THE [illegible] SEASON (112 DAYS FROM [illegible] IN MM.)

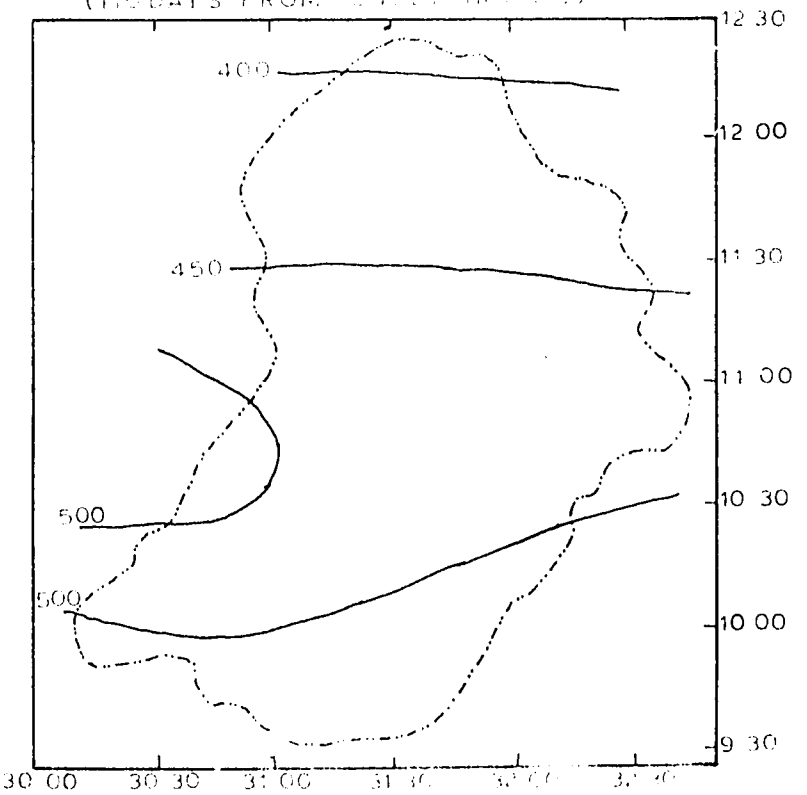


FIG.8.MAXIMUM CROP-WATER REQUIREMENT(MCWR) PER SEASON / MM.

