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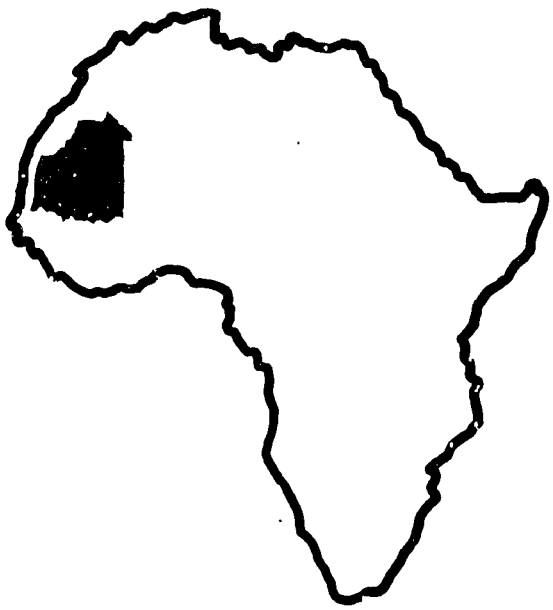
RAMS PROJECT

Rural Assessment and Manpower Surveys

Agro-Ecological Zones
of Mauritania

AS-1



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BASE LINE STUDY N° 1 - MAJOR AGRO-ECOLOGICAL ZONES

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1980

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0 - GENERAL INTRODUCTION

In order to identify the major agro-ecological zones of Mauritania, it was necessary to study the country's physical and human components so as to determine land use throughout the nation.

All rural development projects in Mauritania must take into account the realities of this fragile environment, in particular, the recurrence of drought and its consequences :

- scare and irregular rainfall
- fragility of water resources
- intense degradation of grazing lands
- deplacement of sand by winds
- major soil erosion by winds and water

Thus this is an environment which opposes the prosperous development of the two main agricultural activities practiced in Mauritania : cultivation and the raising of livestock.

The determination of the major agro-ecological zones was based primarily on the type of cultivation practiced in each zone; pastoral activities were taken into consideration, but could not be used as the sole criteria for zone classification in most cases, due to the mobility of herds, the complexity of migration routes and socio-ethnological factors.

The availability of water, the basis for all life, will be studied in detail. The following chapters are devoted to water resources : Climate, Surface Water, and Underground Water.

CHAPTER 1

GEOGRAPHY

1 - GEOGRAPHY

1-0 Introduction

The Islamic Republic of Mauritania has a surface area of 1 036 000 km2. This vast country lies between the 15th and 27th parallels North and is both Saharan and Sahelian (the Sahara covers nearly 60% of its total surface area).

The aridity of this country explains its low population : 1 385 000 inhabitants[1], with an average density of 0.74 inhabitants per km2. The population is essentially concentrated in the south of the nation along the Senegal River valley and the Guidimaka area.

1-1 Physical Setting

1-1-1 Relief and Hydrography [2]

(See Fig. 1-2)

Relief

The relief is characterized by extended plains and plateaus, without high mountains. With the exception of the Zemmour and Kejiet ej-jill (highest point : 915 m) and certain parts of the Adrar and Tagant regions, altitude is less than 500 meters.

In terms of relief, the country can be divided into six major regions:

1) The plateaus of Northern Mauritania and its north-eastern point, carved from the sandstone and limestone of the Tindouf massif.
2) The Saharan peneplains,(Karet, Yetti, Ghallamano, Amsaga), which are extremely flat and extend from the eastern border to the western center of the country (west of Atar).

---

(1) 1977. Central Bureau for Population Census, figure cited by Atlas de Mauritanie, ed. Jeune Afrique, 1977.

(2) Charles Toupet, Atlas de Mauritanie, 1977.

Within the peneplain region, one finds occasional hillocks, the remainders of former reliefs : the Guelb Zednes, the Adrar Sétif eglabs, the Kediet ej-jill (an enormous quartzite block, rich in iron ore). Ergs are also found, oriented from northeast to southwest, due to the predominance of the continental alizé : ergs of Iguidi, el Hamami, Assefal and Akchar.

The peneplains correspond to the zone where the essentially granitic platform reaches soil level (Regueibat dorsal).

3) The Trab-el-Hajra, (or "land of stone "), which includes the Adrar, Tagant and Assaba plateaus. The highest points are generally composed of hard rock (silica sandstone) forming abrupt cliffs.
4) The large regions of sand, extending to the east of the Tagant and Adrar plateaus, which the geographer Al'Bakri called "Majabat al Koubra" (or "land of the great crossing"). This is one of the world's most impenetrable deserts.
5) The Hodh, an immense basin occupying the entire southeast of the country. It is bordered on the west, the north and the east by the Assaba and Tagant escarpments and the dhars of Tichit; The sandstone massifs of the Affolé extend into the R'Kiz.

The great erg of Aoukar covers the northern half of the Hodh. (The three preceeding regions are part of the Taoudeni basin).

The western plains, deeply covered by sand, mark the end of the Azéffal and the Akchar (great erg of Trarza).

6) The coast :

The coastline is rocky to the north of Cap Blanc. Low gypsum zones alternate with rocky points and sand dunes between Cap Blanc and Cap Timiris. The coast is sandy and straight to the south of Cap Timiris. The continental plateau is very wide between these two capes, in the Arguin bank region.

Hydrography :

Three hydrographical domains were distinguished :

1) that characterized by lack of permanent water courses : This includes the Sahara, the Majabat al Koubra and the peneplains in the north of the country, where rainfall is scant. Its limits are imprecise, varying from year to year as a function of rainfall.
2) those areas where seasonal water courses flow, but donot reach the sea : This domain covers the wetter Sahel regions and the mountainous Saharan regions such as the Adrar. At times these waters transform the oeuds into torrents feeding the gueltas and the underground aquifers which support the oases. However, the water is quickly lost through infiltration and evaporation in the graïrs and sebkhas.
3) Senegal River basin: this area covers only a 10th of the country. The Senegal River flows year round. Its tributaries the Karakoro, Garfa, and the Gorgol, are only intermittant oueds.
   At certain times, the river waters fill Lake R'Kiz. Downstream from Kaédi, there is a high water period (August to November). The flow, at its entrance into Mauritania, varies enormously from year to year. It averages 770 cubic meters per second.

1-1-2 Climate

The air masses that sweep Mauritania cause excessive aridity and widely variable temperatures.

1-1-2-1 Air Masses

During the year, Mauritania experiences three major alternating currents:

the maritime alizé (tradewind) which originates in the permanent high pressure zones over the Atlantic Ocean to the northwest of Africa (Azorian Anticyclone).

This wind blows on the coastline all year round, even in mid-summer. It is a cool coastal wind, becoming dryer and hotter as it moves towards the interior. Its western limit is called the "alizian discontinuity". Its characteristics, temperature and hydrometry are very similar to those of the continental alizé. The continental alizé, also known as the Harmattan (or "irifi" in Hassanya) originates in the high pressure zones over the Maghreb in winter or over the Mediterrannean in summer. It is very dry on arriving in Mauritania and its temperature varies greatly from day to night.

These alizé winds, especially the maritime alizé along the Atlantic coast, are constantly reinforced. These reinforcements cause a decrease in temperature and an increase in velocity, resulting in "sand winds" and "dry haze". Since 1968, certain periods of sand winds (or to be more exact, sand-driving winds) have lasted for several consecutive weeks. (It is thought that on a long term basis, these winds have a harmful effect on the nervous systems of both men and animals.)

Table 1 shows the number of days of sand-driving winds at Nouakchott during the drought (1968-73) (1)

TABLE

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1968	9	3	7	7	11	7	5	3	4	2	1	5	64
1969	8	7	18	19	21	15	4	4	2	2	4	4	108
1970	10	3	16	21	17	13	5	8	10	5	6	9	123
1971	8	14	22	25	28	19	15	10	10	10	8	8	177
1972	15	20	20	16	18	20	15	19	8	14	7	9	181
1973	15	16	19	23	25	23	12	10	8	14	12	10	187

(1) Source : ASECNA, Cited by J. Robert Pitte : Nouakchott, Capitale de la Mauritanie, Paris, 1977.

The zenith movement of the sun, and the extension and movement of low pressure zones in the interior (continental depression), cause the maritime alizé to deviate towards the interior to the north of the intertropical front line (ITF); whereas, to the south of this line, monsoon winds penetrate the southern part of the country. The ITF marks the upper limit of the monsoon winds from the high pressure zones over the south Atlantic (Sainte-Helène Anti-cyclone) which penetrate Mauritania. This front attains its northern-most position during July and August. Near the coast, its position is stationary all year long due to the maritime alizé.

The air masses become drier from the west to the east during all the year and from the south to the north when the monsoon blows. Thus, regardless of season, the north of the country is always dry.

1-1-2-2 Precipitation

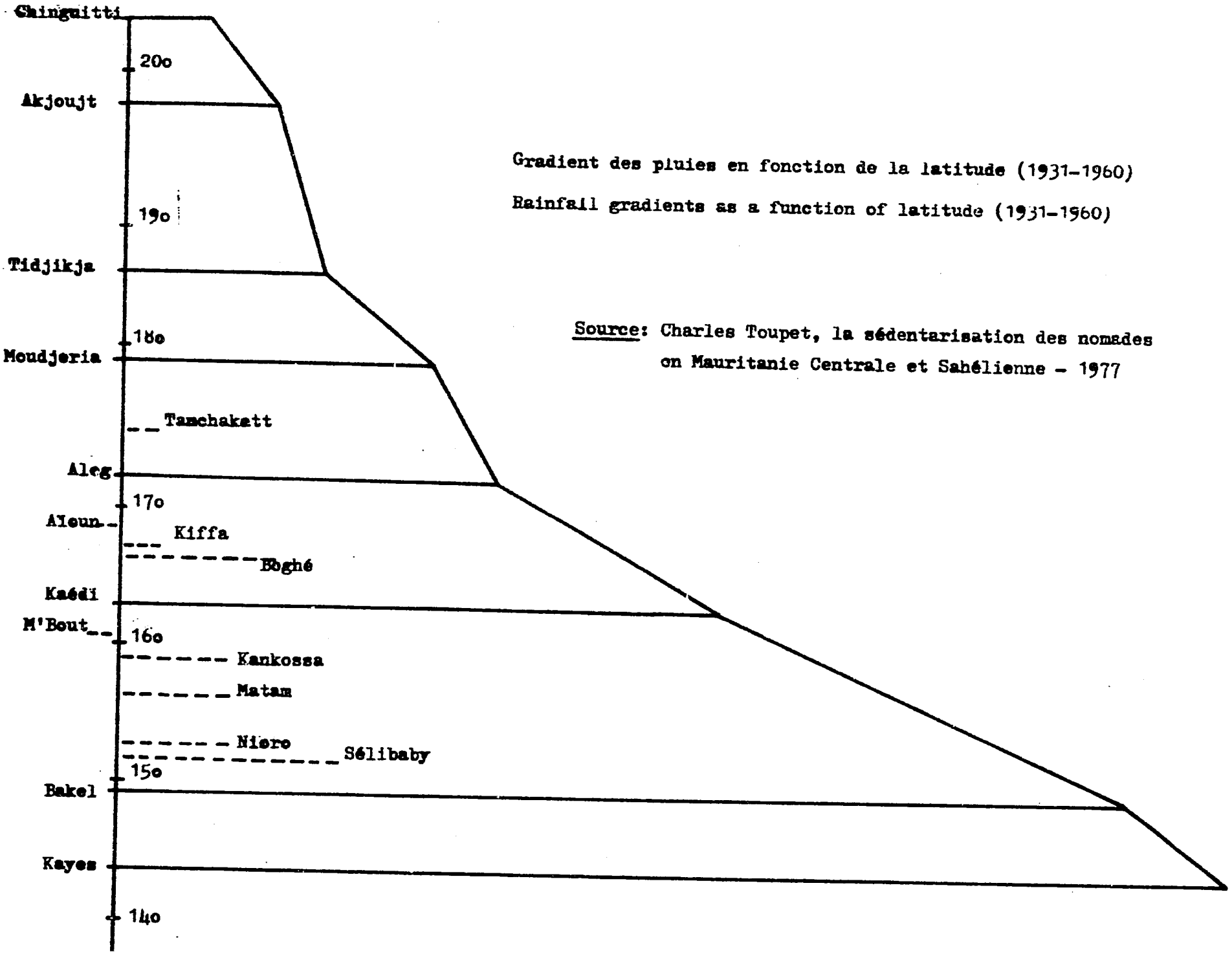
The wind conditions described above are not conducive to rainfall. The maritime alizé is stable and cannot directly produce precipitation. These air masses sometimes contain large quantities of water vapor, which can only be released as dew. On the other hand, the continental alizé is very unstable, especially at the hotter hours of the day, but it is so dry that it produces no rain.

The monsoon winds are humid and unstable, but their thickness never exceeds 1500 meters at maximum penetration into Mauritania; it is overridden by the very dry continental alizé and this prevents cloud formation.

There are no mountains to arrest the humid winds and engender precipitation. Consequently, rainfall can only occur due to atmospheric disturbances (temperate in winter and tropical in summer).

In the winter, light rains fall on the northern part of the country and towards the south along the coastline.

In the summer, heavy shower lines (improperly called "tornados") move from east to west in the south of the country, decreasing as they near the coast.



Gradient des pluies en fonction de la latitude (1931-1960)

Rainfall gradients as a function of latitude (1931-1960)

Source: Charles Toupet, la sédentarisation des nomades en Mauritanie Centrale et Sahélienne - 1977

Thus, precipitations originating in atmospheric disturbances are always stormy, and consequently, always short. The number of days of rainfall remains low, even in summer. Most of the rains are furnished by the monsoon winds. Annual mean rainfall surpasses 600 mm in the extreme south of the country, rapidly decreasing towards the north. At the level of Nouakchott, Atar and to the north of Oualata, rainfall is on the order of 100 mm, decreasing to less than 50 mm in the northeast and along the northern coast. Figure 1 (Rain Gradients as a Function of Latitude -1931-60) illustrates the decrease in precipitation towards the north. Figure 2 (Normal Annual Rainfall - 1941-1970) shows the average position of the isohyetal lines in Mauritania.

Distribution of mean monthly rainfall :

For the period 1931-60 this distribution is shown in Table 3-2 (Chapter 3, "Surface Water").Also shown in the same chapter :

Table 3-1 : Annual Proportion of Stormy Showers (1931-1940)

Table 3-3 : Rainfall Characteristics

Table 3-5 : Frequency of Daily Rainfall (1953-1962)

Table 3-7 : Percentage of Rainfall by Day and by Night, 1951-1960.

In Chapter 2, section 2.2.1 (Drought Cycles) shows maximum and minimum rainfall registered in Mauritania.

An analysis of rainfall under drought conditions is discussed in Chapter 2 : "Environmental Constraints in Mauritania".

1-1-2-3 - Temperatures

Temperature changes and distribution in the country result from two main factors :

- zenithal movements of the sun[1],which generally control annual temperature variations
- geographical factors, particularly the latitude and distance from the sea, on which depend temperature increases and variations.

---

(1) Zenithal sun movements : apparent translation of the sun at its zenith,during the year,between the Tropic of Capricorn (Dec.21) and the Tropic of Cancer (June 21).

The coast is permanently affetced by the maritime alizé and thus benefits constantly from cool, and occasionally cold, temperatures. Coastal daily and annual temperature variations are low. Because of the ocean, the annual maximum occurs in September, the annual minimum in December-January.

On the other hand, within the interior, temperatures are greatly contrasted. Isotherms increase slowly towards the north from Febuary on, progressively, due to the influence of the monsoon. A nucleus of maximal heat, at first limited to the southeast of the country (April-May) also glides towards the north, occupying its northern-most position in July-August. It then regresses in a southern direction beginning in September, when boreal polar influences are re-established. The farther one goes into the interior, the greater the daily temperature variations. In the north, the factors that cause low rainfall cannot modify temperatures; however; in the south, the rainy season does create a temperature decrease. Two maximums are seen during the year : one before the rains and one immediately afterwards.

Data concerning temperature and humidity are given in Table 1-2.(1) The temperatures indicated are averages of annual maximums and minimums, but variations are much greater. For example, at Atar, temperatures vary from 49°C to 2°C; at Nouakchott, from 48°C to 4°C; at Kiffa from 47°C to 8°C, and at Néma, from 46°C to 8°C.

1-1-2-3-1 Humidity

Average humidity of the air decreases regularly in the dry season as one goes inland from the coast. In the summer, the influence of the monsoon creates fairly high humidity for most of the country, with the exception of the northeast.

1-1-2-4 - Evaporation(2)

Evaporation is regularly measured using a Piche apparatus (see Table 1-2). The data thus collected are not absolutely accurate, since some instruments are not identical, and due to differences in the quality of water placed in the evaporometer and the frequency of changing the discs, etc.

---

(1) and (2) : Notice de la Carte de Reconnaissance Hydrogéologique la Mauritanie au 1 000 000e, Ph. Roussel. Bureau Hydrogéologique, Ministère de l'Equipment, Service des Eaux Souterraines, IRM, Jan. 1968.

TABLE 1-2

TEMPERATURE - HUMIDITY - EVAPORATION

	AVERAGE TEMPERATURES		AVERAGE HUMIDITY (%)			EVAPORATION PICHE	EVAPORATION CORRECTED (coefficient 0,6)
	Maximum	Minimum	6h	12h	18h		
Aïoun El Atrouss	35,9	22.5	41	26	24	4920	2892
Aleg	36.8	20.8	-	-	-	3890	2542
Akjoujt	35.9	21.4	56	33	28	4230	2538
Atar	35.8	20.6	24	28	24	4371	2670
Boutilimit	34.4	20.6	53	30	24	4460	2680
F'Derick	33.5	18.6	52	34	26	5619	3360
Bir Moghrein	31.3	16.3	63	34	27	3840	2304
Kankossa	36.7	20.1	-	-	-	3350	2010
Keur Macène	-	-	-	-	-	3440	2064
Kiffa	41.4	21	48.3	27.7	24	3820	2298
Moudjéria	36.6	23.4	68	39	50	-	-
Nouakchott	32.7	19	68	39	60	2351	1290
Nouadhibou	27.1	16.5	69	57	69	2080	1150
Rosso	35.6	18.7	65	34	34	3221	1930
Tidjikja	34.9	19.6	48	29	27	4345	2610

Sources : "Carte de Reconnaissance Hydrogéologique".
Ph. Roussel - Bureau Hydrogéologique RIM-Oct. 1967.

A function of solar radiation and the wind, evaporation is reduced during the rainy season, when the sky is cloudy and the atmosphere saturated with water vapor; evaporation is highest at the end of the dry season.

Evaporation on free water

Water level gagings have been conducted since 1960 on 13 natural water surfaces located south of Brakna and the Trarza. These surfaces include three lakes (Aleg, R'Kiz and Mal) and ten cut-off pools in the flood zone of the Senegal River between M'Bagne and Podor. By comparison with measurements conducted by Colorado buried pan, it was possible to establish that evaporation on free water in the southwest of Mauritania equals 2.70 meters per year (Jacon, 1965). In the southeast, evaporation was estimated empirically, by observation of the levels of certain pools, to be 2.80 - 2.90 meters/year.

Column 7 of Table 1-2 (Corrected Evaporation) gives an approaching value for free water evaporation. These figures, obtained by multiplying Piche evaporation by the coefficient 0.6 (determined empirically for Sahelian and desert climates) gives fairly lower measurements than those obtained by water level gaging; therefore, these calculated values for free water evaporation should be used with caution.

Any non-replenished water surface less than 3 meters deep will be dried up by the end of the dry season[1].

1-1-2-4-1 PET - Potential Evapotranspiration

Measurement of potential evapotranspiration is not possible by the classical Thornthwaite and Stern formulas, which are not applicable to these climates. Although the Turc formula is theoretically applicable to this area, in this case it does not give logical results.

Table 1-3 gives PET measurements by the Penman method for 13 stations in Mauritania.

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(1) Source : Explanatory Note on Carte de Reconnaissance Hydrogéologique de la Mauritanie au 1 000 000e, Ph. Roussel, IRM, Hydrogéological Bureau, Jan. 1968.

TABLE 1-3

PENMAN PET

	JAN.	FEB.	MAR.	APRIL	MAY.	JUNE	JULY	AUG	SEP	OCT.	NOV	DEC
AIOUN EL ATROUSS	232	236	304	323	310	306	262	208	207	226	210	229
ALEG	142	153	210	225	225	291	210	174	174	178	153	137
BOUTILIMIT	223	225	302	313	321	315	276	237	229	246	232	218
KIFFA	231	237	298	317	308	303	265	215	205	219	205	228
MOUDJERIA	171	176	233	246	264	268	251	223	208	201	165	163
NOUAKCHOTT	142	149	201	214	234	213	189	184	180	184	149	133
ROSSO	184	190	270	279	297	268	230	199	188	206	181	188
TIDJIKJA	147	151	205	213	244	251	248	224	204	159	150	138
ATAR	160	167	225	246	289	306	308	283	246	210	172	164
AKJOUJT	161	173	230	251	283	282	262	249	234	218	178	158
NEMA	259	284	305	298	296	269	248	208	203	250	231	234
TAMCHAKETT	202	206	269	205	207	287	257	216	208	214	188	196
SELIBABY	139	158	197	207	249	210	184	160	155	165	139	132

- real values for all stations, except Tamchakett (Aïoun and Moudjéria) and for Sélibaby (Kayes and Matam), obtained by extrapolation.

Source : "Livestock in Southeastern Mauritania "Tome I, P.46 - FED, IRM, Ministry of Rural Development, Livestock Division, July 1976.

1-1-2-5 Climates[1]

The combined influence of the maritime alizé, the continental alizé and the monsoon, plus the distance of the regions from the coastline, permit a division of the country as to climate into two major regions : the Sahara and the Sahel, each subdivided into two sectors : coastal and continental.

The coastline north of Nouakchott is characterized by constant humidity, low temperatures, low daily and annual temperature variations and low rainfall (maximum rains in the autumn). Because of its low temperatures in winter and its relatively low yearly temperatures as compared to the interior, this area may be called a "cold coastal tropical desert".

Saharan Mauritania is that area dried and heated by the maritime alizé and the continental alizé. It is characterized by large temperature variations, both daily and annual, by the extreme dryness of the air, by very low rainfall, rendered insignificant due to the high temperatures and resulting evaporation. This is the most arid of Mauritania's climatic regions.

Sahelian Mauritania is limited on the north by the 150 mm isohyeta line. The coastal area owes its climate characteristics to the maritime alizé : constant humidity, coolness, slight temperature variations. However, the monsoons are responsible for the storm lines which reach it near the end of their journey and cause the summer rains. The continental region has a much more contrasted climate, with a very dry winter season and a rainy summer season. Temperatures are high, with marked variations, especially in the Hodh depression. Temperatures decrease slightly in the middle of the summer. Only the southern part of this region (due to the prolonged presence of the monsoons) benefits from considerable rainfall and a period (not exceeding four months) which can be considered humid.

This brief presentation of the Mauritanian climate would not be complete without mentioning the changing climate conditions,

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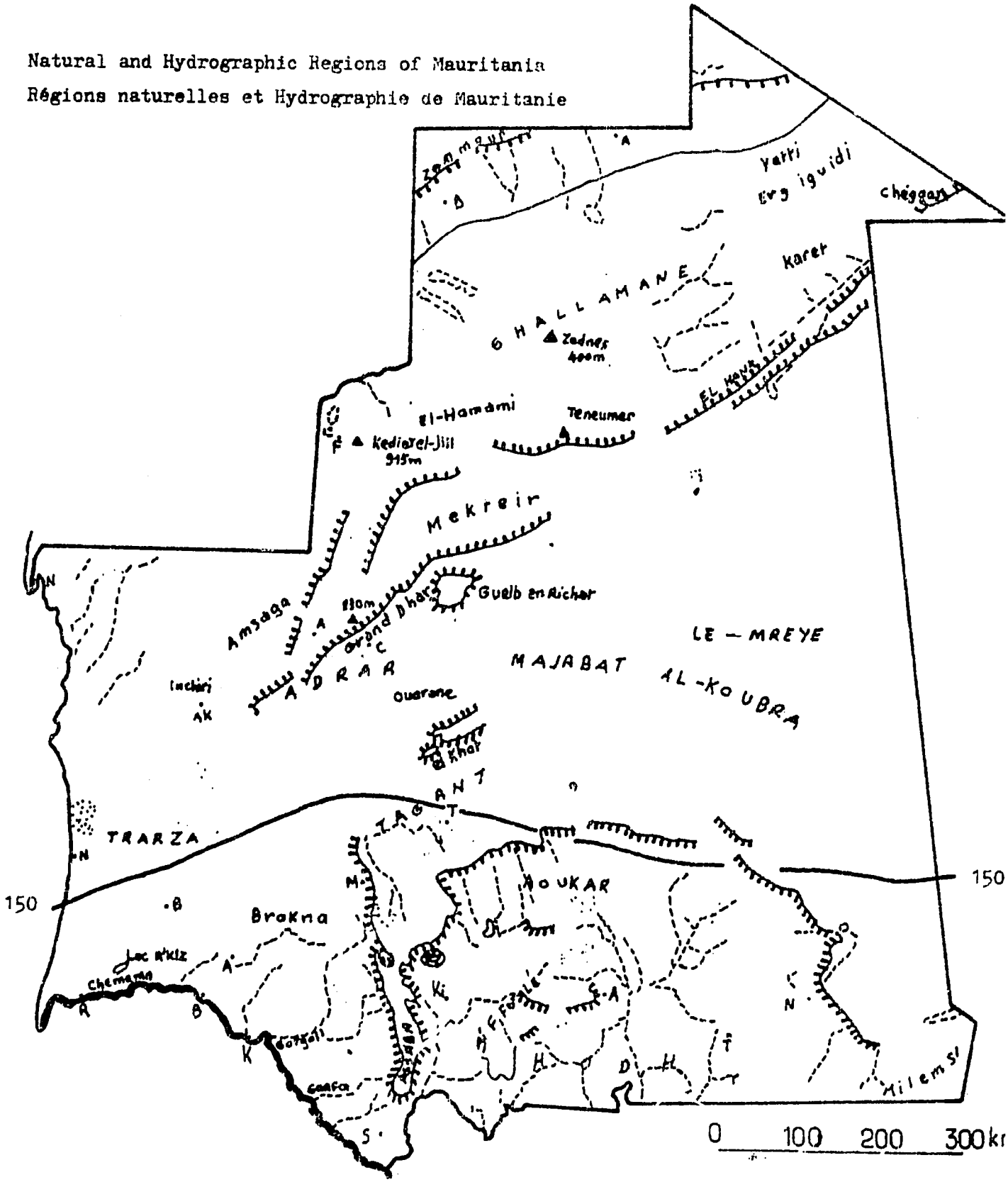
(1) C. Toupet, Atlas de Mauritanie, Ed. Jeune Afrique, 1977.

in particular, the decrease in rainfall which has been experienced in recent years, especially in 1972. It has been noted that for the past several thousand years, rains of temporate origin penetrate less far into the interior of the tropics and that rains of tropical origin brought by the monsoon are slowly regressing towards the south. It remains to be seen whether this slow process will continue; at present, technical means are not sufficiently developed to provide the answer.

Natural and Hydrographic Regions of Mauritania

Régions naturelles et Hydrographie de Mauritanie



1/6 500 000

Scale

Echelle

Oueds

Sebkhas

Escarpements - Escarpments

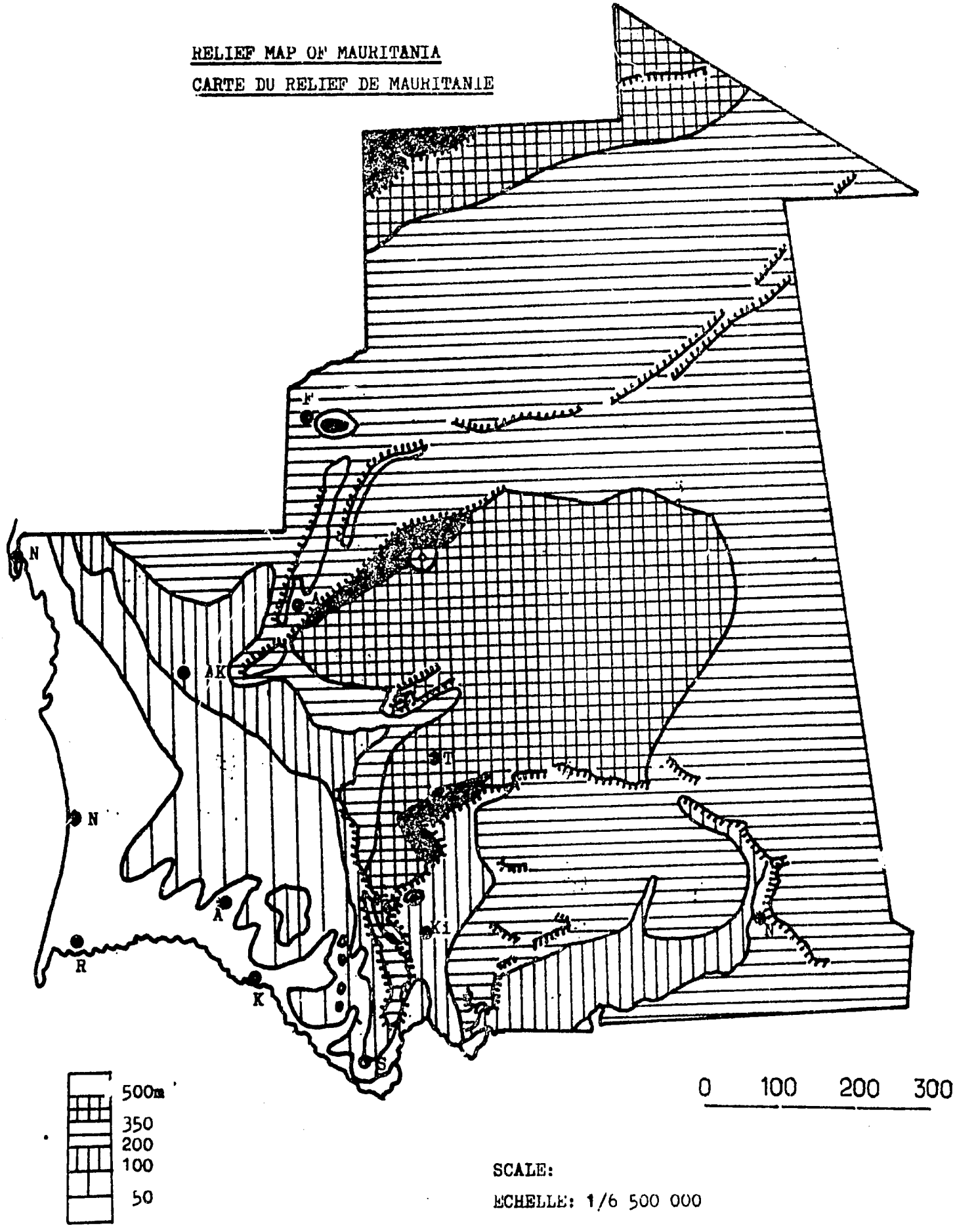
Fleuve Sénégal - River

Isohyete 150 mm - Isohyetal line

ADAPTED: FROM AT LAS DE MAURITANIE 1977.

RELIEF MAP OF MAURITANIA

CARTE DU RELIEF DE MAURITANIE



SCALE:

ECHELLE: 1/6 500 000

ADAPTEE DE L'ATLAS DE MAURITANIE

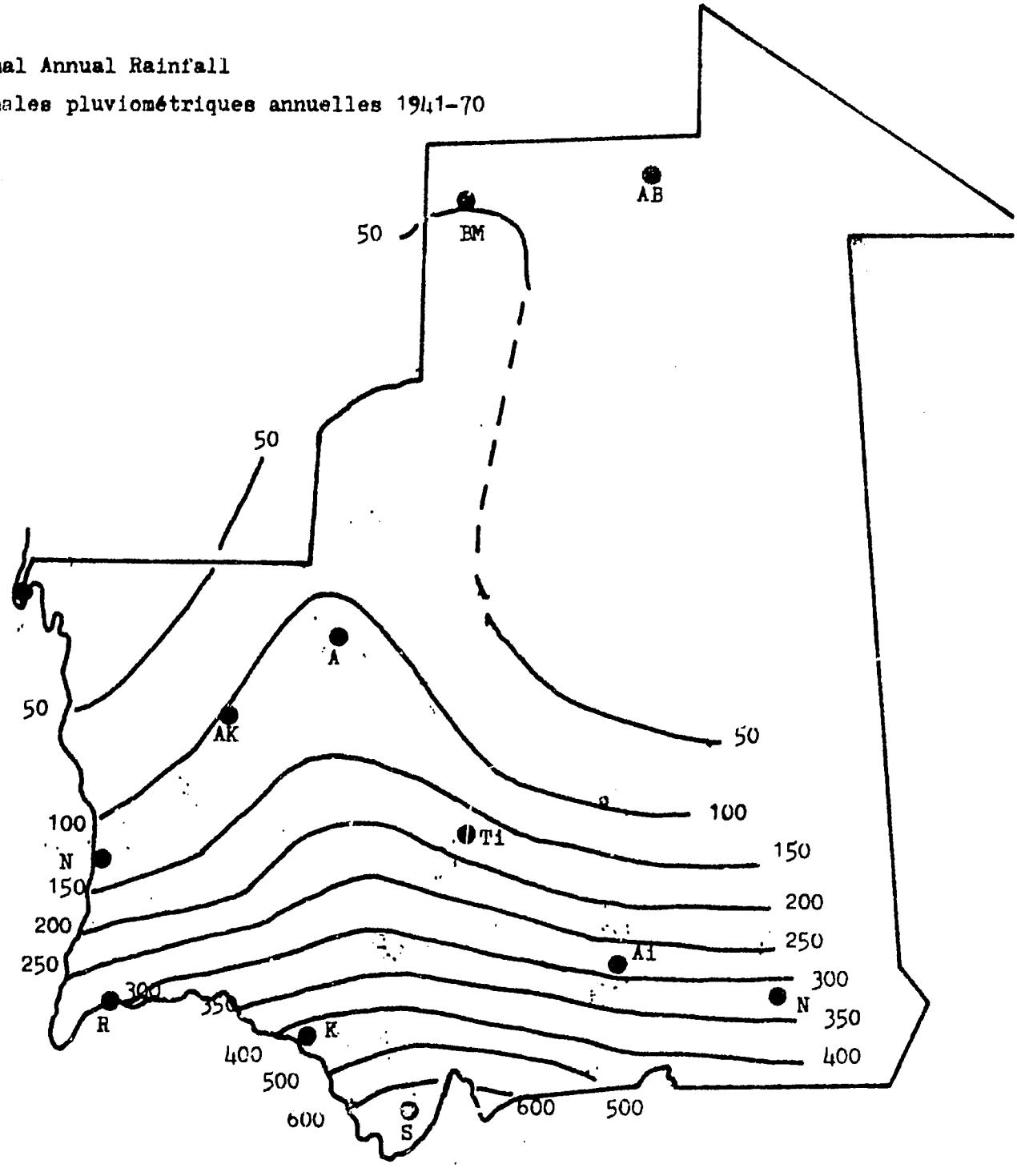
ADAPTED FROM ATLAS DE MAURITANIE

1977.

FIG. 1.4

Normal Annual Rainfall

Normales pluviométriques annuelles 1941-70



Source: PNUD/OMM/AGRHYMET

Scale

Echelle: 1/7 500 000

CHAPTER 2

ENVIRONMENTAL CONSTRAINTS IN MAURITANIA

2- ENVIRONMENTAL CONSTRAINTS IN MAURITANIA

2.0 - INTRODUCTION

The drought experienced over the past several years has shown that the natural rural milieu is very sensitive to man's activities. Poor use of the land or the sea over several years may have disastrous consequences for long term potential.

The environmental impact of development projects must always be taken into consideration. This harsh and hostile physical environment is the major cause of the Mauritanian population's poverty. Since the relationship of man to environment is so precarious, the possible negative effects of development programs must be given special consideration; those programs having a direct beneficial effect on this relationship should be given priority (i.e., irrigation, well drilling, improvement of grazing, reforestation, etc.).

In keeping with this respect for ecological equilibrium, the Mauritanian government will also closely consider sea bottom exploration in the coming years (Third Economic and Social Development Plan, 1976-80, page 71.).

The Mauritanian government recognizes the fundamental role of the environment, both as a major cause of the current drought-related problems and as the essential element to be considered when formulating development programs for the future. While this awareness of environmental constraints is without doubt the result of the most recent drought cycle, it underscores the importance of the environment in all aspects of the Mauritanian economy (livestock, cultivation, mining,etc.). The Mauritanian Third Economic and Social Development Plan insists heavily on environmental problems, not only in view of short-term alleviation of drought conditions, but also in view of long-range programs to improve the environment for the future well-being of the nation and its population.

As all resources are finite, it is only possible to surpass environmental limits for short periods (usually to the detriment of the environment and the populations dependant upon it). For example, while over-grazing may not create immediate degradation of the environment, if repeated, it ends by destroying the basic environment on which vegetation depends. It is also possible to surpass the replenishment rate of shallow aquifers during relatively short periods and to obtain water from fossile aquifers. However, when the fossile aquifers have been depleted, irrigated cultivation becomes impossible.

Resource management requires long term perspectives in order to assure that the potential of basic resources is not exceeded.

The problem of environmental degradation is particularly acute where the environment is already quite fragile and the population and livestock are greater than the bearing-capacity of the land.

Like other arid and semi-arid regions of the world (the Southern part of the Soviet Union, the Western United States, or the Sahel in West Africa, for example), Mauritania is exposed to extreme rainfall irregularity and other harsh climate factors (winds, temperatures), resulting in a fragile environment.

2.1 - CONSTRAINTS DUE TO CLIMATE

The most recent drought experienced by Mauritania and all of Sahelian West Africa attained peaks in 1972 and 1977[1], years when rainfall deficits were particularly severe and generalized. The drought is continuing, as witnessed by major rainfall deficits registered in 1979. Although this drought is the most severe during the last 50 years since climate observations have been available for this region, the country has suffered other

(1) Data from Agrhymet project at Nouakchott

droughts in the past.

2.1.1 - Drought Cycles

Climatology data indicate that less severe droughts occurred in 1913 and again in 1941-42. In addition, Arab literature gives descriptions of drought conditions from the 15th and 16th centuries on, but these tales lack precise meterological data which would permit determination of drought severity.

It is reasonable to suppose that drought cycles have long been part of the Mauritanian climate, since Arab literature describes them during the past four hundred years and precise data confirms their existence over the past 50 years. Thus, Mauritania, and all Sahelian Africa, may expect repeated periods of drought in the future; there is no indication that these drought cycles will cease.

Climatology references for Mauritania and other regions of the West African Sahel, as well as for other arid and semi-arid zones of the world, indicate that drought periods tend to occur about every 25-30 years. As mentioned above, Mauritania experienced drought cycles in 1913, 1941-42 and is currently undergoing a long period of drought. Since 1968, rainfall has always been irregular. Mauritania can probably expect another drought cycle near the end of the century.

Note : Weather predicition is not sufficiently developed to permit determination of when the next drought will occur, nor its intensity or geographical distribution. Thus the hypothesis of another drought around the year 2000 must be considered with caution. However, on the basis of historical facts (scientific observations and literary sources), it seems reasonable to suppose that drought periods will recur, as they have in the past, although it is impossible to predict their severity.

STATIONS	MAXIMUM RAINFALL: YEAR	MAXIMUM (mm)	NUMBER DAYS OF RAIN	MONTHLY MAX (mm	MINIMUM RAINFALL: YEAR	MINIMUM (mm)	NUMBER DAYS OF RAIN	MONTHLY MINIMUM	VARIABILITY INDEX
Aïoun el Atrouss	1958	499	39	Sept. 61	1976	112	23	Aug. 68	4.5.
Akjoujt	1938	221	13	" 107	1971	6	2	Sept. 6	36.8
Aleg	1927	617	21	Aug 29	1972	58	8	Aug. 18	10.6
Amourj	1978	657	39	Sept.210	1973	169	11	Sept. 42	3.9
Atar	1927	244	22	Aug. 56	1977	15	6	Oct. 3	16.2
Bir-Moghrein	1969	151	10	Oct. 7	1961	5	3	Aug. 0,6	30.2
Boghé	1927	586	32	Aug. 295	1977	126	10	Sept. 90	4.6
Boutilimit	1921	365	12	Sept.220	1962	39	13	Aug. 24	9.3
Chinguetti	1957	153	21	Oct. 98	1941	6	3	Sept. 4	25.5
F'Dérick	1969	198	22	Oct. 53	1970	3	5	Feb. 2	66,0
Kaédi	1936	762	38	July 262	1972	130	19	Aug. 60	5.9
Kankossa	1957	563	45	Aug. 229	1961	237	21	July.100	2.4
Kiffa	1968	620	36	Aug. 324	1960	142	25	Aug. 58	4.4
M'Bout	1951	652	37	Aug. 231	1972	111	10	Aug. 60	5.9
Mederdra	1969	470	18	Aug. 251	1972	86	6	Aug 55	5.5
Moudjeria	1969	535	23	Aug. 170	1941	55	14	July 36	9.7
Néma	1954	506	53	July 185	1977	100	22	Sept. 36	5.1
Nouakchott	1956	267	24	Dec. 137	1977	3	5	Aug. 1,6	89,0
Noundhibou	1953	102	21	Oct. 40	1977	0	0	0	-
Oualata	1969	206	13	Aug. 90	1973	44	4	Aug. 31	4.7
Rosso	1947	162	29	Aug. 498	1972	51	14	Sept. 25	12.0
Selibaby	1936	1099	46	Aug. 415	1972	289	22	Sept. 72	3.8
Tamchakett	1958	470	25	July.182	1942	95	14	May. 35	4.9
Tichitt	1940	167	11	Aug 95	1921	10	5	Aug. 10	16.7
Tidjikja	1966	421	33	Oct. 146	1942	34	8	Aug. 15	12.4
Timbedra	1954	603	44	Aug. 284	1976	120	9	Sept.113	5,0

Source : Author - RAMS - 1979
(Dabas obtained from ASECNA)

In addition, it is not possible to affirm that the intermediate periods between droughts will be favored by "rainy" years (average or above average rainfall). The last year of good rains in Mauritania was 1969; only three years later (in 1972) a severe drought was experienced. Thus climate conditions can change over a short period from very wet to extremely arid. These abrupt transitions from humidity to drought preclude the possibility of predicting and preparing for such disastrous situations. Therefore, even when Mauritania has experienced a number of rainy years, planning must always anticipate the recurrence of drought.

While the current drought has limited use of Mauritania's resources to the lowest level, rainy cycles do permit an increase in resources and thus in rural production. Thus, planning should also consider optimal climate conditions and the means to profit from them, while anticipating the probable return of drought. During the rainy periods, increased agriculture must be considered as a "short term" effort. Large investments in regions where climate conditions are often severe are not justified, as returns are often limited (or non-existant during long droughts).