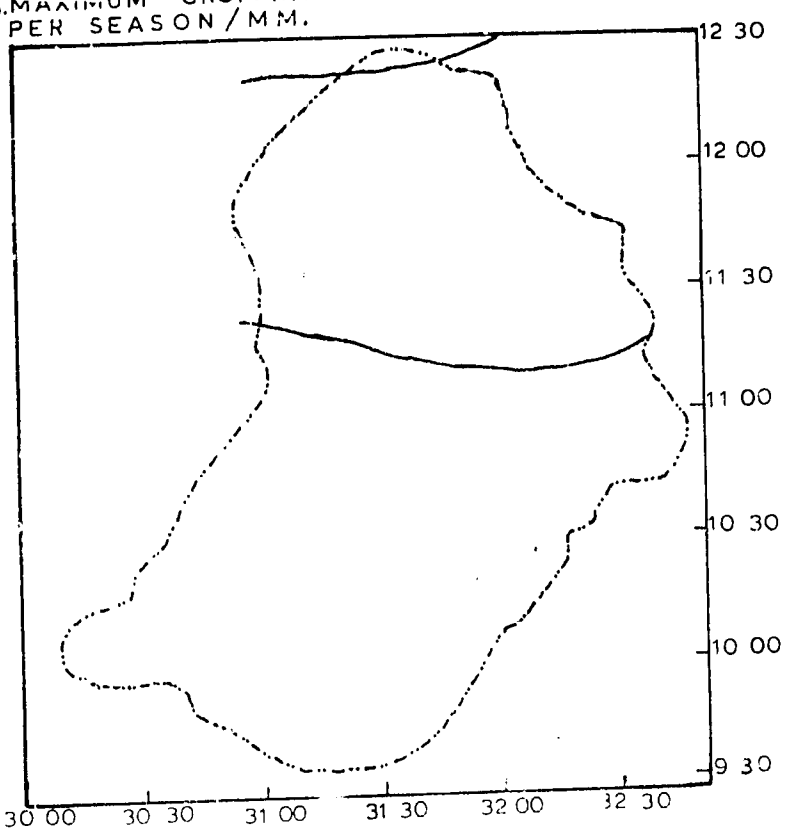


FIG.9.MEAN TIME OF MAXIMUM SOIL MOISTURE IN DAYS FROM ONSET OF WET SEASON.