Planning must include the means for very rapid evacuation of herds from devastated zones, in order to reduce the impact of over-grazing and avoid destruction of the fragile environment. This type of planning supposes great sensitivity to and permanent supervision of the milieu, and appropriate and rapid preventive intervention on the part of the government. This type of action is not common throughout the world, but should be urgently applied by governments having to contend with a difficult environment, as is the case in Mauritania.

2.1.1.1 Rainfall and the Drought

Precipitations play a direct role in the distribution of most human and environmental variables : type and quality of vegetation, soil types and distribution, water resources, replenishment of aquifers, livestock and cultivation, etc. Although it is evident that rainfall varies greatly in arid and semi-arid regions such as Mauritania, the relative scarcity of

precise data concerning precipitation makes it difficult to conduct an in-depth evaluation of potential problems confronting these regions. Government actions must take into consideration that environmental conditions are often reduced to the lowest common dehominator, that is, one year or an entire drought cylce. For Mauritania to attain the highest possible degree of self-sufficiency, minimum rainfall must be anticipated and prepared for, so as to reduce the environmental impact of drought.

Meteorological data furnished by the ASECNA (Table 2-1) show the maximum and minimum rainfall for all meteorological stations in Mauritania. In the 1940's only one station (Tichit) recorded maximum rainfall. Many of these stations were created after World War II. Only one station (Amourj) recorded maximum rainfall between 1970 and 1978, whereas during the 1950's and 1960's, maximums were recorded at 16 stations out of 26. Rainfall data show that from 1950 to 1969, the climate was fairly humid; the 1970's were considerably dryer. However, as this data covers a period of 40 years and varied climate zones, its interpretation should be undertaken with caution.

For the first nine years of the 1970's, 17 stations out of 26 show a lower minimum rainfall than ever previously recorded. The 1970's, and in particular its first half, were very dry years.

On the other hand, only 4 stations show very low minimum precipitations between 1950 and 1969, which was a wetter period than usual in Mauritania.

Despite the fact that these meteorological recordings are not uniform for all stations, four stations show a low minimum rain volume in the 1940's. 1941 and 1942 were the driest of the decade; they correspond to the drought cycle preceeding the current drought, which began in the 1970's.

According to limited climatological data obtained from other countries and from documents concerning the Sahelian zone, a drought cycle also occurred in 1913.

Thus in Mauritania, it would seem that recent drought cycles have occurred at about 30 year intervals, which concurs with the droughts observed in other arid and semi-arid regions of the world. It is therefore logical to suppose that another drought cycle is possible around the year 2000.

For most of the Mauritanian recording stations, the months of maximum rainfall occur from July to September, due to the intertropical front moving north and the maritime equatorial air masses penetrating the south during the summer ("rainy season").

However, maximum rainfalls in the north (Bir Moghrein and F'Derick stations) and at the coastal stations of Nouadhibou and Nouakchott generally occur from October to December; the equatorial air masses from the south only slightly affect these northern regions; the northern rains are caused by low pressure zones ("cyclones") which move down from the Mediterranean and across North Africa during the winter.

In Table 2-1, we see that maximum annual rainfall volume for most stations occurred in 1969 and that minimum annual volumes occurred in 1972. Thus, in a period of only three years, Mauritania went from optimal rainfall conditions to total drought, a dramatic illustration of this nation's extremely variable climate.

Two isohyetal maps were established : Figure 2-2 shows rainfall distribution for 1969; Figure 2-3 shows rainfall distribution for 1972. On these maps, the average 100 mm, 150 mm, 400 mm and 600 mm isohyetal lines (mean 1941 -1970, see Aghrymet map) have been represented by broken lines, in order to facilitate comparison with the 1969 and 1972 rainfall distributions.

1969 Rainfall (Figure 2-2 : Isohyetal Map)

The isohyetal curves show a distinct bulge towards the north in the western center of the country, indicating better than average rainfall volume for this region. However, in comparison to the mean isohyetal lines in the south of the country, it appears that rains were less uniform, particularly along the southwestern border in the Kaëdi region. The northern-most stations received much greater volumes than average. The entire picture therefore remains fairly close to average rainfall conditions.

1972 Rainfall (Figure 2-3 - Isohyetal Map)

In 1972, rainfall was much lower than average. For example, in southwestern Mauritania, the 150 mm isohyetal line is about 400 km farther south than the average line. In the east, the 150 mm line deviates southwards by only about 100 km (to the north of Néma). This means that a vast zone, estimated at 250 000 km2, which normally receives more than 150 mm of rainfall, suffered a very significant deficit in 1972. During this year, this area was over-grazed by herds unable to migrate to the arid north; since the pasture lands were already in poor condition due to preceeding dry years, degradation was severe. Since then, rainfall has continued to be irregular. In 1977 (See Figure 2-10), the 150 mm isohyetal line moved even farther south than in 1972. In 1979, the southern 2/3rds of the country suffered a rainfall deficit (but the northern third had better than normal rainfall). (See Figure 2-8 : PNUD, Aghrymet).

1972 is often cited as a reference-year for drought in the Sahel. While this year marked major rainfall deficits for the entire country, 1977 was actually worse in the regions of Atar, F'Derick, Nouakchott, and in the southeast at Aïoun el Atrouss, Tamchakett and Néma.

Table 2- shows 1977 deficits as compared to the 1941-70 average. Table 2- shows rainfall in 1977 compared to that of 1972 and 1976, and demonstrates that 1977 rainfall deficits were larger than those of 1972 for 18 stations.

Figures 2-10 and 2-11 illustrate rainfall conditions for the months of June, July and August, 1977.

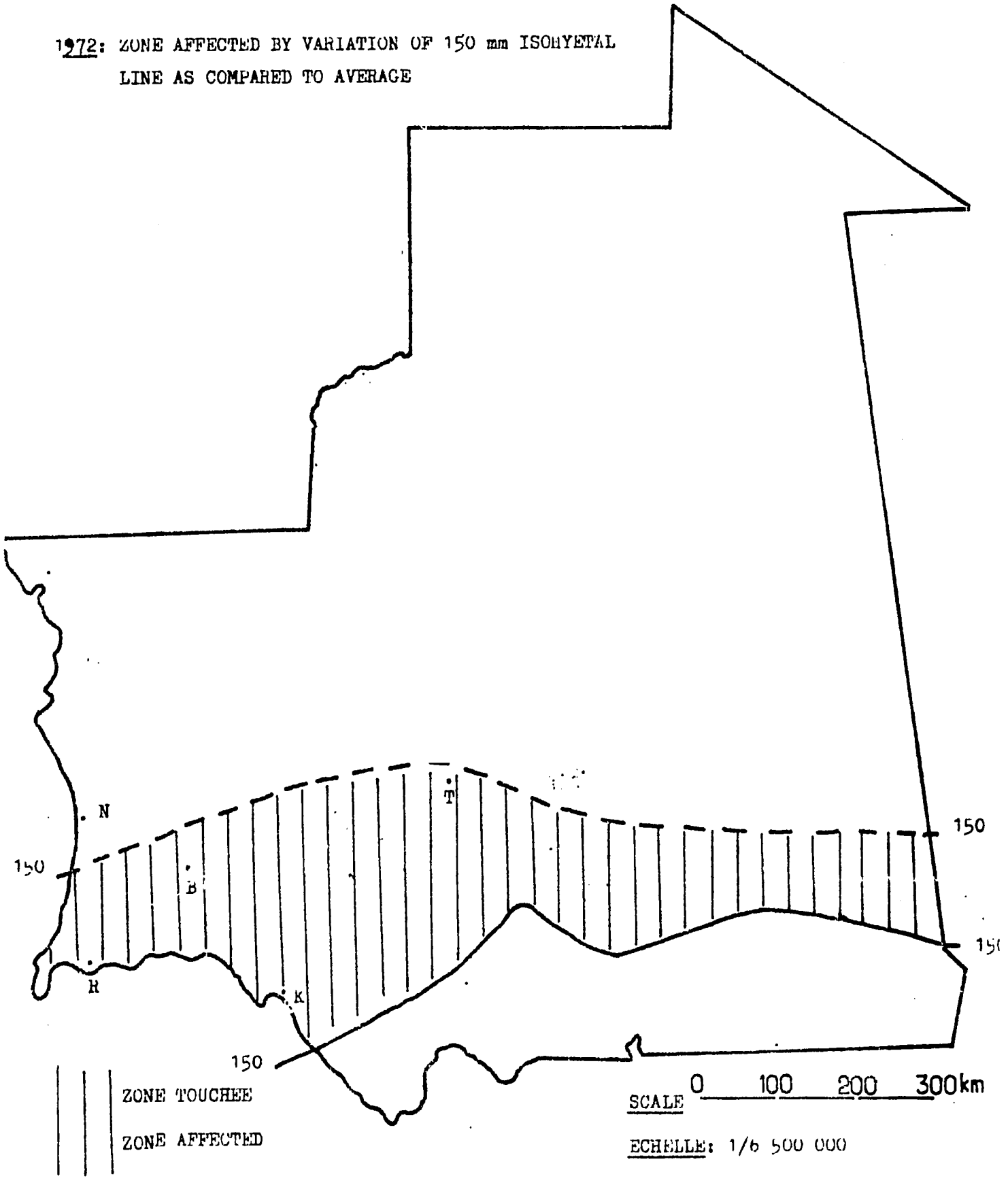
Figure 2-3 shows that the extreme south of the country, which usually benefits from more than 600 mm of rainfall, received less than 300 mm in 1972 (a deficit of more than 50%).

Table 2-1 gives the variability index calculated for each meteorological station. This index was obtained by dividing the maximum rainfall volume by minimum rainfall volume ($\frac{R.\ Max.}{R.\ Min.}$) without regard for the date. The index varies from a minimum of 2.4 for Kankossa in the south to a maximum of 89.0 for Nouakchott.

1972: ZONE TOUCHEE PAR LA VARIATION SPATIALE DE L'ISOHYETE 150 mm EN 1972 PAR RAPPORT A LA NORMALE

FIG. 2.1

1972: ZONE AFFECTED BY VARIATION OF 150 mm ISOHYETAL LINE AS COMPARED TO AVERAGE



SOURCE: RAMS 1979.

Figure 2-4 shows the variability index expressed in isohyetal lines. The general orientation is east-west and reflects the increasing irregularity of rainfall from south towards the north.

- The variability Index 4 isohyetal line corresponds approximately to the 150 mm rainfall minimums for all years since recordings began.
- Variability Index 5 isohyetal line corresponds more or less to the 100 mm minimum rainfall.
- Variability Index 16 isohyetal line corresponds approximately to a minimum rainfall of 15-30 mm.

CONCLUSIONS :

In the southern part of Mauritania, and particularly just north of the border with Senegal, irregular rainfall is a significant climatic factor. This poses a grave obstacle to agricultural development and must be taken into consideration in all rural planning.

For example, before introducing new plants to serve as grazing, it is not sufficient to study the plants' requirements on the basis of average rainfall; rather it is necessary to evaluate their aptitude to resist extremely variable rainfall, before undertaking any major replanting project.

Drought cycles and isolated drought years are likely to recur in the future; development projects must always take this into consideration. For example, it is important to avoid large concentrations of herds in a given region, even after many years of good rains; if sudden rain deficits occur, disastrous conditions may result (such as in the Trarza region).

TABLE 2-2

RAINFALL DURING 1977 RAINY SEASON

STATIONS	JUNE	JULY	AUGUST	CUMULATIVE	NORMAL	% OF NORMAL
Aïoun el Atrouss	1.3	54.5	28.4	84.2	224.8	37
Akjoujt	2.8	0	10.6	13.4	38.3	35
Atar	0	1.5	0	1.5	40.1	4
Boutilimit	0	0	16.6	16.6	106.9	16
Boghé	0	11.0	25.0	36.0	209.1	17
F'Derick	0	5.0	4.7	9.7	16.1	60
Kiffa	tr	45.8	71.5	117.3	236.0	50
Kaédi	12.0	70.2	97.0	179.2	238.3	75
Nouakchott	0.3	0.3	1.6	2.2	67.4	3
Néma	3.4	34.9	21.3	59.6	211.0	28
Rosso	0.5	tr	36.7	37.2	177.0	21
Sélibaby	39.6	21.3	102.0	162.9	423.3	38
Tidjikja	tr	11.2	8.2	19.4	90.8	21

Source : Projet RAF/74/076 - AGHRYMET.

TABLE 2-3

1977 RAINFALL COMPARED TO 1972 AND 1976 RAINFALLS.

CUMULATIVE RAINFALL : RTOTAL RAINFALL FOR 4 MONTHS : JUNE, JULY, AUGUST, SEPTEMBER.

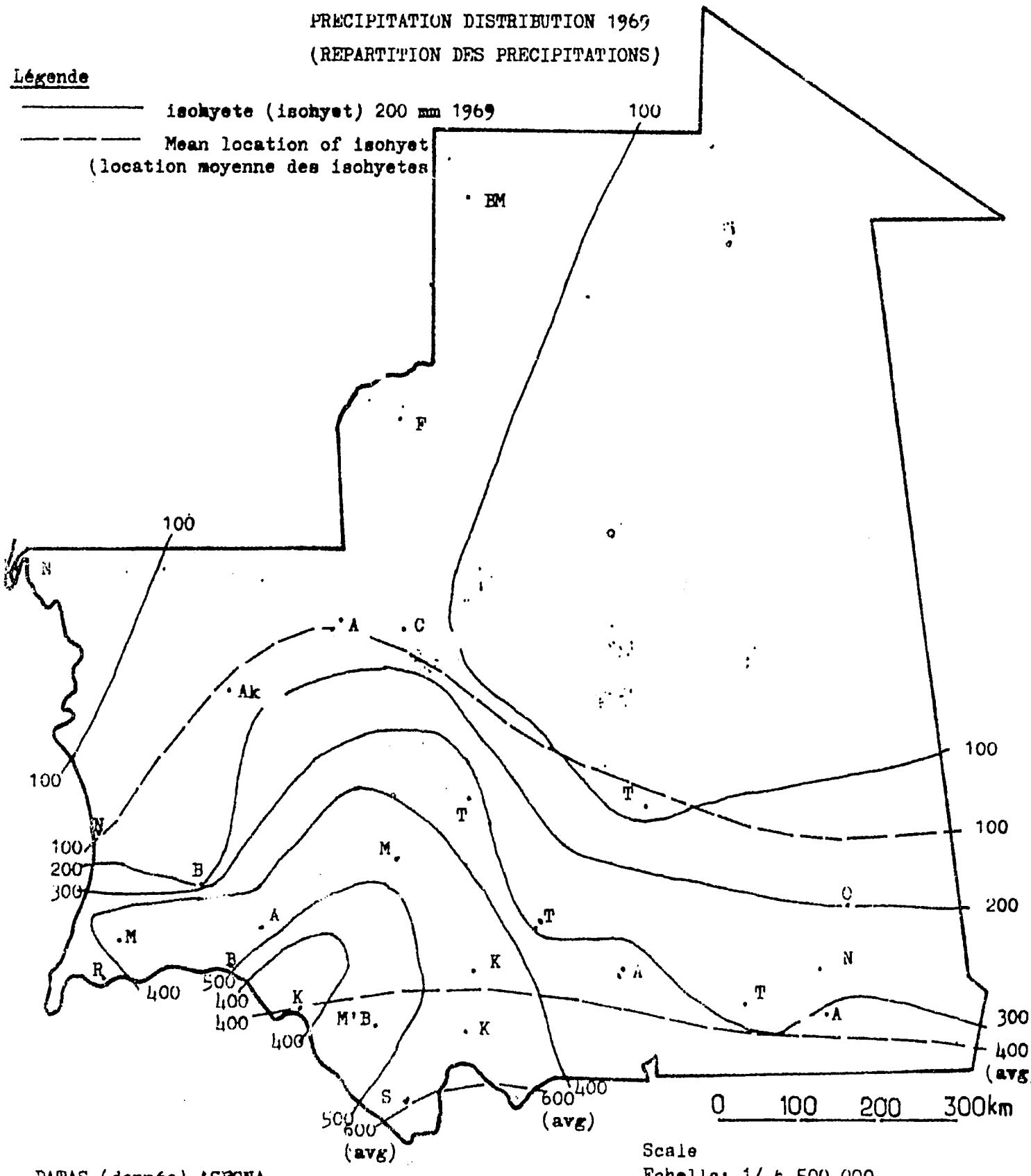
STATIONS	1977 CUMULATIVE RAINFALL	NORMAL 1941-70	RATIO 77/N	1976 CUMULATIVE RAINFALL	RATIO 1977-76	1972 CUMULATIVE RAINFALL	RATIO 1977/72
Aleg	(100.7)	227.6	44 %	145.5	69 %	28,5	353 %
Aïoun el Atrouss	102.8	281,7	36	98,7	104	110.0	93
Akjoujt	20.2	70.7	29	79.0	26	20.8	97
Atar	3.7	74.6	5	91.6	4	9.9	37
Boutilimit	35.5	163,5	22	94.0	38	38.5	92
Boghé	105.6	297.7	35	228.0	46	112.0	94
Bir Moghrein	0	15.2	0	2.4	0	7.0	0
F'Derick	13.1	29.0	45	53.6	24	46.0	28
Kiffa	169.2	326.8	52	285.4	59	103.3	164
Kaédi	227.5	339.5	67	211.1	108	117.2	194
Mederdra		213.1		183.0		81.2	
Nouakchott	2.5	115.0	2	48.8	5	65.7	4
Néma	95.6	271.9	35	196.6	49	196.4	49
Nouadhibou	Trace	11.2	0	3.0	0	Trace	0
Rosso	123.3	256.5	48	227.5	54	44.5	27
Selibaby	351.7	574.1	61	304.6	115	215.5	163
Tidjikja	44.6	135.8	33	66.2	67	62.8	71
Tamchakett	95.5	224.7	43	207.2	46	116.5	82

Source : Projet RAF/74/076 - AGHRYMET.

FIG 2-2

PRECIPITATION DISTRIBUTION 1969

(REPARTITION DES PRECIPITATIONS)

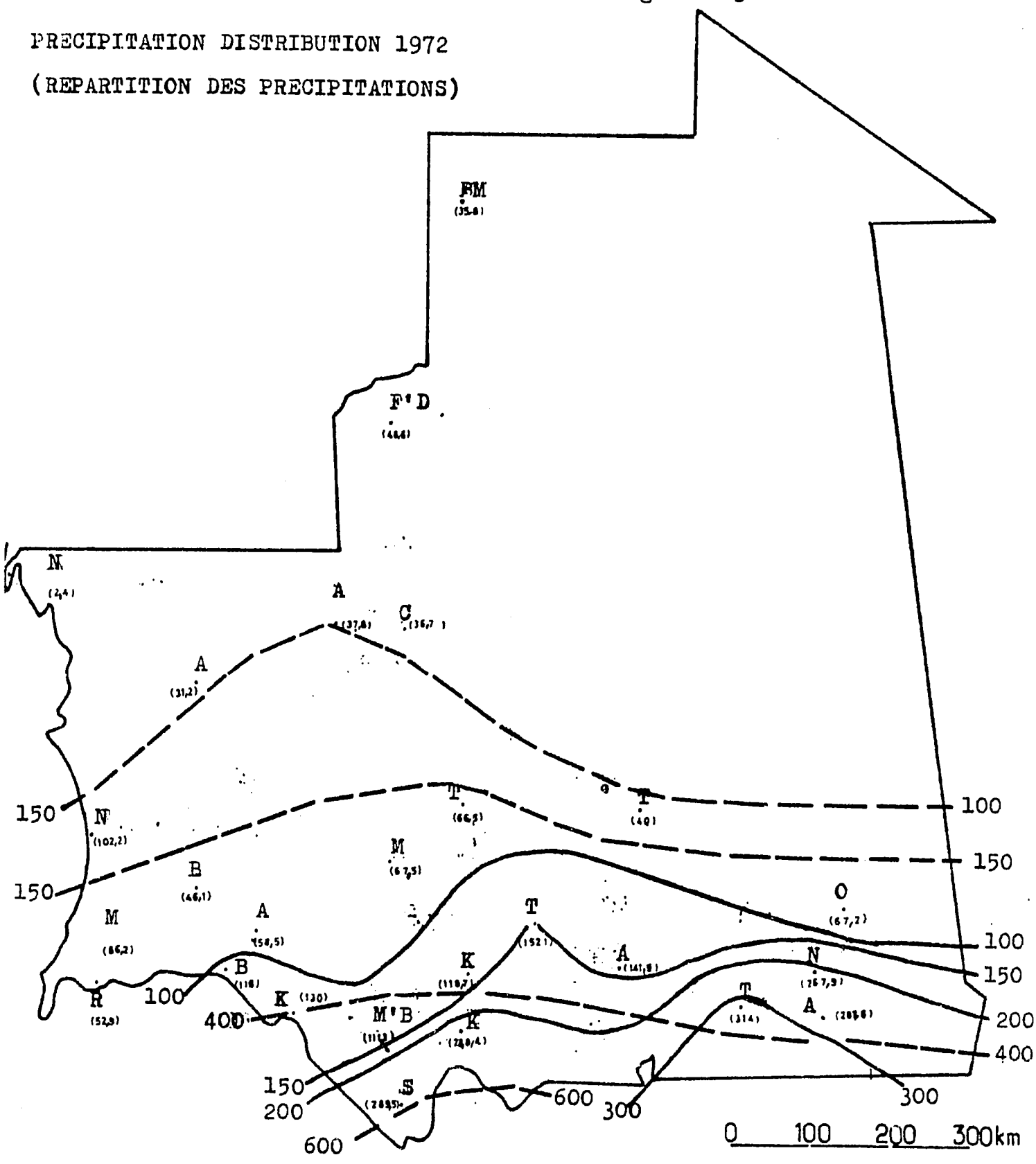


DATAS (donnée) ASECNA

Fig. 2 - 3

PRECIPITATION DISTRIBUTION 1972

(REPARTITION DES PRECIPITATIONS)



Legend (légende)

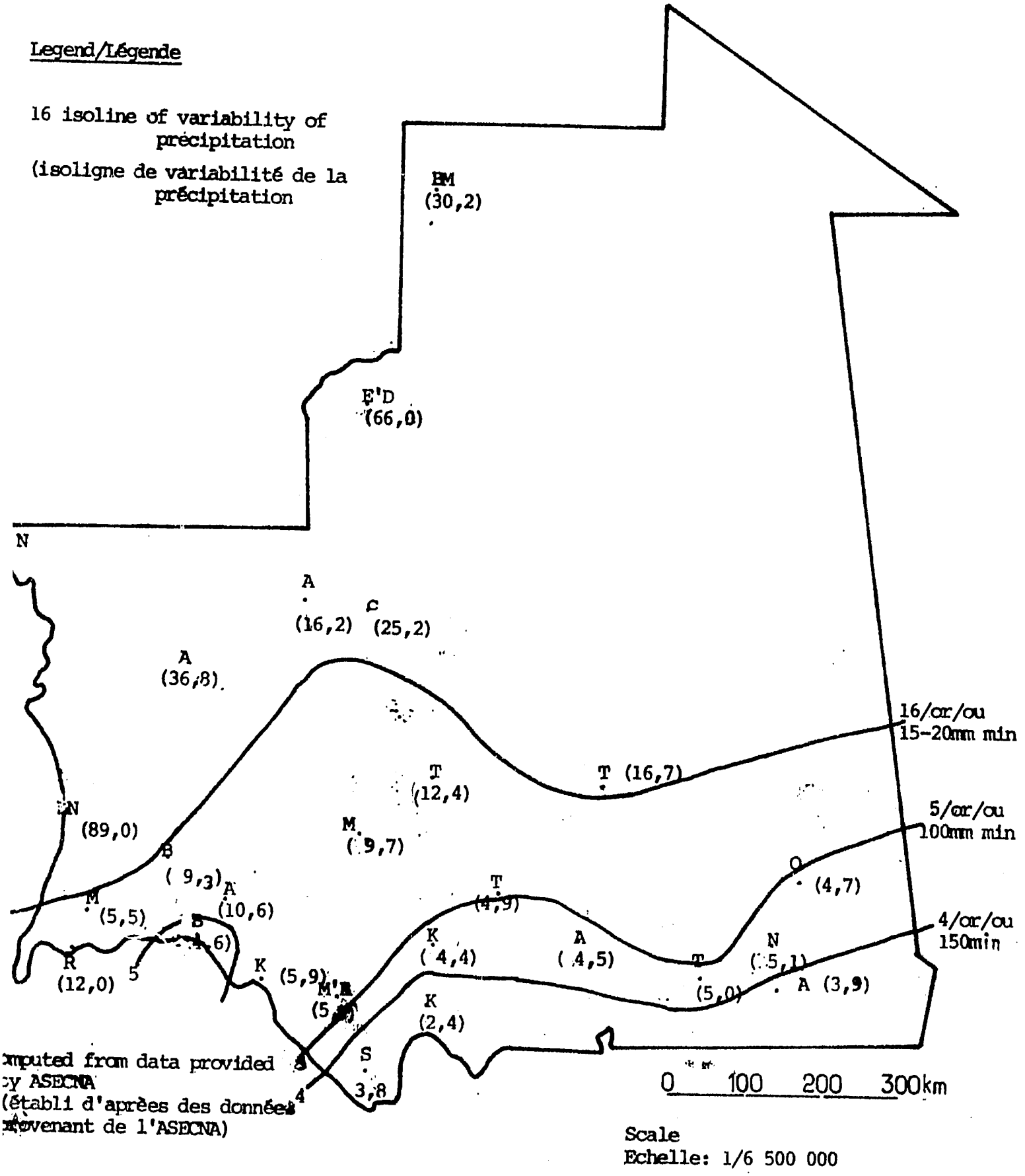
isohyet (isohyète 200 mm, 1972

localisation moyenne des isohyètes

(Datas/données ASECNA)

Fig. 2-4

VARIABILITY INDEX MAX P/1969/
(INDEXE DE VARIABILITE) min P/1972/



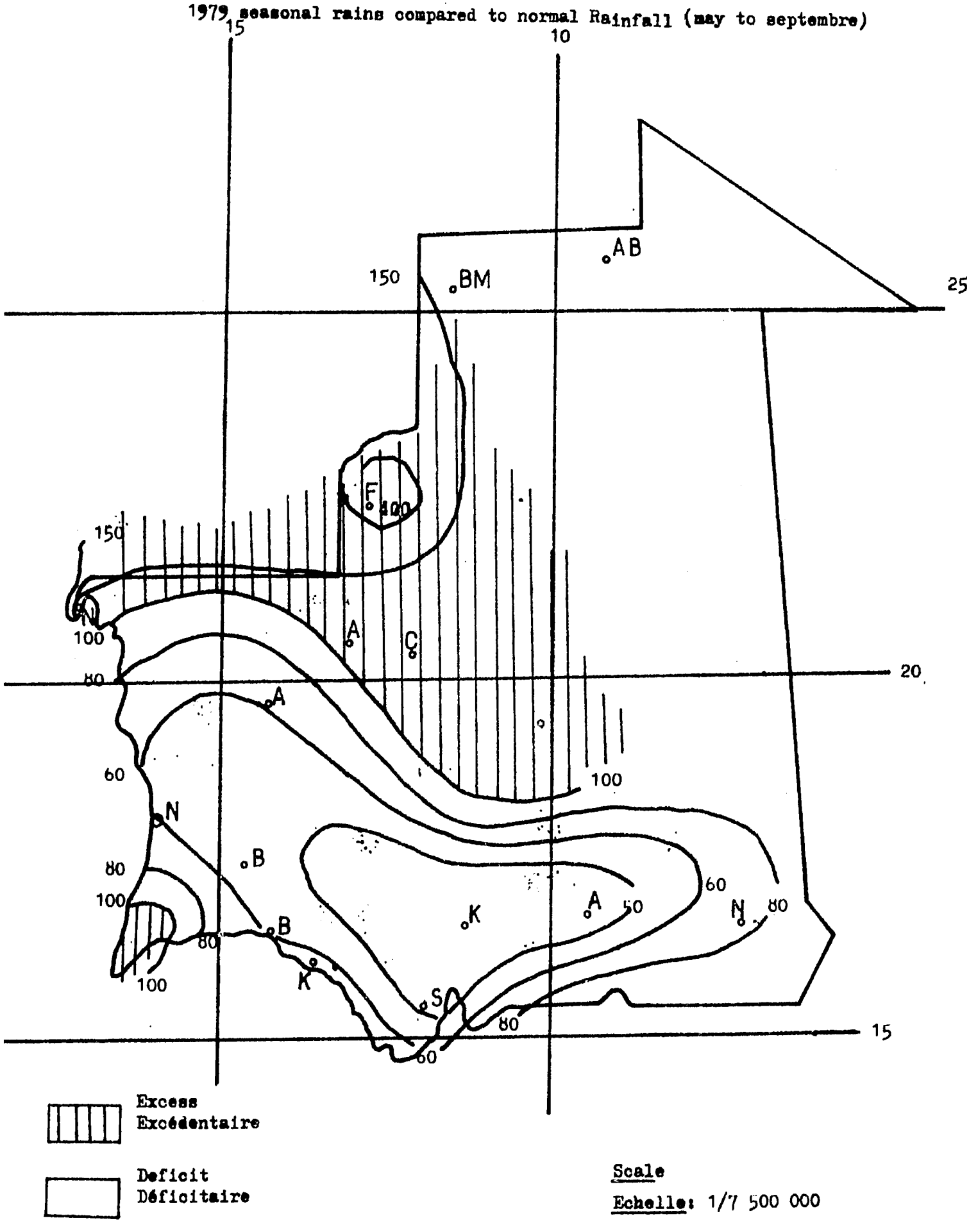
omputed from data provided
y ASECNA
(établi d'après des données
provenant de l'ASECNA)

Scale
Echelle: 1/6 500 000

Fig. 2-5

Rapport à la normale des pluies saisonnières mai à septembre

1979 seasonal rains compared to normal Rainfall (may to septembre)



Excess
Excédentaire

Deficit
Déficitaire

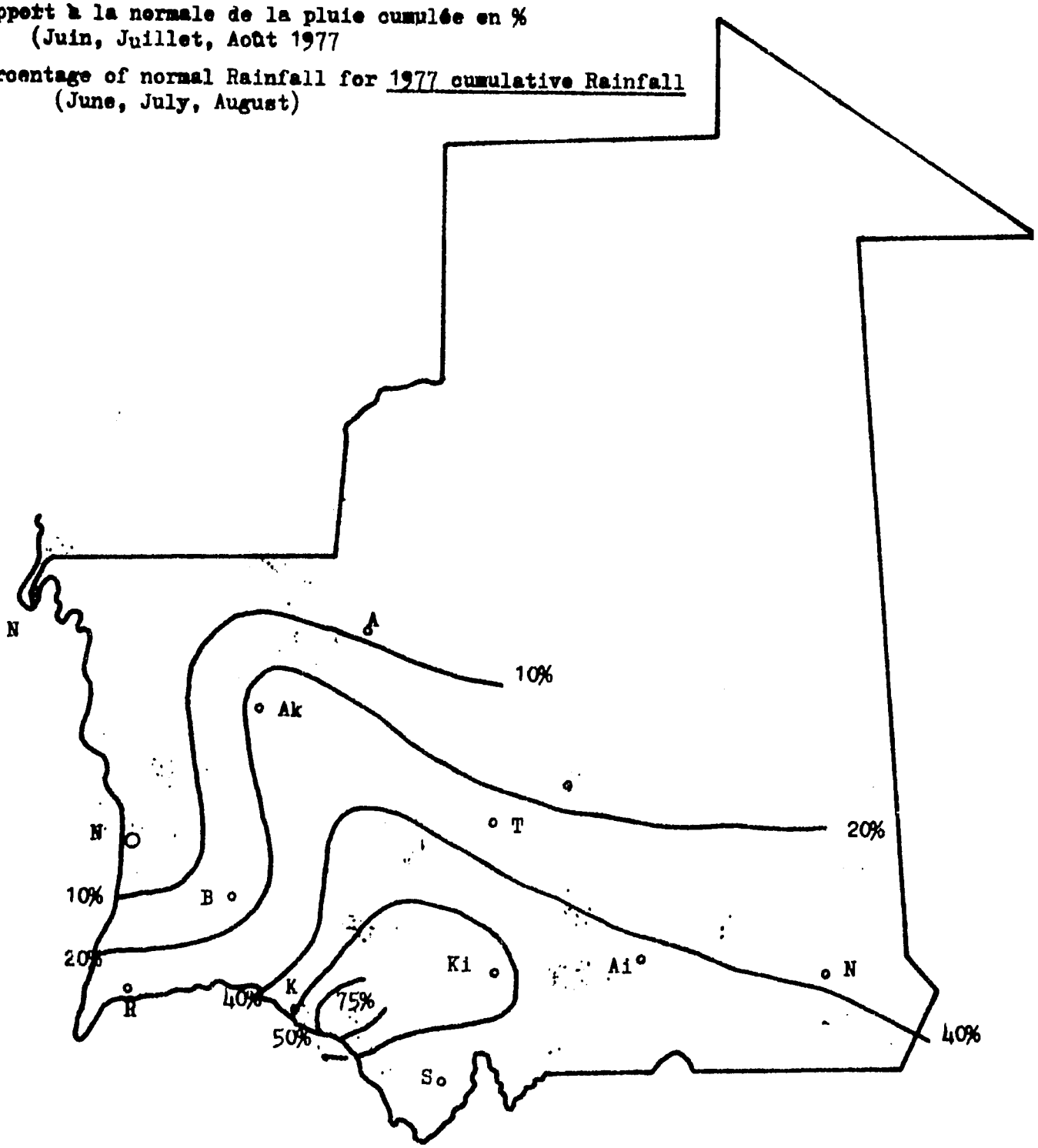
Scale

Echelle: 1/7 500 000

Fig. 2- 6

Rapport à la normale de la pluie cumulée en %
(Juin, Juillet, Août 1977

Percentage of normal Rainfall for 1977 cumulative Rainfall
(June, July, August)



Source: PNUD/OMM/AGRHYMET

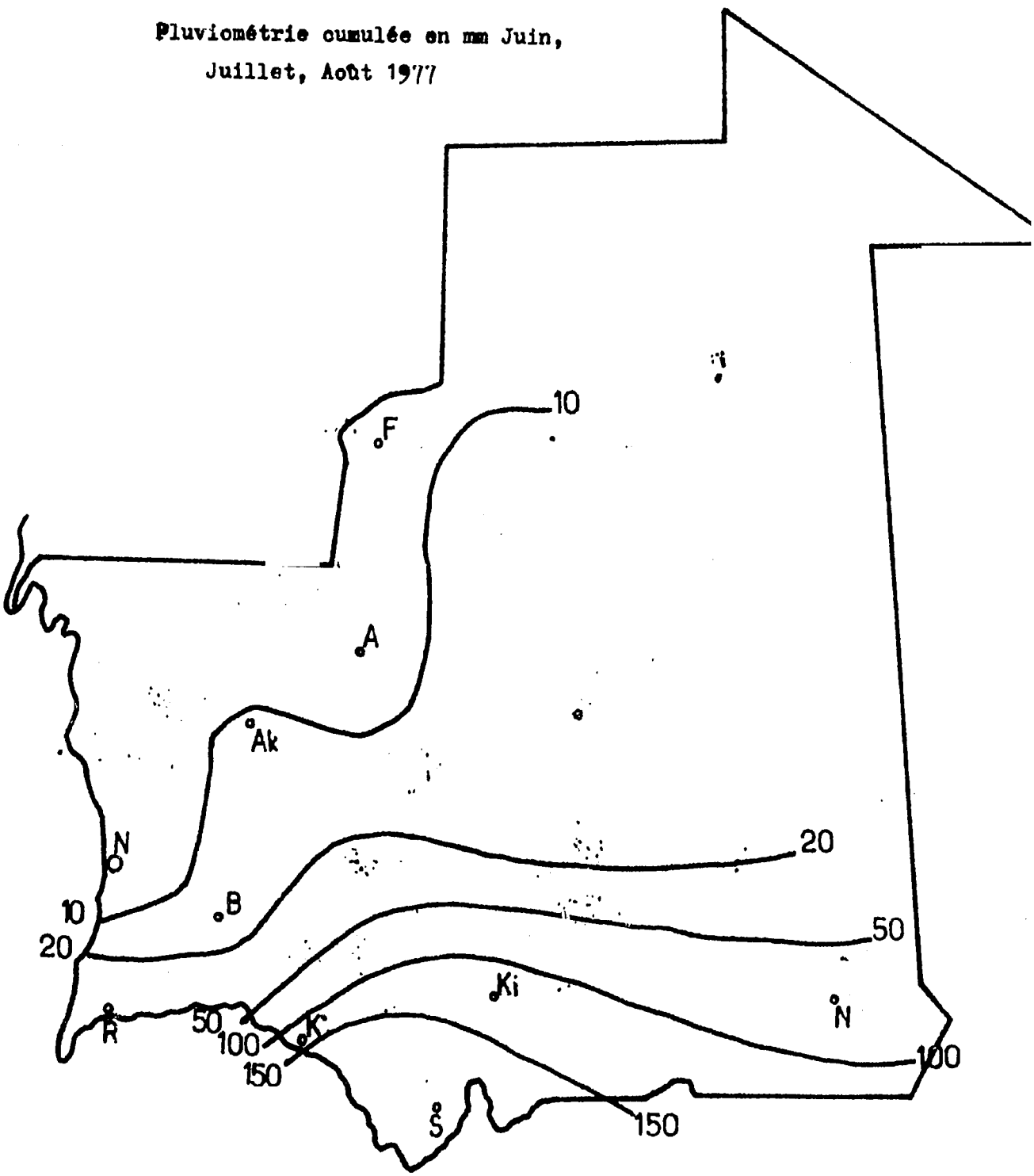
Scale

Echelle: 1/7 500 000

Cumulative Rainfall June,
July, August 1977 (mm)

Fig. 2-7

Pluviométrie cumulée en mm Juin,
Juillet, Août 1977



Source: PNUD/OMM/AGRHYMET

Scale
Echelle: 1/7 500 000

2.1.3 - Evaporation

Evaporation is considerable in desert and semi-desert regions such as Mauritania. Evaporative water loss causes serious problems for all living beings in this zone; only those that adapt can survive. For example, man migrates according to the availability of water; certain animals are nocturnal to reduce water needs; certain plants have leaves designed to minimize evaporation during the day.

Development projects for these dry regions must take the problem of evaporation into account; in this region where water is the most precious resource, every aspect of water economy must be studied. Particular attention should be given to cultivation methods which do not require plowing the land and to plants which have low water requirements. Flood irrigation when possible, should be avoided in favor of "drip irrigation" (where pierced pipes distribute water directly at root level underground). When building dams, reservoirs should present the least possible free water surface in order to reduce evaporation losses.

Piche evaporation measurements are available for 12 meteorological stations in Mauritania (See Table 2-2 : giving maximum and minimum annual evaporation and maximum and minimum monthly evaporation).

Two maps represent the distribution and characteristics of evaporation in Mauritania (Figures 2-5 and 2-6) :

Figure 2-5 : (Maximum Evaporation Losses) shows the influence of the Atlantic ocean and the alizés blowing on the western coast of the country. Evaporation decreases towards the west and increases towards the east. Along the Atlantic ocean, the isohyetal lines are parallel to the coast. Maximum evaporation occurs in the eastern center of the country, due to subtropical high pressure cells (Néma recorded the highest evaporation : 7,081 mm).

Slightly lower evaporative values are seen in the southern center of the country (south of Guidimaka); this region receives maximum rainfall and is influenced by maritime air masses from the equatorial Atlantic zone. These hot, humid air masses penetrate the southern center and reduce evaporation in the zone.

Figure 2-6 (Minimum Evaporative Losses) shows the same general outline. In the region along the coast, isohyetal lines are parallel to the ocean; evaporation increases towards the interior up to the heart of the Sahara , where subtropical high pressure cells dominate.

Evaporation decreases slightly in the southern center of the country due to penetration of humid air masses from the Atlantic equatorial zone.

An evaporation variability index was determined for each meteorological station (See Table 2-4). This is presented in Figure 2-7. Each index was obtained by a ratio of maximum to minimum evaporation for each station. (For example, at Nouakchott, maximum evaporation : 3387 and minimum evaporation : 1669 mm; ratio = 2.63.)

Towards the southeast of Mauritania, evaporation variability increases (from 1.62 at Aïoun to 1.84 at Nëma.)
The evaporation variations shown in Figure 2-7 reflect the influence of subtropical high pressure cells which dominate the eastern center of Mauritania and the Sahara desert. The presence of these cells over the Sahara assure constant sunshine and aridity all year round; they oppose the penetration of humid air masses from the south and west which could modify evaporation losses in this region.

On the other hand, in the western coastal zone of Mauritania, evaporation is extremely variable. Maritime air masses from the Atlantic ocean reduce evaporation losses; however, northeastern alizés from the Sahara may bring dry air to the coast and cause higher evaporation in the years to come. Evaporation variability also increases towards the southeast; during certain years, subtropical high pressure cells dominate and cause high evaporation; other years, maritime air masses from the equatorial Atlantic reach the south of Mauritania, siginificantly reducing evaporation.

Seasonal evaporation variability reflects variations of both solar radiation and air masses. Northern stations such as Bir Moghrein and F'Derick show maximum evaporation during summer months (max. : July), when temperatures and daily hours of sunshine are highest (Table 2-2). Evaporation is minimum for these stations in winter (December and January), when temperatures are lower and days shorter.

Southern stations such as Aïoun el Atrouss and Kiffa show the highest evaporation in April and May. The case of Nëma is somewhat different (See Table 2-4). This seasonal maximum evaporation is due to increased sunshine and length of days in the summer. However evaporation attains its peak just before the arrival of the maritime air masses from the south; once these humid equatorial masses arrive, evaporation decreases to minimum.

The above information is necessary to determine the different types of cultivation and irrigation systems possible for each region. Due to the high evaporation levels in Mauritania, irrigation by flooding causes great evaporative losses. Water can be saved by using other irrigation methods (such as "drip irrigation" to directly supply roots by underground pipes). While drip irrigation requires high initial investments, the water savings may justify costs.

When new plant varieties are introduced (whether for local consumption or for cash crops), they should, when possible, require less water than existing crops. As shown in Table 2-2, there are wide seasonal variations for evaporation. This factor should be considered when planning land use and scheduling of crops Fallow periods for irrigated lands should coincide with the months of maximum evaporation. For example, in southern Mauritania, evaporation is highest just before the summer rains (March to May). Water savings will be realized if land is left fallow during this period, while awaiting the humid period.

In the northern zones, such as at Bir Moghrein, minimum evaporation occurs from November to February. Irrigation during this winter period (for crops able to withstand the seasonal temperatures) would permit savings of the precious water reserves of the desert.