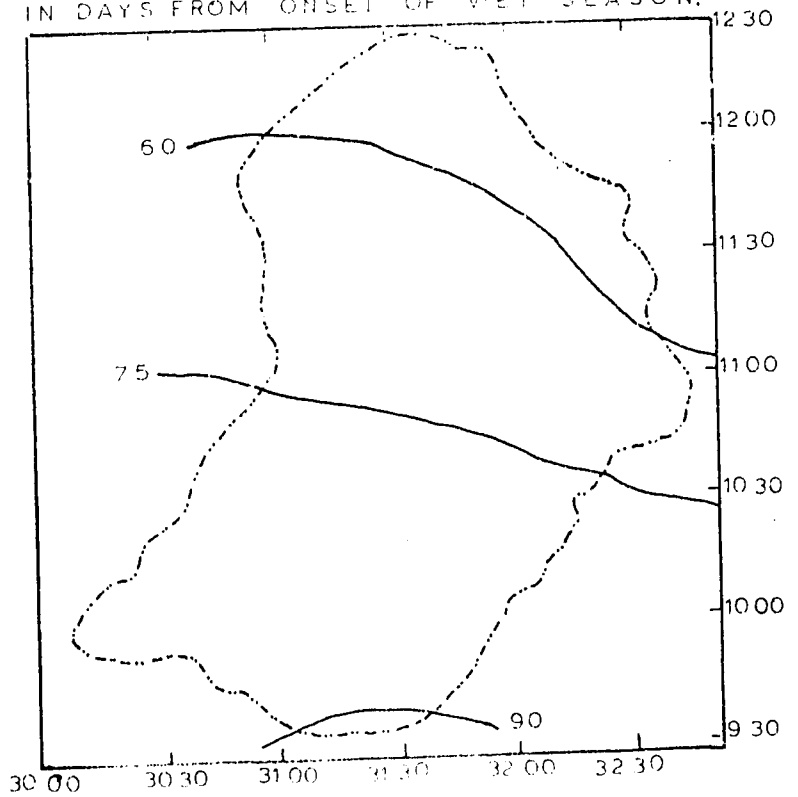
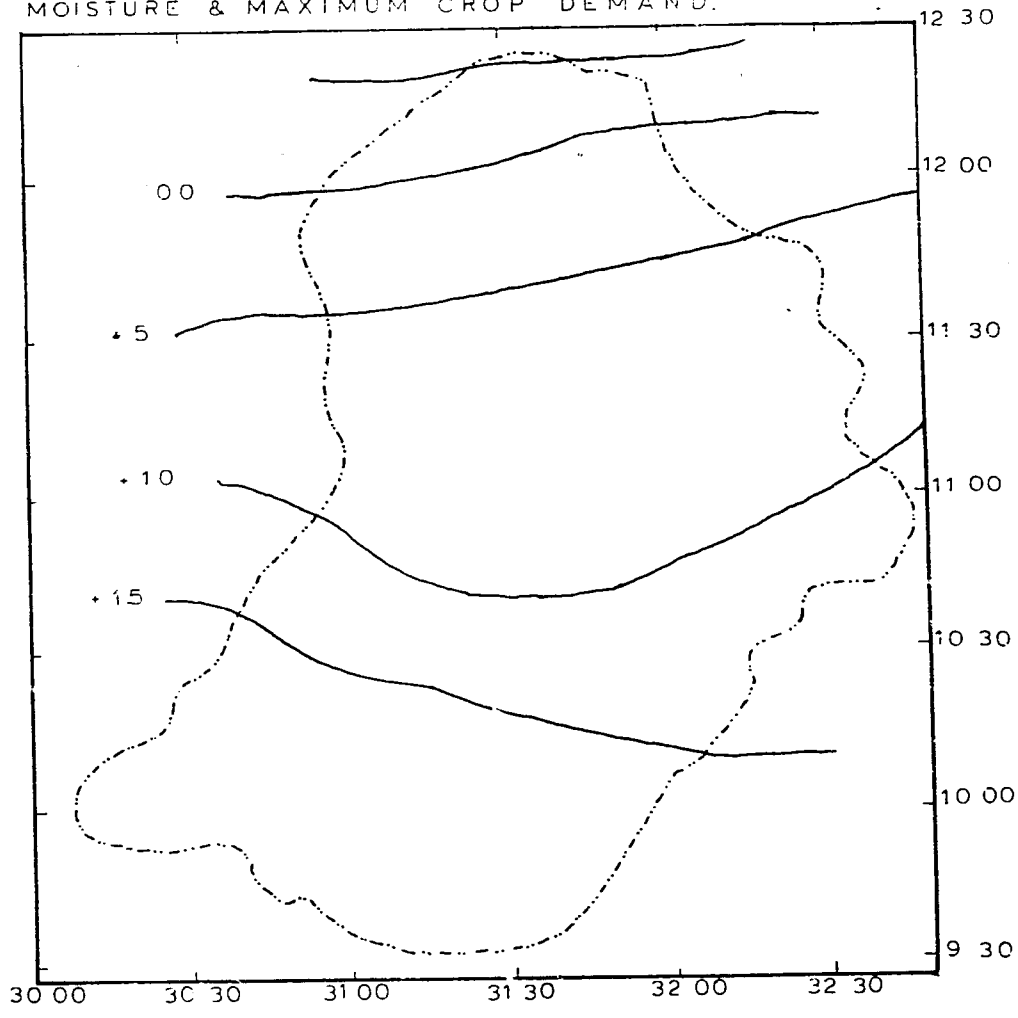