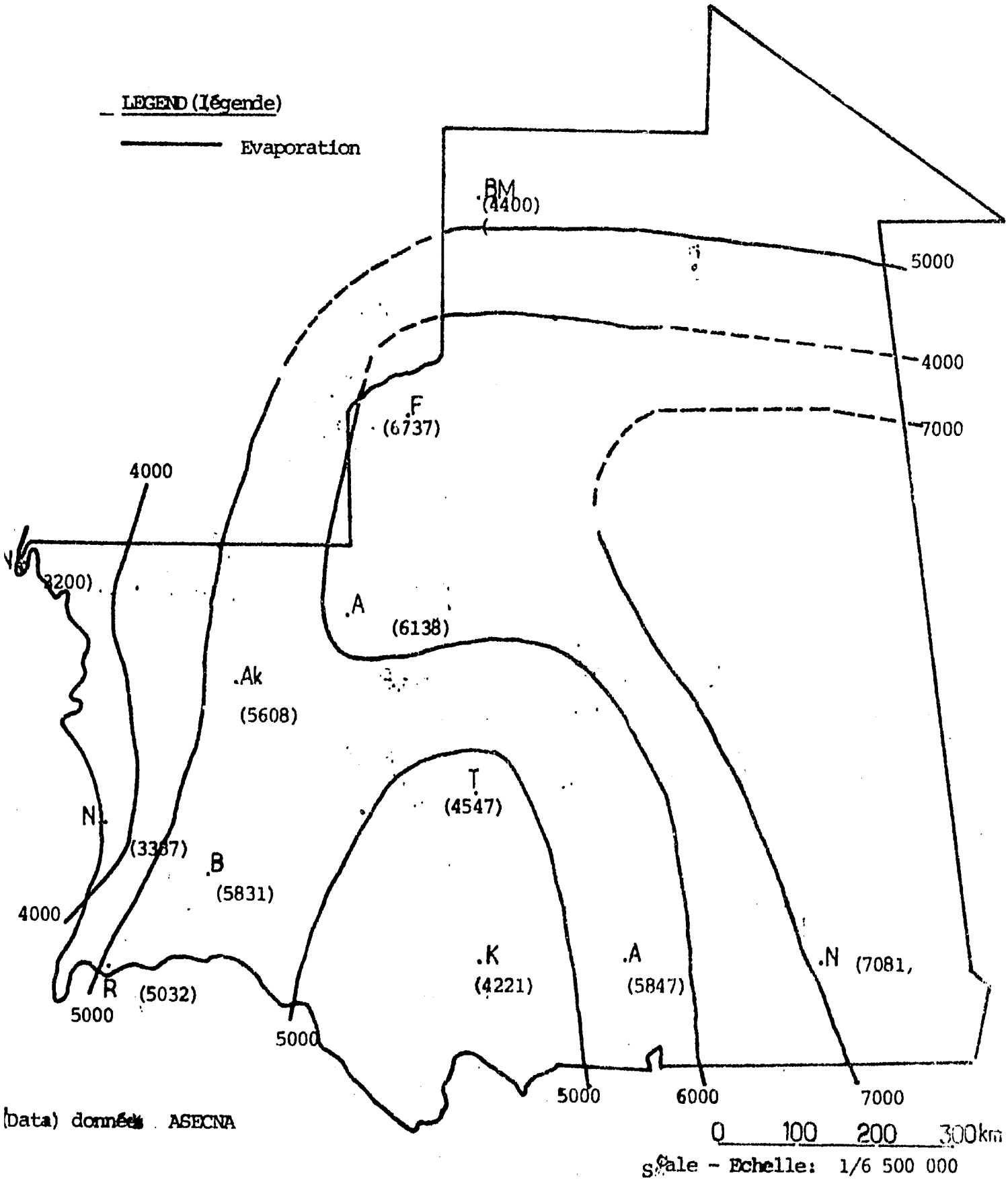
Figures 2-6 and 2-7 show that south central Mauritania has relatively low evaporation losses due to the humid air masses from the south. Therefore, irrigation in this zone will require less investment and give better return than in regions having higher evaporation.

However, evaporation is only one factor in planning rural development. Those populated zones having high evaporation rates must not be neglected, in spite of economic factors, if Mauritania is to halt the rural exodus and the resulting increase of unemployed migrants in urban centers.

Fig. 2-8

MAXIMUM EVAPORATIVE LOSS MAURITANIA

(PERTE MAXIMUM PAR EVAPORATION EN MAURITANIE)



(Data) données ASECNA

Fig. 2-9

MINIMUM EVAPORATION LOS MAURITIANA

(PERTE MINIMUM PAR EVAPORATION EN MAURITANIE

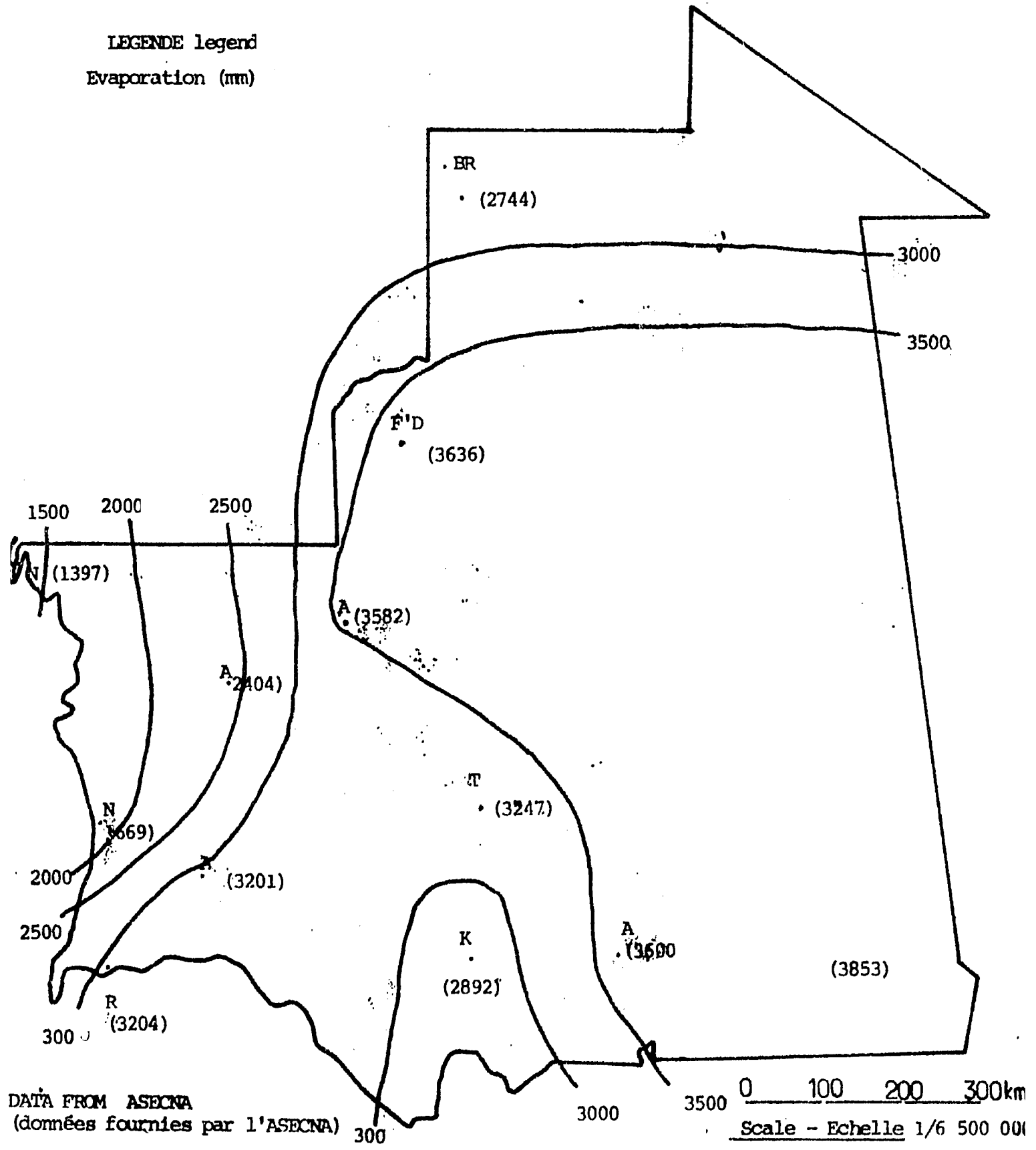
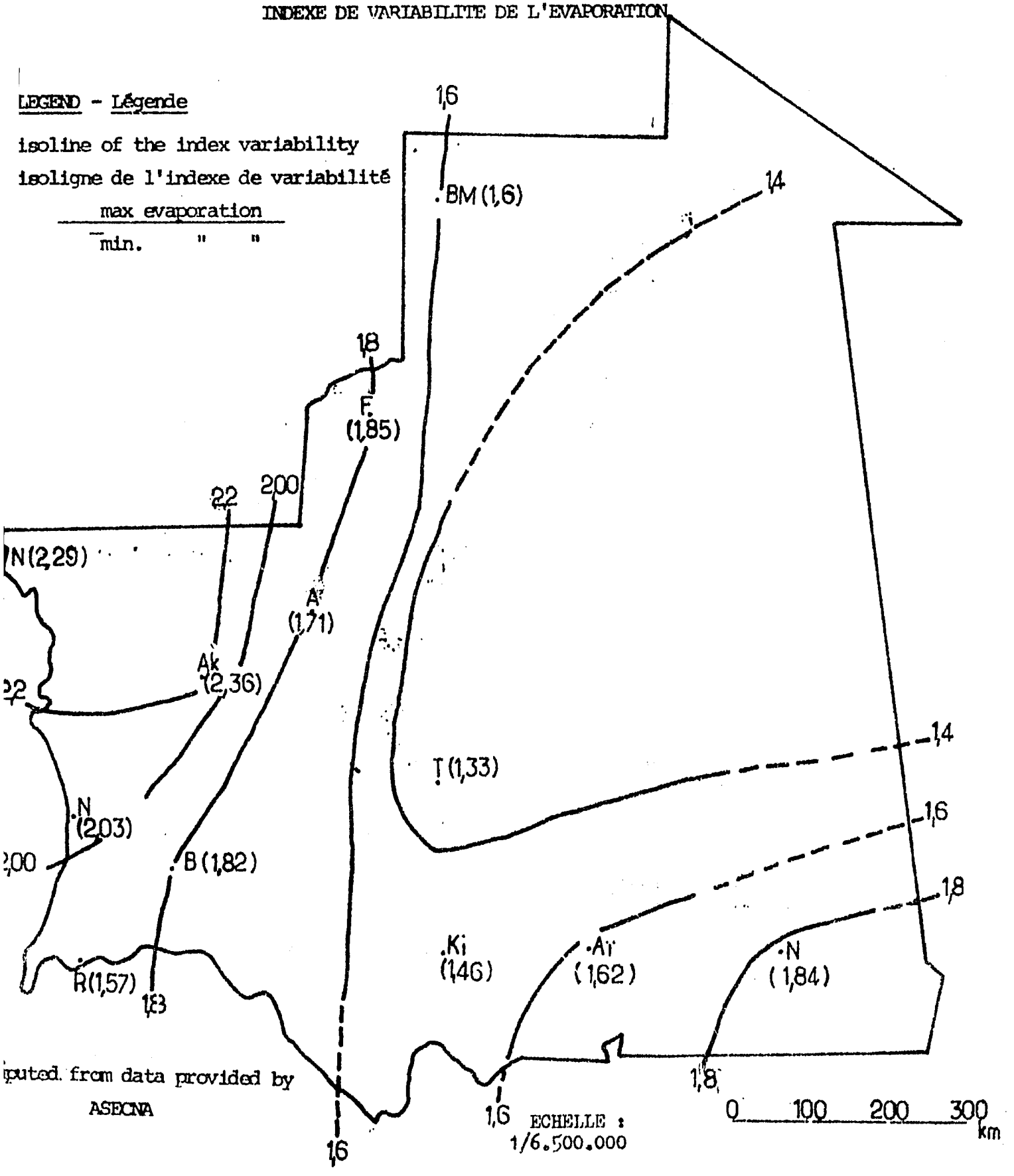


Fig. 2-10

VARIABILITÉ INDEX OF EVAPORATION

MAURITIANA MAURITANIE

INDEXE DE VARIABILITE DE L'EVAPORATION



CHAPTER 3

SURFACE WATER

3. - SURFACE WATER

3.0 - INTRODUCTION

Surface water is a renewable resource resulting from rain-water which has not been lost to evaporation or infiltration into the soil.

Surface water is used for floodland cultivation, and in the form of intermittant water courses (oeuds), it replenishes the aquifers on which Mauritania so largely relies (see Chapter "Underground Water").

It has not been possible to increase the volume of rainfall in Mauritania (artificial rain-making experiments have proved both costly and inefficient[1]); however, it is possible to develop more rational use of the existing surface water.

Whereas most underground water in Mauritania is fossil water (and as such, risks depletion on a more or less long term basis, according to use), rain water surface run-off is renewable. However, the volume of run-off varies considerably from year to year, and even during the same year from dry to humid season.

The Mauritanians have long known how to catch run-off water; the great number of traditional dams indicates that they have seen the necessity of stocking water during the rainy season.[2] At present, modern dams (with much greater reservoir capacity) are being built along the oueds to permit floodland cultivation.[3]

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(1) Robert Garnier (1973), Nouakchott Colloquium on Desertification South of the Sahara, Dec. 17- 19, 1973 - "Artificial Rain, A Remedy for Desertification?"

(2) These traditional dams are earth dikes, several meters high, at times consolidated by sandstone slabs, constructed across a narrow part of a oued.

(3) The traditional dams being very poorly maintained, they are slowly being replaced by modern dams, composed of a compacted earth dike, cement spillway and evacuation works with cofferdam. Both the SONADER and the Génie Rural build these modern dams.

Traditional Mauritanian agriculture is based on the notion of rational storage and use of surface water; planners for rural development can thus be assured that the limited water reserves will be used appropriately.

The term "floodland cultivation" refers to the method of damming a water course and then planting the humid banks as the water is withdrawn. It can also apply to ponds, in which case, the water level decreases through evaporation, progressively freeing the banks for planting.

3.1 - Factors Influencing Flow

The quantity of water flow in a given milieu depends on a certain number of factors :

- volume of rainfall
- frequency and intensity of rainfall
- temperature
- characteristics of soil surface
- slope
- vegetation cover
- distribution of rainfall over time

This large number of variables makes it difficult to evaluate the precise volume of water flow in a given milieu. However, it is possible to obtain an approximate idea of the volume of flow in Mauritania from certain measurements concerning a few catchment basins in the country.

The Geography/Environment Research Group studied flow in the southern third of Mauritania (south of the 18° latitude north), which is the area of greatest agricultural activity.

ERTS satellite teledetection pictures of this zone were used to study water use for cultivation and livestock in areas where rural improvement has the greatest potential.

3.1.1 - Volume of Rainfall

The total volume of rainfall received by a region is one of the major factors determining the quantity of water flow. However, surface water flow is not possible unless rainfall exceeds 200 mm/year. The 200 mm isohyetal line crosses the center of the Tagant massif north of Moudjeria and more or less follows the 18° parallel. To the south of the 200 mm isohyetal line, average rainfall is sufficient to permit use of run-off water. The northern limit for both traditional and modern dams coincides approximately with the 200 mm isohyetal line (see map of main dams in Mauritania). An exception is the Adrar plateau, which extends to the north of the 200 mm isohyetal line. In this northern massif area, flow is favorized by the vast rocky surfaces (mostly sandstone) which permit even relatively small volumes of intense rainfall to concentrate in the oueds (at Atar, average annual rainfall is 100 mm). There are numerous dams in the Adrar plateau.

During a visit to Atar, on August 25, 1979, we noted the effects of a 22 mm rain : the Seguellil oued overflowed, the rising flood cutting off the downstream Nouakchott road. The reservoir dam at Atar was full. Many small oueds which had been dry the day before became torrential streams, carrying sand, gravel and rocks in the direction of the downstream Seguellil oued. Ponds appeared everywhere, in the smallest depressions, strangely transforming the countryside from its dry appearance of the day before.

Most dams in Mauritania are located in the heart of the sandstone massifs or their piedmonts and along the southern side of the Mauritanides range between MBout and Magta Lahjar, in zones where sand dunes do not stop the flow, where the rock is impermeable and where the hydrographic network is relatively dense.

Dams across the oueds for floodland cultivation and watering herds are progressively replaced as one goes south by rainfed cultivation. The southern limit for floodland cultivation is approximately along the 450 mm isohyetal line.

3.1.2- Intensity of Rainfall

Rainfall must be sufficiently intense to permit the formation of distinct linear water courses. An intensity of more than 10 mm/hour usually suffices to provide surface water flow[1]. When rainfall intensity is lower than 10 mm, water is lost by evaporation, and to a lesser degree by direct infiltration (depending on the type of soil).

In Mauritania, most precipitation is caused by convection cells which create storms in the south of the country (See Table 3-1) during the summer months (June to October). During this season, humid air masses from the intertropical front (ITF), called "monsoons", progressively invade the south from the high pressure zones over the south Atltantic (Saint-Hélène anticyclone). The monsoon penetrates the south of Mauritania near the end of May or beginning of June and progressively covers all of the Sahel; in August, finally depleted, it reaches the edge of the Sahara near the 22° parallel (region of F'Derick). F'Derick and Nouadhibou are rarely attained by the ITF.

TABLE 3-1[2]

TOWN	ANNUAL PROPORTION OF STORMY RAINS 1931-1940	LATITUDE
Sélibabi	70 %	15° 14' N
Kiffa	67 %	16° 38' N
Tidjikja	60 %	18° 33' N

(1) Rainwater flow is a function of many variables : slope, nature of soil, temperature, vegetation, rainfall distribution in time, soil humidity, etc. It is therefore difficult to adopt a standard model. According to Charles P. Peguy (Précis de Climatologie, 1961, p. 246), a rainfall of 1 mm/hour is sufficiently intense to provoke flow. J. Dubief (1953) estimates the threshold for formation of run-off in arid zones at 5 mm total rainfall with 1mm/hour intensity.

(2) Charles Toupet, "La Sédentarisation des Nomades en Mauritanie Centrale Sahélienne", p. 58, 1977.

As of September, the ITF is pushed back towards the south by the boreal alizés; it crosses the southern border of the country around mi-October.

Therefore, during 8 months, all of Mauritania is submitted to the boreal alizés and receives only scarce winter rains (with the exception of occasional polar flows which can reach the Adrar in winter (December) and even more southern latitudes such as Kayes (in Mali). However, these flows are much depleted; Kayes registered only 1.4 mm from December to March in 1931-60)[1]

(1) Charles Toupet, "La Sédentarisation des Nomades en Mauritanie Centrale Sahelienne", 1977, p. 58

TABLE 2-4

STATIONS	MAXIMUM EVAPORATION				MINIMUM EVAPORATION				
	YEAR	ANNUAL MAXIMUM RECORDED (mm)	MONTHLY MAXIMUM RECORDED (mm)	MONTHLY MINIMUM RECORDED (mm)	YEAR	ANNUAL MINIMUM RECORDED (mm)	MONTHLY MAXIMUM RECORDED (mm)	MONTHLY MINIMUM RECORDED (mm)	EVAPORATION VARIABILITY INDEX
AIOUN	1953	5847	May/752	Aug/229	1970	3600	May/180	Aug/155	1.62
AKJOUJT	1942	5668	June/764	Jan/220	1953	2404	May/452	not available	2.36
ATAR	1955	6138	May/754	Nov/348	1974	3582	June/409	Feb/240	1.71
BOUTILIMIT	1975	5831	May/900	Sept/233	1942	3201	April/435	Feb/221	1.82
BIR-MOGHREIN	1964	4400	July/613	Dec/105	1965	2744	July/396	Jan/124	1.60
F'DERICK	1951	6737	July/858	Jan/360	1975	3656	July/414	Jan/187	1.85
KIFFA	1974	4221	May/488	Dec/256	1968	2892	May/344	Sept/163	1.46
NEMA	1950	7081	Nov/877	Aug/154	1948	3853	April/527	Sept/195	1.84
NOUAKCHOTT	1945	3387	Jan/438	Aug/179	1953	1669	March/198	Aug/83	2.03
NOUADHIBOU	1952	3200	April/319	Nov/191	1965	1397	Dec/227	June/OCT/86	2.29
ROSSO	1977	5032	May/553	Sept/227	1965	3204	May/455	Sept/132	1.57
TIDJIKJA	1949	4547	June/512	Jan/263	1967	3427	June/411	Dec/192	1.33

Source : Author, RAMS, 1979. (Dabas obtained at ASECNA).

TABLE 3-2

RAINFALL DISTRIBUTION 1931-1960

	J	F	M	A	M	J	J	A	S	O	N	D	YEAR
BIR-MOGHREIN	3,3	3,5	0,8	0,3	0,1	0,7	0,3	3,9	12,4	12,9	7,7	9,9	51,1
F'DERICK	1,2	3,7	2,3	0,7	0,3	0,6	3,2	10,5	14,9	13,0	6,0	1,8	61,2
NOUADHIBOU	1,9	1,3	1,7	1,1	0,2	0,8	0,3	2,6	6,9	7,1	8,0	4,4	36,3
ATAR	2,1	1,4	1,5	0,3	1,3	2,4	5,9	31,9	37,8	7,5	7,5	4,3	103,5
TIDJIKJA	0,4	3,8	1,7	0,0	4,2	8,9	20,5	53,2	35,8	8,8	3,4	1,6	142,3
NOUAKCHOTT	0,9	1,7	0,7	0,5	0,6	1,2	13,4	60,4	39,8	9,4	3,0	6,8	138,4
BOUTILIMIT	0,7	1,2	0,4	0,9	4,2	5,4	44,7	70,3	54,9	14,8	2,8	3,0	203,3
AIOUN	0,3	2,0	4,0	0,2	1,0	14,8	99,0	106,5	52,4	4,5	1,5	1,6	288,0
KIFFA	0,6	0,9	0,8	0,9	3,7	24,6	91,3	121,1	85,9	16,6	2,4	2,0	350,7
NEMA	1,1	0,3	0,2	1,7	11,2	35,5	69,0	116,7	62,3	13,7	1,0	2,3	315,0
ROSSO	0,6	1,2	0,0	0,9	1,5	8,0	43,0	135,6	81,3	31,9	1,9	4,1	310,0
KAEDI	0,4	1,5	0,2	2,3	3,1	29,1	86,9	165,9	94,7	20,0	0,4	1,5	409,9
SELIBABY	0,0	0,3	0,1	1,7	13,6	71,2	142,1	226,3	154,6	35,3	2,3	1,5	649,0

Source : Charles Toupet, 1977. "Sedentarisation des Nomades en Mauritanie Centrale Sahélienne".

TABLE 3-3

RAINFALL IN mm	ANNUAL FREQUENCY NUMBER RAINS/YEAR OR/NUMBER OF YEARS	TOTAL NUMBER OF PRECIPITATIONS (Total : 510)
10-20	10,2	235
20-30	5,6	129
30-40	2,6	61
40-50	1,8	42
50-60	0,8 (or 1/1,2 year)	19
60-70	0,4 (or 1/2,5 years)	9
70-80	0,26 (or 1/4 years)	6
80 -90	0,13 (or 1/7.6 years)	3
90-100	0,09 (or 1/11,1 years)	2
100-110	0,09 (or 1/11,1 years)	2
110-120	0,04 (or 1/25 year)	1
180-190	0,04 (or 1/25 years)	1

Sources : "Hydrologie du Cercle du Guidimaka".
Ministère de l'EXpansion et du Plan
BURGEAP R. 244, December 1958.

TABLE 3-4

PRECIPITATION CHARACTERISTICS

Station	Average mm	Number of rains days (Average)	Maximum (mm)	Minimum (mm)	Percentage of rainfalls exceding 10 mm: %20 mm	% 50 mm	% intensity	% 50 mm/h	Hauteur max. en 24h(mm)
AIOUN	300	31	499	168	60	8	9	67,5	5/1953
AKJOUJT	105	14	221	13	50	8	14	90	9/1944
ALEG	205	20	439	122	65	8	11	78	9/1954
ATAR	104	13	247	14	45	7	19	93,7	9/1955
BOGHE	319	20	587	176	70	4	6	94	8/1927
BOUTILIMIT	188	19	406	69	50	9	14	93	8/1943
D'DER ICK	56	12	187	1	25	0	22	43,5	11/1942
KAEDI	412	27	762	193	70	5	5	162	9/1960
KIFFA	353	28	620	142	70	4	3	98	9/1952
M'BOUT	430	20	611	226	70	3	6	132	9/1956
MEDERDRA	255	22	414	102	60	5	9	114	8/1943
MOUDJERIA	214	18	405	56	65	15	25	93,2	9/1931
NEMA	312	31	506	161	65	4	4	125	8/1957
NOUAKCHOTT	130	16	267	3	45	10	12	76,4	8/1945
NOUADHIBOU	31	7	102	1	25	8	4	78,1	10/1938
ROSSO	320	28	468	106	65	5	8	100	8/1947
SELIBABY	635	38	1100	350	75	4	3	207	8/1965
TAMCHAKETT	250	20	513	95	70	11	12	(150)	8/1943
TICHITT	84	10	167	11	50	10	13	51	8/1966
TIDJIKJA	150	18	421	30	65	14	19	80	9/1956
TIMBEDRA	320	26	520	151	65	9	9	88	8/1936
OUALATA	102	12	(216)	(69)	50	10	(14)	50,8	8/1965
BIR MOGHREIN	35	7	109	10	50	-	18	45,5	12/1957
CHINGUETTI	[illegible]	9	153	6	35	8	[illegible]	57,5	10/1957
KANKOSSA	436	28	583	237	65	4	5	(142)	

Source : "Carte de Reconnaissance Hydrogéologique de la Mauritanie : Notice explicative", Bureau Hyrogéologique, Ministère de l'Equipement, Service des eaux souterraines, January 1968.

Remarks : This table covers a period which has preceded the drought which began in 1968. These values may have slightly changed but the percentages and ratios have probably not much varied. Most station have been observed over a period of more than 30 years, except Aïoun (22 years), Kankossa (15 years), Bir Moghrein (17 years), F'Dérick (29 years), Oualata (13 years) ant Tichitt (25 years).

All Mauritanian recording stations show maximum rainfall in the heart of the summer, generally in August. Table 3-2, "Distribution of Rainfall, 1931-1960", shows the weakness of winter rains and the delay in rains towards the north, due to the ITF.

As concerns flow, the south of the country is favored by longer and larger summer rains than the north. In addition, the proportion of stormy showers increases from the north to the south.

Frequency measurements were conducted at Sélibabi for rainfall greater than 10 mm (see Table 3-3). Over a period of 23 years, 510 rains greater than 10 mm were recorded; they represent 60 % of the total number of precipitations (851). This percentage is usually only attained with rainfall created by stormy convection cells. These storms become more frequent from the north to the south of the country (see Table 3-1) and attain 70% at Sélibabi.

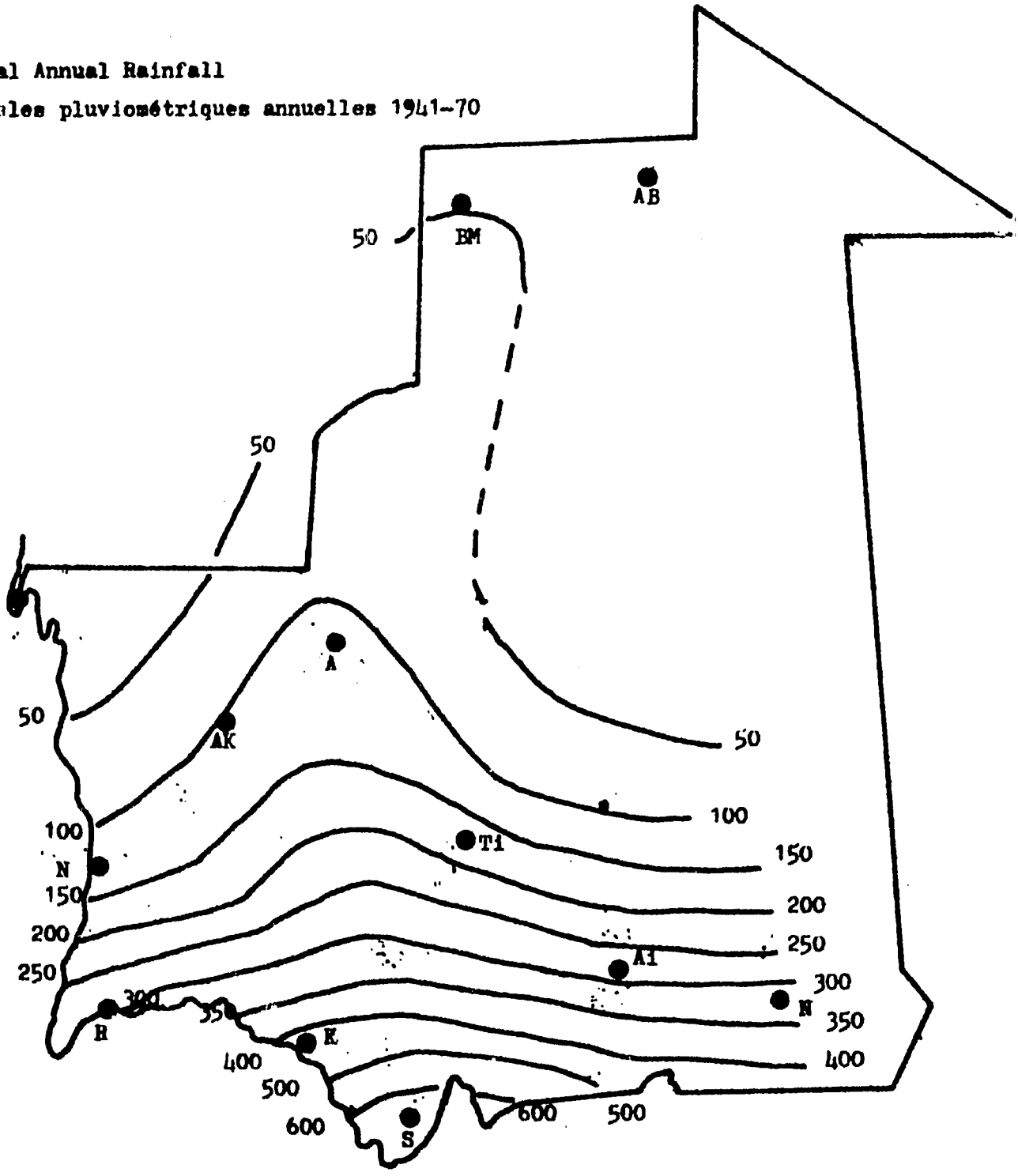
Measurements conducted at other Mauritanian stations show interesting proportions for rainfall of intensity greater than 50 mm/hour (which is very high), as well as proportion of rainfall volumes greater than 20 mm (see Table 3-4, "Rainfall Characteristics") This table shows that the proportion of intense storms (greater than 50 mm/hour) increases with the latitude; at the same time, the proportion of average number of days of rain decreases towards the north. These rains are of increased intensity, but fall over shorter periods in the north. Thus while annual rainfall volume is weak in the north, this is compensated for by rainfall intensity, which is favorable to flow (however, increased rainfall intensity may also have very unfavorable consequences due to water erosion).

In the extreme north and northwest of the country, average annual rainfall volumes are too slight to provoke enough flow to permit agricultural damming (F'Derick : 56 mm, Bir Moghrein : 35 mm, Nouadhibou : 31 mm), due to high evaporation losses (most of these rains fall during the hottest months)

FIG. 3.1

Normal Annual Rainfall

Normales pluviométriques annuelles 1941-70

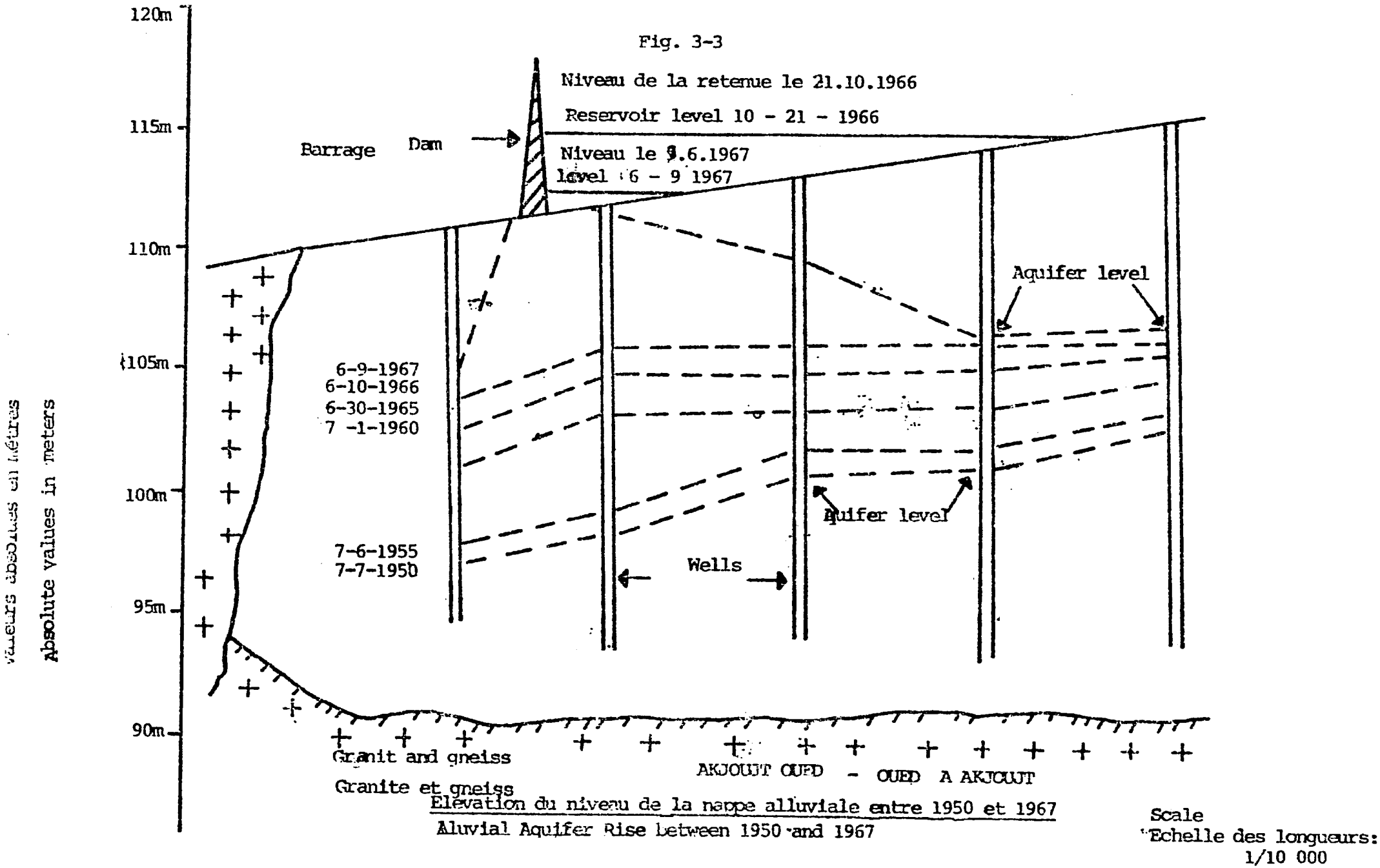


Source: PNUD/OMM/AGRHYMET

Scale

Echelle: 1/7 500 000

Fig. 3-3



Elévation du niveau de la nappe alluviale entre 1950 et 1967

Aluvial Aquifer Rise between 1950 and 1967

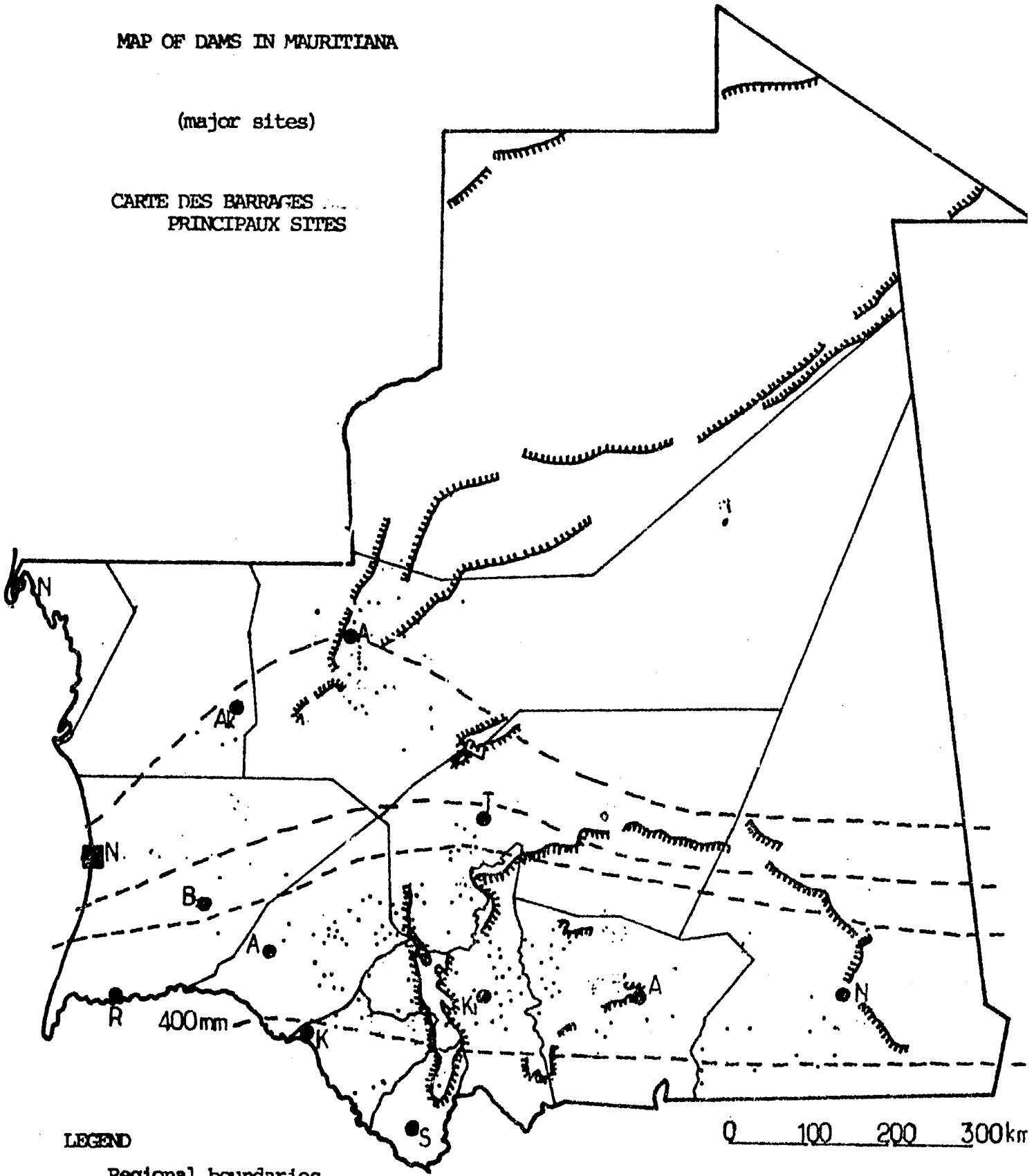
SOURCE: CARTE DE RECONNAISSANCE HYDROGEOLOGIQUE DE LA MAURITANIE 1968.

Fig. 3-2

MAP OF DAMS IN MAURITIANA

(major sites)

CARTE DES BARRAGES ...
PRINCIPAUX SITES



LEGEND

Regional boundaries

National capital

Towns

Isohyetal lines

Escarpements

Dams

Source: SONADER - Feb 1970

Scale - Echelle $\frac{1}{6\ 500\ 000}$

TABLE 3-5

FREQUENCY OF DAHY RAINFALL (1953-1962) (1)

TOWN		NUMBER OF DAYS WHEN HEIGHT MEASURED IN 24 HOURS WAS : 0.1 to 0.9 mm	1 to 4.9 mm	5 to 9.9 mm	10 to 19.9 mm	20 to 49.9 mm	50 to 99.9 mm	100 mm or more	Total Observations
ATAR	N	56	72	29	23	7	3	-	190
	%	30	38	15	12	3.5	1.5		
TIDJIKJA	N	136	125	66	44	19	1	-	391
	%	35	32	17	11	5			
KIFFA	N	180	175	111	95	48	9	1	619
	%	29.5	28.5	18	15	8	1		
SELIBABY	N	185	206	165	164	113	13	1	847
	%	22	24	20	20	13	1		

TABLE 3-6

AVERAGE MONTHLY EVAPORATION - NIGHT AND DAY (1951-1960)

MONTH	JAN		FEB		MAR		APR		MAY		JUNE	
Hours	N	D	N	D	N	D	N	D	N	D	N	D
ATAR	4.2	6.6	4.7	7.4	5.1	8.3	6.5	9.5	8.0	11.7	9.1	11.
KIFFA	4.0	6.4	4.6	7.2	5.0	7.0	5.4	9.4	6.0	9.5	5.2	7
	JULY		AUG		SEPT		OCT		NOV		DEC	
	N	D	N	D	N	D	N	D	N	D	N	D
ATAR	8,7	11.5	7.1	9.4	6.7	10.4	5.8	9.0	5.2	7.2	4.0	6.
KIFFA	3.9	5.3	2.2	3.6	2.0	3.8	3.2	6.0	3.8	6.4	3.6	5.

N : NIGHT (18 h to 08 h) D : Day (08 h to 18 h)

(1) Source : Charles Toupet (1977) - "Sédentarisation des Nomades en Mauritanie Centrale Sahélienne".

While very intense rains (greater than 50 mm/hour) increase towards the north, the frequency of large volumes of rainfall increases towards the south (See Table 3-5).

For the purposes of planning, it would appear that Mauritania experiences sufficiently intense rainfall to provoke adequate flows for agricultural damming (except in the northern regions such as Nouadhibou, F'derick, Bir Moghrein, as explained above). Table 3-4 shows that for most recording stations in Mauritania, more than 60% of precipitations are greater than 20 mm, with the exception of the western coastal region from Nouakchott to Nouadhibou and the northern regions. However, adequate flow does not always occur, due to :

- the irregularity of rainfall (which increases towards the north). This is a serious handicap; one can never know from year to year, even in the south of the country, whether rainfall will be normal,a situation which has worsened since the drought began in 1968.
- the fact that flow is only possible below the 200 mm isohyetal line (with the exception of the impermeable sandstone massifs). Above this line, the intensity of rainfall does not compensate for losses due to evaporation and infiltration.

Thus, those areas where rain water runoff can be used for agricultural damming are more limited than the favorable rainfall statistics seem to indicate.