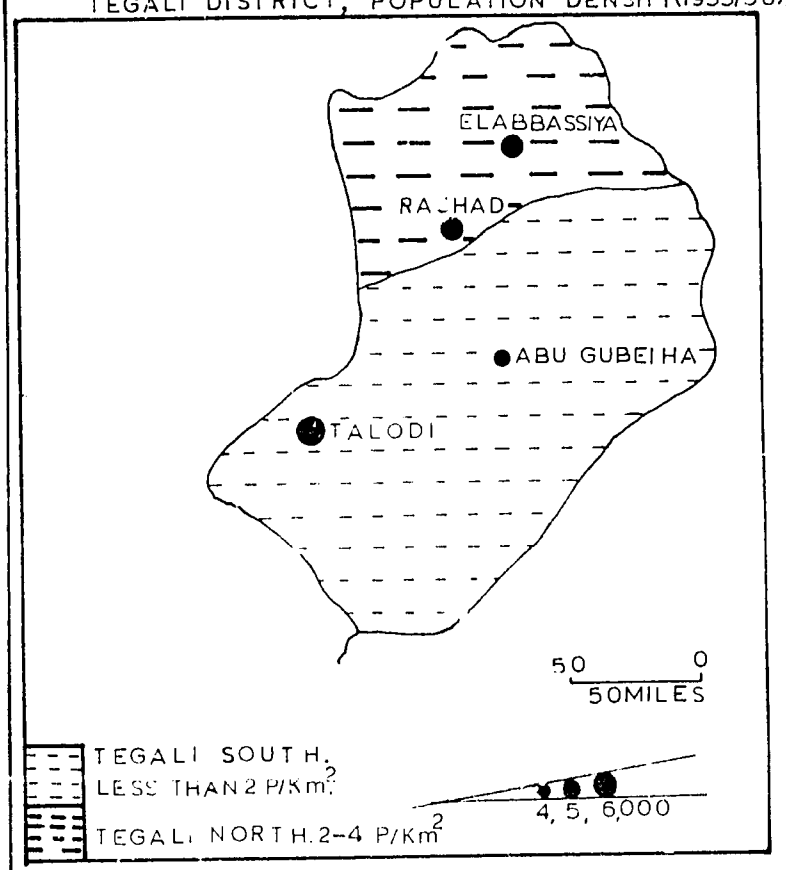