3.1.3 Temperatures

Temperatures influence the volume of flow. In Mauritania, most rain falls in the summer months, when daily and monthly temperatures are highest, causing considerable evaporation.

Table 3-6 illustrates average monthly evaporation, during the night and during the day, for the Atar and Kiffa stations (1951-1960). Night rains are more advantageous than day rains, as evaporation loss is about one third less (on the basis of statistics from Atar and Kiffa).

In Mauritania, more rain falls at night than during the day, due to the majority of convective storms which occur during the end of the day or at nightfall (the meteorological night begins at 18 hours).

Table 3-7 below shows the difference between night and day rainfall. It concerns only the month of August (1951-60), which is the month receiving, on an average, the greatest volume of rainfall.

TABLE 3-7

PERCENTAGE OF RAINFALL QUANTITIES BY DAY AND BY NIGHT - MONTH OF AUGUST (1951-1960)

TOWNS	DAY (08 to 18 hrs.)	NIGHT (18 to 08 hrs.)
Atar	34 %	66 %
Tidjikja	47.5 %	52.5 %
Kiffa	44 %	56 %
Selibabi	28 %	72 %

The higher nightime rainfall is advantageous for the conservation of superficial water resources, as it is not subjected to the considerable evaporation characterized by the hot, sunny daytime, particularly in the summer.

3.1.4 Characteristics of Ground Surface

When rain falls on a relatively impermeable surface, such as the rock outcrops in the massifs (usually sandstone, schist or granite), flow is considerable due to the absence of infiltration. When the surface is permeable (such as sandy material), rainfall is rapidly absorbed and runoff is limited.

However, in certain cases, rainfall will provoke runoff when the sand contains a high proportion of clayey materials, or when rainfall intensity is such that the sand cannot rapidly absorb the volume of water received. On steep dunes, the erosion gullies demonstrate that superficial runoff does occur even on sand.

Thick sand dunes are characterized by the absence of hydrographic networks (with the exception of occasional ancient networks, dating from a much wetter period). A large part of Mauritania is covered by wind-borne sand; about 40 % of the country's surface area to the south of the 18° latitude north is almost entirely covered by sand formations. Runoff is very slight in this zone, due to the nature of the surface. Most agricultural dams are found in the areas of impermeable massifs and rocky surfaces more favorable to runoff.

Since the drought began, sand dunes have begun to invade the oueds, perturbing hydrographic networks. The Khatt oued to the northwest of Tidjikja, for example, was recently invaded by sand which totally blocked water flow.

3.1.5 Slope

Slope is an important factor in rain water runoff. The incline may facilitate or oppose infiltration, and consequently, increase or decrease flow. The steeper the slope, the greater the quantity of runoff (and the greater the runoff coefficient).

The possibility of a sudden rise in water level after a heavy rain, or flood, is a factor to be considered when designing and building dams. Certain existing dams (both traditional and modern) cannot resist exceptional floods; flow intensity must be studied in order to design appropriate structures.

For the most part, steep slopes are found only in the highlands : the sandstone massifs of Adrar, Tagant, Assaba, Affolé and the isolated reliefs (" nselbergs"). The summits of most of these sandstone massifs are formed of vast plateaus with very gentle slopes; steep inclines are found only on the sides of the massifs and along valleys (example : Tamourt an Naaj in the Tagant massif).

3.1.6 Vegetable Cover

Vegetable cover slows rain water flow, especially when dense (i.e., herbaceous cover). In addition, vegetable cover permits better infiltration of rain water and protects the soil against water erosion.

However, in Mauritania, at the beginning of the rainy season, the first rains fall on dry ground, where grasses have not yet begun to grow. Therefore, flow is not halted (on the other hand, water erosion is a problem).

In the Sahara and the Sahel, grasses are usually widely spaced and do not afford a high degree of coverage. In addition, they survive for only a short period after development, due to grazing and bush fires. Tree and shrub coverage is usually too sparse to affect runoff.

3.1.7 Distribution of Rainfall Over Time

Runoff varies according to the spacing of rainfall over time. When a heavy rain saturates the ground and is rapidly followed by another rainfall, runoff is increased. However, when there is a long interval between storms, evaporation dries the surface, and the second rain tends to infiltrate, especially in the case of very permeable materials, thus greatly reducing the quantity of runoff.

In Mauritania, the extreme irregularity of rainfall makes it impossible to predict the spacing of rains. In terms of agriculture, this problem affects mainly rainfed cultivation. It is less important for floodland cultivation, if rainfall volume is sufficient to fill reservoirs or depressions during the cultivation season (and before the colder months make sorghum growth impossible).

3.2 MEASUREMENT OF FLOW

There exist some measurements of rain water flow in Mauritanian catchment basins. Table 3-8 (Characteristics of Several Mauritanian Catchment Basins) shows the different measurements conducted in the southern part of the Arc of the Mauritanides, in the Tagant and in the Affolé. The values for runoff coefficients shown in this table, clearly depend on the lithological nature of the

TABLE 3-8

HYDROLOGICAL CHARACTERISTICS OF SEVERAL MAURITANIAN CATCHMENT BASINS

Catchment Basin	Surface Area km2	Period of Study	Co-ordinates Lat.	Co-ordinates Long.	Location	Characteristics of ground surface	Average annual fall(mm)	Run-off coefficient %	Max.Flow year(m3/s)
Dionaba	116	1957-59	17°06	12°40	East of Aleg	Rags and dunes	300	8,5	14
Djajibine	143	1964-65	15°50	12°30	South M'Bout Mauritanides	Rocks and rags	470	30	?
Echkata	149	1964-65	15°55	12°12	Guidimaka, S. Mauritanides	Sand covered rocks.Steep.Slope	450	8	?
Oued Ghorfa at Ghorfa Aval	5020	1964-66	15°30	13°20	Region of Gorgol Senegal river	Glacis + Sand Gentle slope	527	12,2	10,2
Oued Ghorfa at Oulombone	2500	1964-66	15°40	12°20	South Mauritanides	Glacis + Sand Dense vegetation Gentle Slope	524	8	0,71
Oued Niorde at Harr	1550	1965	15°15	12°35	N.W.Selibaby, Mauritanides	Glacis + Sand Dense vegetation average slope	688	9,3	3,14
Oued Tourime at Tourime	484	1965	15°20	12°07	Guidimaka Mauritanides	Glacis + Sand Dense vegetation Steep Slope	759	12,6	1,47
Oued Haousse at Tassota	214	1965	15°[illegible]	12°08	Region Selibaby Mauritanides	Idem	611	15,5	0,64
Oued Moktar	12,6	19[illegible]7-60	17°50	12[illegible]	Nagant	Debris-covered Sandstone average	250	10,5	18
Oued Ali Lehbile	11,3 143	1957-60 1960	17°50 16°45	1[illegible] 16[illegible]	Nagant Afrolé	Rocks and rags Rocks and rags average slope	250 320	10 9	16 ?

surface and the slope of the catchment basin; the more impermeable the surface and steep the slope, the higher the runoff coefficient. However, even heavy rains may not provoke runoff due to infiltration in permeable soils and gentle inclines (often associated with permeable soils).

The runoff coefficient is quite variable from area to area in Mauritania. No standard model can be adopted until numerous and detailed studies of catchment basin flow have been conducted in Mauritania. When planning hydro-agricultural improvements, basic knowlegde of hydrological regimens will help avoid difficulties.

Part of the runoff replenishes the shallow alluvial aquifers by infiltration (see Chapter 4 : Underground Water); part is lost through evaporation. Some of the oueds feed into larger oueds which in turn flow into the Senegal River : Kolimbiné, Karakoro, Garfa and Gorgol oeuds. This exoreic zone occupies less than 10% of the country, and is part of the Senegal River catchment basin.

Evaporation on free water surfaces attains at least 10 mm/day on a yearly average, which causes major water loss from the reservoirs! In addition, according to a 1968 study by the Underground Water Services[2], very shallow aquifers are affected by evaporation : all water reserves located less than 3 meters below ground are lost to evaporation!

Agricultural dams serve not only for floodland cultivation, but also contribute to the replenishement of alluvial aquifers, as still water infiltrates much more readily than moving water (see below, the example of Akjoujt dam).

The drought years have also caused a major decrease in runoff which formerly replenished the shallow aquifers, resulting in a reduction of water reserves.

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(1) Charles Toupet; La Mauritanie, P. J. F., 1977.

(2) Carte de Reconnaissance Hydrogéologique, Notice Explicative, p. 15, IRM - Ministère de l'Equipement, 1968.

The use of underground water, particularly by motor pumps and modern wells, must be permanently supervized during drought years, in order to avoid surpassing the recharge capacity of the aquifers, which would have catastrophic results for men and animals (See Chapter 4 : Underground Water).

The examination of drought cycles and dry years must be an integral part of development planning for oued valleys, oases and other areas directly dependent on shallow aquifers, which are very sensitive to climate variations.

Rain water runoff volume is large only in those regions having massive rock surfaces or very clayey surface soils. On sandy surfaces, direct infiltration greatly reduces runoff. However, when rains fall in sufficient quantity, direct infiltration does allow the replenishment of aquifers (such as those located in the sand dune region). According to Archambault (1960), more than 400 mm of annual rainfall are necessary to fill an aquifer; this direct replenishment is limited to the extreme southern portion of Mauritania.

As mentioned above, it is interesting to note that in Mauritania, the distribution of dams coincides with the regions of rock outcrops(1). The dams extend above the 400 mm isohyetal line up to the Adrar region, which receives only 100 mm of rainfall annually.(2) Due to several factors (intense rains, surface impermeability, steep slopes), it is possible to replenish aquifers in this zone; the existence of reservoirs reinforces replenishment.

A few remarks on the characteristics of alluvial aquifers and the possibility of improving replenishment by dam construction : most alluvial materials are both permeable and porous; water filters easily into the alluvium; storage capacity is large. These alluvial materials favorize the formation of aquifers capable of water storage during drought years, when the aquifer is deep enough to withstand evaporation (more than 3 meters below ground, otherwise, water is lost to evaporation).

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(1) See map of dams in Mauritania, based on a Feb. 1979 SONADER document

(2) In these areas, cultivation can extend beyond the 400 mm 450 mm isolyetal line, which is the northern limit for rainfed (dryland) agriculture (diéri).

Observations at the Akjoujt dam clearly demonstrate that aquifer replenishment is favorized by reservoirs. In 1950, a dam was built across the Akjoujt oued (Dam G13)[1]. During the 17 years which followed, the level of the aquifer behind the dam was measured (see Figure 3-3)[2]. The results were encouraging : the aquifer level behind the dam was raised, particularly near the structure itself, where water remains the longest. This is an example of the important role of collinear dams in the replenishment of alluvial aquifers.

3.3 CHARACTERISTICS OF LAND SURFACES IN SOUTHERN MAURITANIA (South of 18° latitude N)

A map based on ERTZ (NASA) satellite pictures[3] shows the large surface areas covered by sand south of the 18° latitude north. Even though sand does not cover some areas 100 %, it is massively present everywhere. To the north of the 18° latitude, 100% sand coverage is the rule. In the south central area and along the southern edge of the Dhar Néma, rocky surfaces dominante (75%); the rest is sand. Elsewhere, sand and rock are present is equal proportions, with the exception of the Dhar Oualata (sand 75%, rock 25%).

As far as rain water runoff is concerned, the southern center with its average proportion of 75% rock and 25% sand, appears a favored region. This has already been discussed in the paragrap concerning the extension of agricultural dams.

Surfaces covered 100% by sand formations can only be employed for pastoralism (except for those zones where rainfed cultivation is practiced: diëri along the Senegal River valley). The sandy zones furnish good grass grazing lands during the rainy season; however, most rainfall infiltrates in these sandy soils, with resulting absence of surface runoff.

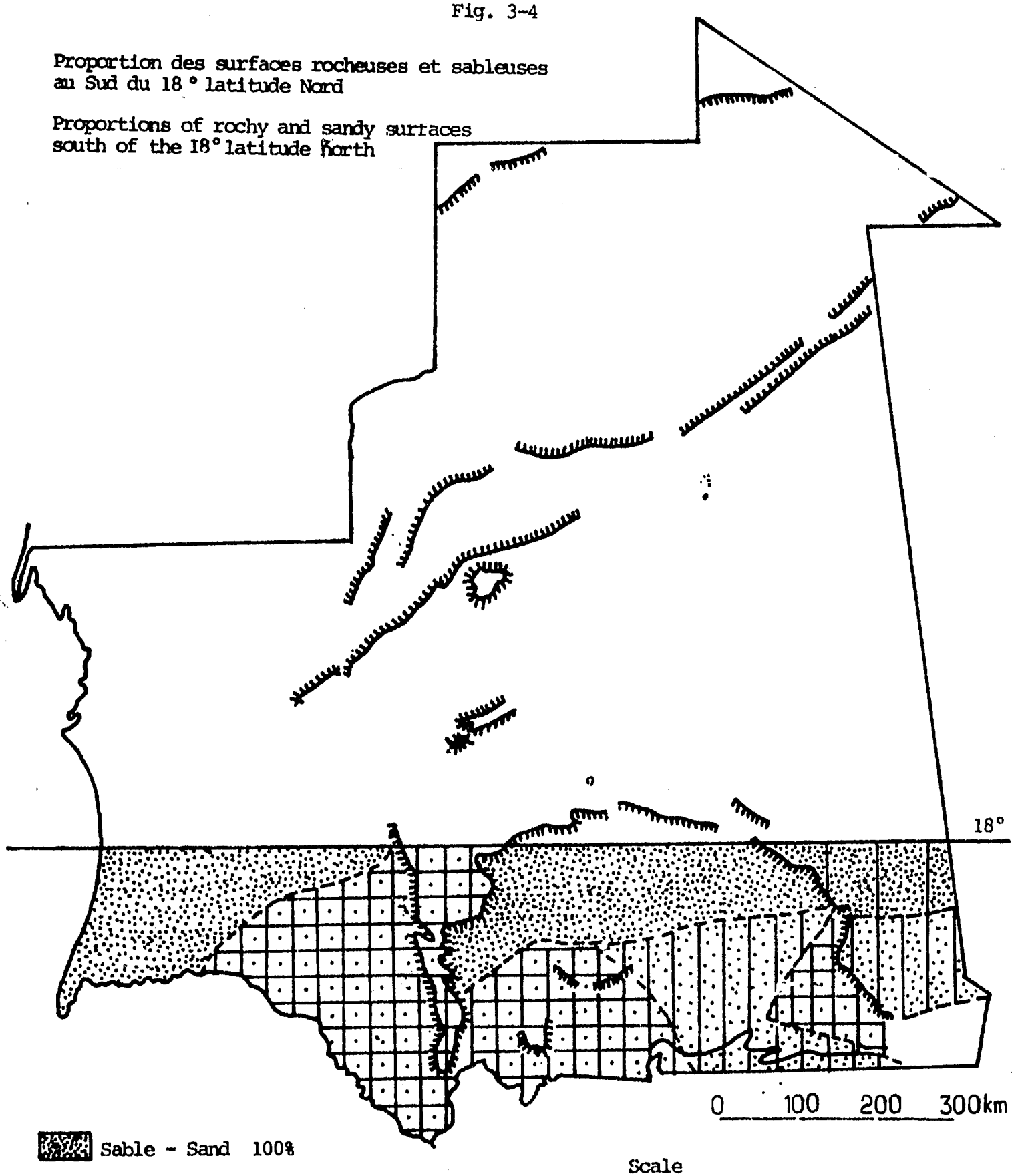
(1) and (2) : Carte de Reconnaissance Hydrogéologique de la Mauritanie, Notice Explicative, Bureau Hydrogéologique, Ministère de l'Equipement, Service des Eaux souterraines, 1968.

(3) Drawn by the author

Fig. 3-4

Proportion des surfaces rocheuses et sableuses au Sud du 18° latitude Nord

Proportions of rochy and sandy surfaces south of the 18° latitude North



Sable - Sand 100%

Roche - Rock 75% Sable - Sand 25%

Roche - Rock 50% Sable - Sand 50%

Roche - Rock 25% Sable - Sand 50%

Limite agriculture sous pluie
Limit for Rainfed cultivations

Scale
Echelle: 1/6 500 000

map established by author 1980.

Analysis of Figure 3-4

NATURE OF SOILS

SOUTH OF 18° LATITUDE NORTH

(based on NASA - ERTS Satellite pictures)

Nature of soils	Approximate Surface area %	Major Zones Concerned
100% covered by sand. Gentle slope or flat terrain, except between dunes.	35.6	North of Western and Eastern Hodhs, Aouker, Trarza, Brakna
75% covered by sand. 25% rocky, gentle slope.	6.2	Northeast of Dhar Oualata
50% rocky; 50% sandy. Gentle to average slope.	18.5	South of eastern Hodh; East of Dhar Néma.
75% rock outcrops; 25% sand cover. Average to steep slopes, particularly along escarpments.	39.7	Catchment basin of Gorgol Wa-Wa, Guidimaka, Assaba, Tagant, Affolé. Western border of the cuesta of Dhar Néma (escarpments.)
TOTAL	100 %	

3.4 CONCLUSIONS

The large surface areas covered by sand in Mauritania, added to the weak and irregular rainfall, constitute a grave obstacle for rain water runoff and the creation of water reserves.

Only the rocky highlands and stoney or clayey southwestern rags (south of Brakna, Gorgol, Guidimaka) are favorable to runoff, as only 25% of their surface areas are covered by sand.

However, sandy soils (with the exception of shifting dunes) support good grazing grasses in the rainy season (see Chapter on Major Vegetation Groups and Grazing Lands).

The drought experienced by Mauritania since 1968 has resulted in sparce vegetable cover, which cannot efficiently anchor the soil. Sands have become increasingly mobile, whether as shifting dunes or as sand covers invading the oued valleys, perturbing water flow. Rapid measures must be taken to halt these disastrous sand movements. One of the best remedies to counter the progression of sands is the protection afforded by vegetable cover, which anchors the soil. Over-grazing must be avoided to protect the vegetation; in zones showing signs of degradation, grazing must be forbidden.

For urgent cases of rapidly advancing shifting dunes, a vegetable barrier of Euphorbia balsamifera may be efficient.

The possibilities for regeneration of the environment in Mauritania will be examined in much greater detail in another report.

CHAPTER 4

UNDERGROUND WATER

4. UNDERGROUND WATER

4.0 Introduction

Because of the poor rainfall experienced by Mauritania, underground water is of special importance as a potential resource for the alleviation of water shortages caused by the drought. Unfortunately, the hydrological and geographic conditions in Mauritania do not favor the accumulation of underground water and the replenishment of existing aquifers. There are no high mountains to capture rainfall and permit runoff. Over most of the country, altitudes are less than 500 meters; the rare exceptions are all less than 1000 meters high (the hill near F'Derick, Kediet-ej-Jill = 915 m, and certain summits in the Adrar massif, the highest of which attains 830 m). In addition, Mauritania is located in the heart of the subtropical zone which dominates the latitudes around the Tropic of Cancer. No regions located along these latitudes, throughout the world, experience abundant rainfall.

An examination of the various studies conducted in Mauritania reveals a complete lack of data on the recharge capacity of aquifers. There exists no information concerning the rate at which use exceeds recharge capacity; there is no way to determine how much water may be drawn before risking aquifer depletion. It is probable that present climate conditions do not permit sufficient aquifer recharge. With the exception of the shallow oeud aquifers, most Mauritanian aquifers are of fossil origin, dating from much wetter periods. Unfortunately, no dating of Mauritanian underground water resources has been undertaken to this time. These fossil aquifers are a vital non-renewable resource, and given the present climate, they must be employed with caution.

South of the 400 mm isohyetal line (see map), most specialists agree that rainfall is sufficient to largely contribute to aquifer replenishment. However, the great majority of the country (about 9/10ths) extends above the 400 mm isohyetal line.