FIG.10. DIFFERENCE IN DAYS BETWEEN MAXIMUM SOIL — MOISTURE & MAXIMUM CROP DEMAND.



TEGALI DISTRICT, POPULATION DENSITY(1955/56)



TEGALI DISTRICT, POPULATION DENSITY(1973).

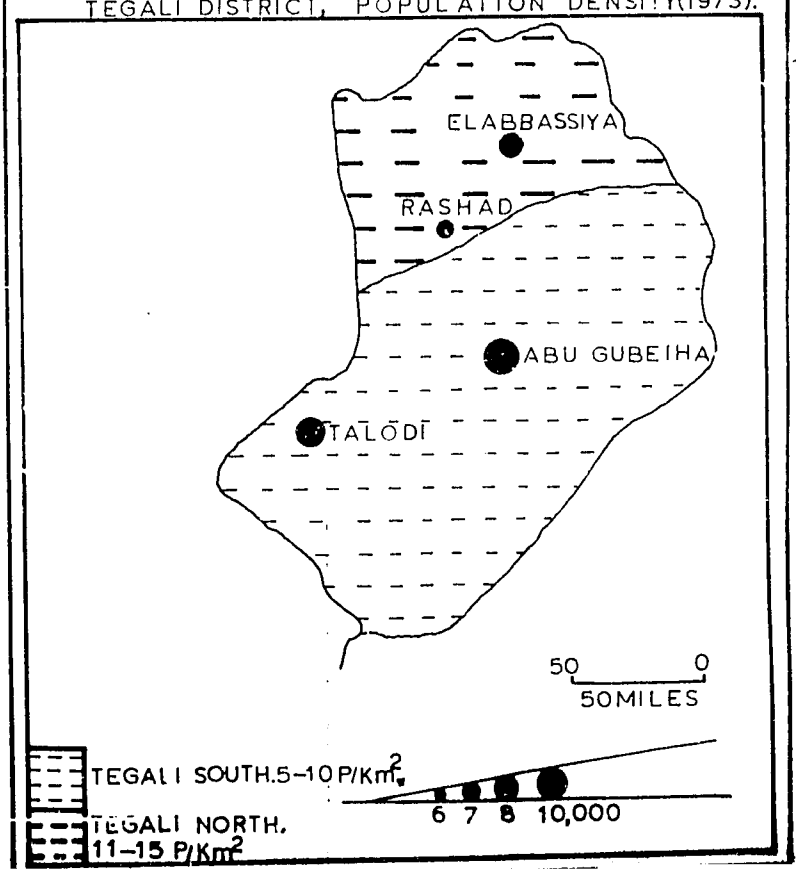
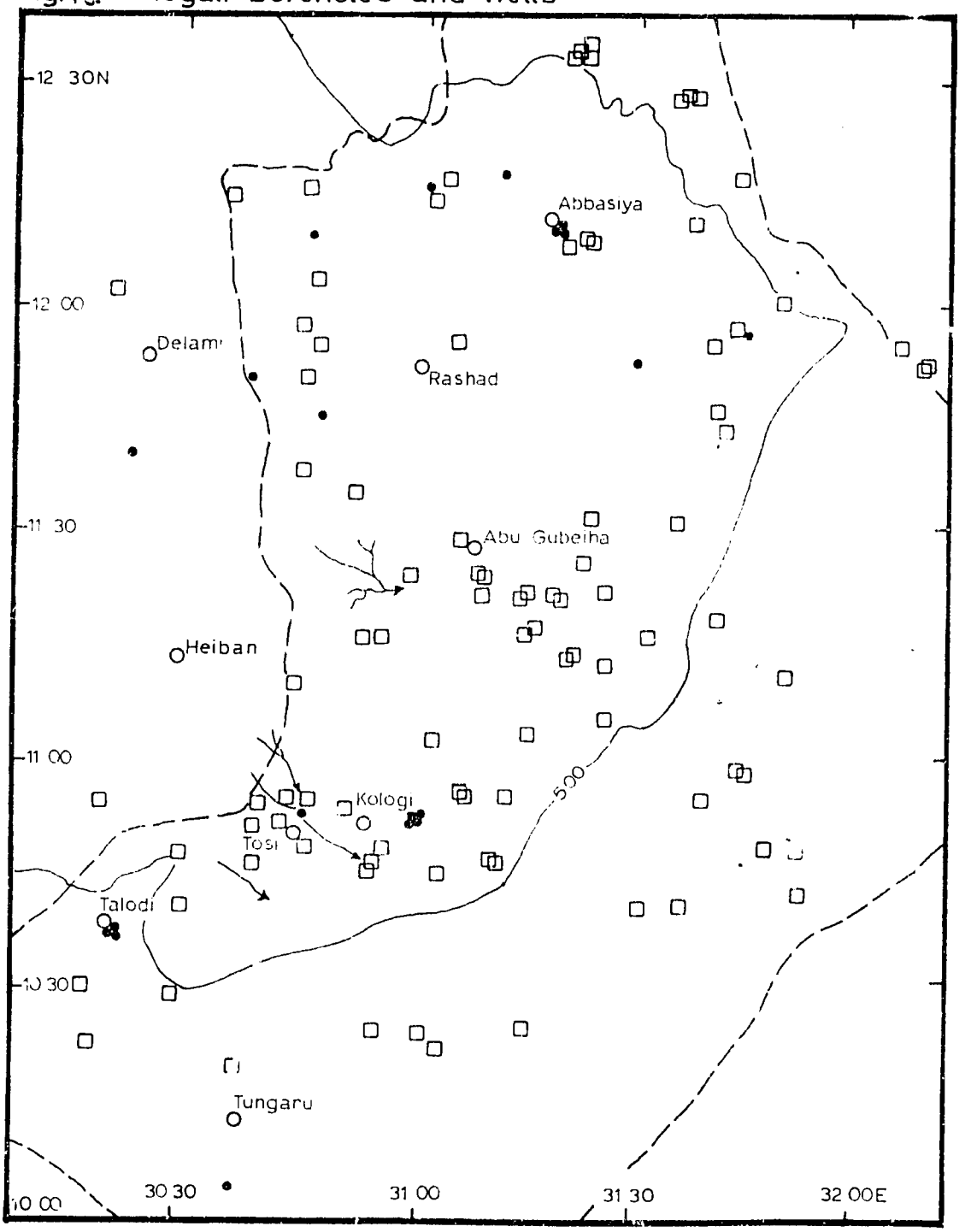
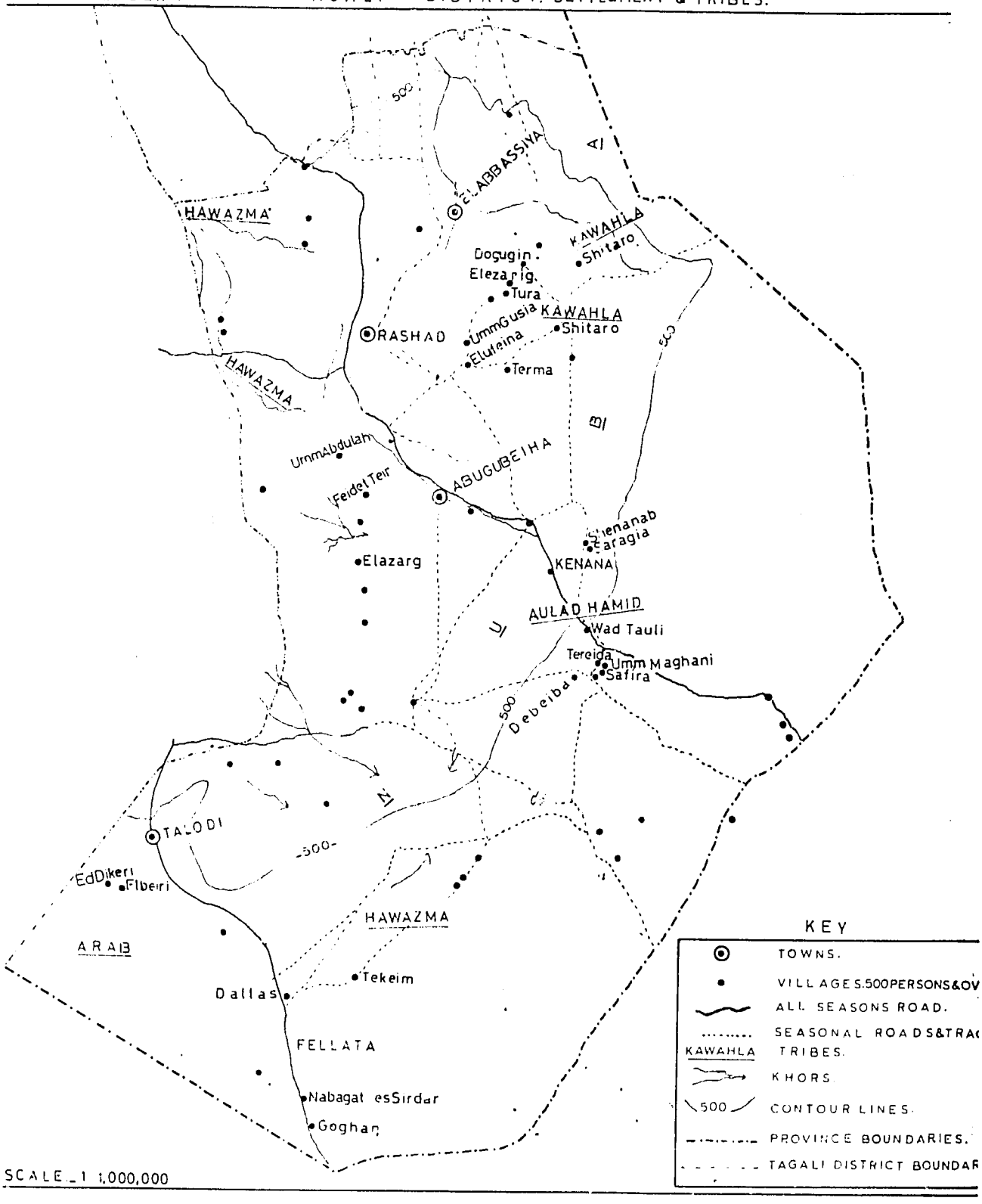


Fig. 13. Tegali Boreholes and Wells



SOURCE: Files Dept. of Rural Development.

APPENDEX.1. TAGALI DISTRICT: SETTLEMENT & TRIBES.