LEGENDE - LEGEND

I Bassin sédimentaire côtier
Coastal sedimentary basin

Ia nappes à eau douce
Fresh water aguifers

Ib nappes à eau salée
Salt water aguifers

II Pêches cristallines
Cyristalline rock

IIa arc des Mauritanides
Arc of Mauritanides

IIb Dorsale Regueïbat (granites)
Regueïbat Dorsal (granites)

III Bassin de Taoudéni
Taoudéni basin

IIIa Quartzites dalomites
Quartzite, dolomite

IIIb grés fins à grossiers
Fine to coarse sandstones

IV Bassin de Tindouf
Tindouf basin

Limite de biseau sec
Edge of dry Nedge

Limite d'unité géologique
Limits of geoligical unit

Limite sous-unité de bassin
Limits of basin sub-unit

Limite front salé
Limit salt water front

Adduction d'eau
Water conduits

Pluviométrie 200 et 400 mm
200 and 400 mm rainfall

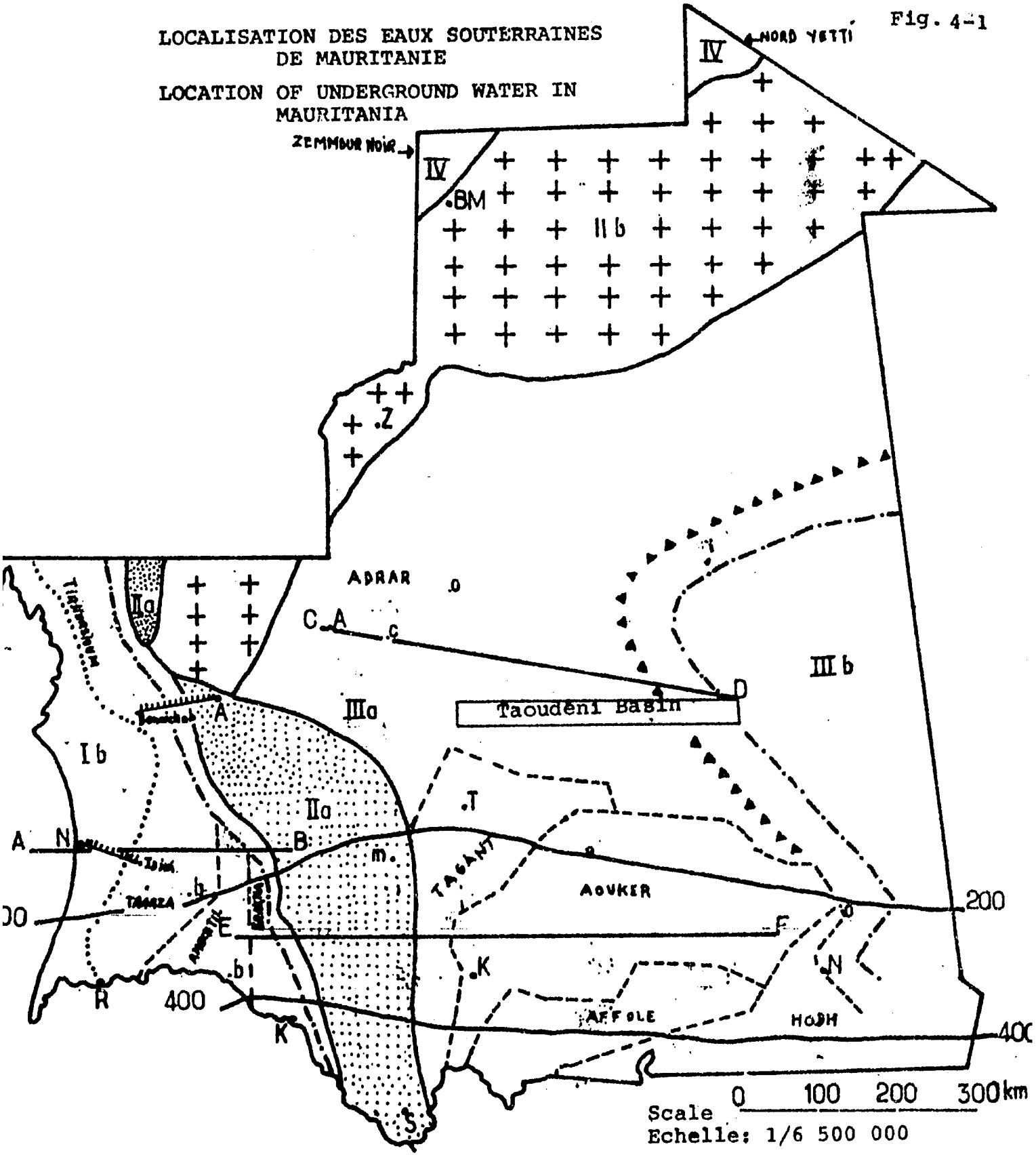
Limite hypathétique du continental terminal
hypathetical limit of continental terminal

Géological cross-section A——B

Fig. 4-1

LOCALISATION DES EAUX SOUTERRAINES DE MAURITANIE

LOCATION OF UNDERGROUND WATER IN MAURITANIA



The lack of information concerning the lifetime of the aquifers as a function of use is a serious problem; one of the government's main priorities should be to estimate the volume of water contained in the main aquifers and the exploitation rate they can sustain:

- for urban consumption (the population of Nouakchott has been "swelling" annually since the drought began).
- for industry
- for irrigation (except in the Senegal River basin)

This Chapter will attempt to define the different types of underground water resources, according to their locations and formations. A general survey, this review will not evaluate each local situation. The most complete inventory of underground water resources in Mauritania thus far conducted was published by the United Nations in 1975[1].

4.1 Major Zones Where Aquifers are Found

The major zones where aquifers are found correspond to three major structural zones of the country : (see map)

- the Taoudeni sedimentary basin
- the Senegal-Mauritanian sedimentary basin (currently most used for industrial and urban water supplies)
- the Mauranitanides platform and mountain range (cristalline rocks)

In addition to these three major structural formations, both the superficial wind-borne sands (very largely represented in Mauritania) and the oued alluvial materials may harbor shallow aquifers, most of which can be exploited during the rainy season, and a few of which can be used during the dry season. The Tindouf Basin , which extends only slightly into Mauritania, will also be briefly discussed.

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(1) Renforcement du Service des Eaux Souterraines : Conclusions et recommandations du Projet, DP/UN/MAU-67-502-2 (New York : Nations Unies, 1975).

4.1.1 The Taoudeni Basin

This sedimentary basin covers about two-thirds of the country. It is limited on the west and the north by the Mauritanides platform and mountain range and by the Regeuibat Dorsal, against which lean the sandstone massifs of Assaba, Tagant and Adrar. It is part of a large sedimentary basin extending over about 2000 km, from Algeria in the north to Nigeria in the east.

In the west of the Taoudeni Basin (see Map 4-1, Zone 111a and cross-section C-D), the rock is relatively dense (quartzite sandstone, sandstone and dolomites); these rocks do not usually contain good aquifers, which are generally found in alteration zones or fissures(diaclases), such as found in the Tagant and Adrar plateaus. In this area, only the oeuds may sometimes give-rise to rather large aquifers, due to under-flow : the Oueds of Seguelil, Tidjikja and Tamourt en Naaj. In the case of the Assaba massif, numerous springs are found at the foot of cliffs, probably due to direct infiltration of rain water in the diaclases of the sandstone plateau.

Large cracks and plications, particularly in the northern part of this dense rock area (see cross-section E-F), have separated these rock formations and reduced the size of aquifers.

The sedimentary formations of the west and center of the Taoudeni Basin date from the primary era.

The east of the Taoudeni Basin (see Zone IIIb, Map 4-1 and cross-section C-D), is composed of younger rocks, dating from the secondary era (Intercalated Continental, Jurassic supposed) mostly coarse sandstone extending towards the east.
These sandstones contain good aquifers : the Dhar Néma Oualata aquifers. A dry wedge, several tens of kilometers wide, exists to the east of the Dhar, along the edge of the Intercalated Continental formation (see Map 4-1).

The best aquifers, of regional extension, are located in the southeast of the country.

- in the Continental Terminal, the water contained in the Dhar Oualata and Néma aquifers is all fresh and exploitable yields are high (up to 100 m3/hour).[1] There are two aquifers, separated by a fault :
  - The Dhar Néma-Oualata : which flows in more or less clayey sandstone. The water is fresh.
  - The Ouartemachet pit aquifer : which flows in an older Intercalated Continental sandstone formation, in contact with the above aquifer at the large displacement fault.
- The aquifers of the Aouker-Hodh "Window". They are located in the southeast of the country, a zone relatively well supplied with rain water and are fed by numerous wells. Three distinct aquifers, of regional extension, were surveyed :
  - The Aouker eolien sand aquifer : This is a water table located in a sandy massif 16 to 60 meters thick. It is exploited by more than 350 wells and oglats. The exploitable quantity is on the order of 1 to 3 m3/hour.
  - The Hodh pelite aquifer : Located to the south of the Aouker aquifer, it circulates in the fissures of the primary formation (Cambrian). Its hydraulic continuity has not been established, in spite of the very large number of wells (781). Yields vary from 0.2 to 2 m3/hour.
  - The Soft Sandstone Aioun aquifer : Located to the west of the Hodh aquifer. The Aioun sandstones, due to their little consolidated characteristics and the tectonic vicissitudes they have undergone, are good aquifer materials. The 1975 exploratory boring campaign demonstrated that there is a generalized aquifer in these sandstones[2]. Exploitable yields vary from 0.2 to 2 m3/hour.

Thus, the Taoudeni Basin contains a certain number of aquifers which can be used for the improvement of southeastern Mauritania.

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(1) "Renforcement du service des eaux souterraines", 1975, Mauritania, Conclusions and recommendations, DP/UN/MAU-67-502/2

(2) "Etude des possibilités d'implantation d'une unité de traitement de viande dans le sud-est mauritanien", May 1977, Ministère de la Cooperation, Service de l'Elevage, SCET International.

4.1.2 The Senegalo-Mauritanian Basin

Having a surface area of about 100 000 km2, this sedimentary basin follows the Mauritanian coast and extends from the border with Senegal in the south to Nouadhibou in the north (see map). The different strata of this basin, porous or impermeable, constitute "storage rocks", which contain the best aquifers in the country. These sedimentary formations date from the secondary (Maestrichtian) and tertiary eras and descend as they go towards the west.

Water is present in most of these formations. Due to the unequal level of the platform in the west, the existence of clayey materials at the base of the Eocene or the Continental Terminal (continental deposits from end of tertiary), variations of the lateral facies, particularly of the tertiary formations (Eocene), which are sandy in the east and become calcareous in the west, one can distinguish several different levels and aquifers : (see map)

- the Brakna aquifer (sandy Eocene)
- the Amehtil aquifer (calcareous Eocene)
- the Trarza aquifer
- the Bennichab aquifer
- the Tirhersioum aquifer

These are so called "regional aquifers", which extend over nearly 100 000 km2 in Mauritania. The Trarza aquifer is located in clayey sandstone; it is quite extensive, going from the Senegal River valley in the south to the Inchiri in the north; it extends practically from Aftout-es-Saheli on the Atlantic coast to Boutilimit in the east. Yields from wells are relatively high, usually more than 1 m3/hour.

This aquifer supplies the city of Nouakchott, from 18 water bore holes drilled at Idini (located some 50 km to the southeast of the capital on the Boutilimit road). Some of these wells furnish 25 m3/hour to 35 m3/hour, and even up to 90 m3/hour.(1) The city of Nouakchott alone consumes 12 000 to 15 000 m3/hour according to the season (increased consumption during hotter months). The depths of these wells varies from 30 to 70 meters;

(1) Service de l'Hydraulique and SONELEC.

some reach 100 meters in depth. The depth of wells increases from the west to the east. This aquifer also supplies (by wells) the towns of of Boutilimit and Mederdra (wells are 80 to 90 meters deep at Boutilimit). Since this aquifer contains mostly fossil water, its exploitation must be carefully supervized.(1)

The Bennichab Aquifer, is identical to the Trarza aquifer, but located farther north. It supplies the Akjoujt mining center, which in 1973 used 5 200 m3/day, of which 300 m3/day were for the town of Akjoujt.

The Tirhersioum aquifer, part of the Continental Terminal, as are the two preceeding aquifers, is located in the extreme northwest of Mauritania. It supplies the city of Nouadhibou. by bore holes.

The Brakna aquifer, contained in tertiary sandy materials (coastal sands from middle Eocene), is located along the eastern edge of the Senegalo Mauritanian basin. It is a good aquifer; wells are from 20 to 30 meters deep. However, towards the east, the rise of the impermeable base of the Mauritanides range causes the appearance of a sterile band 20 to 30 kilometers wide (parallel to the mountain range).

The Amechtil aquifer, located to the west of the Brakna aquifer is exploited over a area of 30 to 40 kilometers. It is contained in dolomite-limestones dating from the tertiary era (Eocene). Wells are from 40 to 85 m deep; due to fissuration of the limestone, yields are mediocre or very low.

The extension of these aquifers is limited in the west, towards the Atlantic Ocean,by salt water penetration under the fresh water formations (See Map 4-1 and cross-section A-B). The salt zone covers about 20 km along the edge of the Aftout-es-Sahéli and becomes more than 100 km wide in the Inchiri where it separates the Trarza aquifer from the Bennichab aquifer.

The exploitation of these aquifers must be studied and rigourous supervision employed , due to the risks of salinity.

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(1) Page 10, Atlas de Mauritanie, 1977.

4.1.3 Aquifers in Cristalline Rock Regions

(Base of Regueibat Dorsal and Mauritanides mountain range)

A continuous zone of cristalline rock separates the two sedimentary basins :

- to the north, the Regueibat Dorsal, a vast granite unit (IIb on Map 4-1) oriented from northeast to southwest. The rock presents little evidence of major cracking.
- the Mauritanides Arc (IIa on Map 4-1), approximately oriented north-south, crosses the western area of Mauritania, from the level of Nouadhibou in the north to south of Guidimaka (and extends into Senegal). Most of the Mauritanides Arc is composed of schist with granite intrusions. In the northern part of the Mauritanides Arc, yield varies from 0.1 to 10 m3/hr in the sandstones, jaspers and dolomites. In the South (Guidimaka), yield is from 0.1 to 3 m3/hr in schist and volcanic rock, and from 0.1 to 0.5 m3/hr. in the ante-Cambrian schists (in the Aftout between Sélibaby and M'Bout). There are large faults in the southern part of the Mauritanides Arc. The water is usually of good chemical quality.

The aquifers of the Regueibat Dorsal are exploited by a small number of pastoral wells, but these aquifers are more extended and continuous than the other aquifers found in cristalline rocks. Yields could be greater, but salinity is usually high : for example, from 1 to 20 grams/liter at Tiris, North of Zouérate; 0.5 to 18 grams/liter in the Amsaga, and 1 to 5 grams/liter in the heart of the Regueibat Dorsal. (1)

In the cristalline rock regions, aquifers are usually quite localized and are generally associated with faults, fissures and zones where the chemical and mechanical actions of atmospheric agents have created permeable materials in which water can accumulate.

On the whole, there are few large aquifers in the cristalline rock formations; only along the stratification planes and alteration zones can reasonable quantities of water be found. The large faults cracking the southern part of the Mauritanides Arc prevent the formation of large water basins, as they separate the region into multiple distinct units.

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(1) Renforcement du Service des Eaux Souterraines, PNUD, 1975.

The precise dating of the underground water contained in cristalline rock has not been undertaken in Mauritania; it would be interesting to determine their age by chemical and radiometric examination, in order to better control the use of this fossil water. However, it appears probable that these waters are fossil, accumulated during a period when the climate was wetter in the Sahara. The profound alteration of the granites in the north of the country confirms the existance of more humid climates in the past.

At present, average annual rainfall in the north of Mauritania is less than 100 mm. Therefore, there is only slight replenishment of these aquifers.

To the south of the 18° latitude north, the Mauritanides Arc receives an average annual rainfall varying from 200 mm in the north to 600 mm in the south (Guidimaka). In these regions, precipitations probably participate directly in replenishing aquifers in those areas where altered cristalline rock and cracking are extensive. Cristalline rock aquifers are also replenished when rainwater causes the oueds to flow, due to infiltration of the altered rocks in contact with the oued alluvium (see cross-section G-H).

The quantity of oued flow which contributes to aquifer replenishment is not known; given the modest volumes of average annual rainfall, it is not certain that present aquifer recharge is assured above the 400 mm isohyetal line. Therefore, the use of underground water in cristalline rock must be strictly controlled, in order to avoid the exhaustion of these hydraulic resources, in particular during the current drought cycle.

4.1.4 Shallow Aquifers

There are many shallow aquifers under the oued alluvial formations (and under the only permanent water course in Mauritania, the Senegal River) and under the sand-covered zones corresponding to eolian dune formations (see cross sections G-H and I-J).

These shallow aquifers are usually less than 10 m deep and the water level (piezometric level) is reached a few meters underground. The shallow aquifers are usually found only in alluvial zones, in the beds of oeuds or topographical depressions. In the sand dune areas, shallow aquifers are more extended (especially in the south of the country, where rainfall is higher, around 400-600 mm/year). Elsewhere, the sand zone aquifers are located in depressions between dunes (see cross-section I-J). In general, these aquifers are continuous, as they circulate in soils with fairly homogeneous textures (sands, gravels, etc.). Water is obtained by infiltration (water accumulates in the topographic depressions where it stagnates after heavy rains). Thus, the number and size of these shallc aquifers depends directly on the volume of rainfall and soil texture.

In the north of the country (receiving less than 200 mm annual rainfall), these aquifers cannot be exploited without risking depletion. In the south (Senegal River alluvial zone, for example), rational permanent pumping can be planned, as the aquifers are much thicker and are replenished either continually or at least periodically(1).

These shallow aquifers are exploited by several thousand oglats, a traditional structure well-adapted to shallow aquifers on soft terrains; unitary yields are low. These traditional shallow wells are dug by hand (see cross-sections G-H and I-J). Water is also drawn by hand, laborious work which may require an entire day. Formerly the task of slaves, drawing water is now performed by the users.

The utensil for drawing water is called a delou. Traditionally, this recipient was made of goat skin, shaped into a hemisphere with the opening maintained by an iron circle. For the last 20 years, most delous have been fabricated from old inner-tubes. By lowering the delou into the well on a rope, a man can draw an average of 300 liters per hour(2).

Most shallow aquifers contain fresh water, and are employed only to supply drinking water for men and animals.

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(1) Renforcement du Service des Eaux Souterraines, PNUD, 1975.

(2) Charles Toupet, p. 235, "Sedentarization of Nomads in Central Sahelian Mauritania", 1977.

The oued palm groves develop spontaneously, due to the direct water supply to the roots from the aquifer.

It is difficult to calculate the total yield exploited from shallow aquifers in Mauritania, due to the season variation of use and the methods of drawing water. It is about 25 000 m3/day.(1)

The shallow aquifers can be classified in 3 sub-groups, despite their dispersion, and considered as hydro-geographic units on the basis of the type of deposits and formations covering them(2)

- -fresh water alluvial aquifers
- -salt water alluvial aquifers, with fresh water lenses
- -fresh water alluvial aquifers under eolien sands

4.1.4.1 Fresh water alluvial aquifers

Three types of fresh water alluvial aquifers can be distinguished :

a) constantly replenished aquifers

This is the case for the aquifers of the Senegal River and Gorgol River, in the south of the country. The Senegal River is the only permanent water course in Mauritania. Exploitable yields in these river valleys are :

minimum : 3 m3/hour
maximum :30 m3/hour

The aquifer of these two water courses is hydraulically continuous with the coastal basin water table.

The Senegal alluvial aquifer is linked to the river floods, during which the river bed can attain 20 km in width. The flood water impregnates the alluvium, infiltrating the adjacent formations (sands, sandstones, limestones). This aquifer is employed by the towns and villages along the river basin. Its yields depend on

(1) and (2) PNUD project - Mauritania 1975 - DP/UN/MAU-67-502/2

the nature of the storage rocks and the age of the well.

b) regularly replenished aquifers (annual replenishment)

Most of these aquifers are located between the river and the 200 isohyetal line (see map).

The exploitable yields recorded are quite variable :

minimum : 0.1 m3/hr

maximum : 80 m3/hr

c) irregularly replenished aquifers

These aquifers are located north of the 200 mm isohyetal line. The exploitable yields are quite variable, from 0 to 25 m3/hour.

Of these three types of shallow aquifer, the first is the most advantageous and the third the least advantageous from the standpoint of size, thickness of aquifer and yield. Types b and c occur in the oued alluvial materials and are usually referred to as "oued aquifers". They are of primordial importance; for example, in the Adrar, the Seguelil aquifer (Atar) permits the existance of a palm grove, due to underflow. Most oases depend directly on oeud aquifers. These aquifers are quite fragile, their replenishment being dependant on annual or periodic oued floods.

Among the better oued aquifers are :(1) the Ajkoujt Khatt, where the aquifer is large due to alteration of the dolerites, and the Seguelil oued aquifer, where the aquifer alluvium penetrates the fissures and dissolution holes of the limestone near the sand-covered oeud bed. The resources of the Tidjikja oued (Tagant) are more limited, for the subjacent sandstone is impermeable and unaltered, so that the aquifer is restricted to the sand-covered oued bed.

(1) Atlas de Mauritanie, 1977, p. 12

4.1.4.2 Salt Water Alluvial Aquifers with Fresh Water Lenses

a) Coastal aquifers contaminated by sea water

These aquifers are located in the Aftout-es-Sahéli and the Delta. Only the fresh water lenses, formed by rain water infiltration, are exploited.
These aquifers are located within the limits of the coastal salt-water wedge. (See map 4-1). The exploitable yields are low, about 0.1 m3/hr maximum.

b) The Sebkha aquifers (Sebkhas are saline and gypsum depressions)
The fresh water lenses are exploited by oglats. The coastal sebkha of the Aftout-es-Sahéli are usually distinguished from the sebkhas in the interior (numerous in the north of the country).

4.1.4.3 Eolien sand fresh water aquifers ("Perched aquifers")

There are two types, according to rainfall :

a) Irregularly replenished aquifers

Located to the north of the 200 mm isohyetal aline. Example : the Akchar and Azeffal dunes on the west coast (about 20° latitude north), the vast eolian sand formations of theOuaran, in the center of the country (North of the Aouker) and the Mreyye in the east and center of the country (Majabat al Koubra), etc. Exploitable yields are low : 0.1 to 0.2 m3/hour.

b) Regularly replenished aquifers located south of the 200 mm isohyetal line

These aquifers are found in the numerous eolian sand-covered zones south of this isohyetal line, especially near Aoukar, Hodh and the Affolé, etc.
Exploitation yields are variable :

minimum : 0.1 m3/h
maximum : 10 m3/h

These aquifers exist when rainfall permits and where an impermeable subbase prevents deep infiltration.

In the case of the aquifers in the coastal dune zone, lenses of fresh water from rainfall lie on a denser salt-water layer. These shallow aquifers are important as they are often the only resource for herdsmen and certain towns in the north and center of Mauritania. They are very fragile and require constant supervision and limited exploitation. The Senegal river basin aquifers present much less risk, as the river water is a permanent source of renewal.

Some Remarks on the Tindouf Basin

Only a small area of this basin is represented within Mauritanian territory, in a region known as the "Zemmour Noir", the southern end of the Tindouf basin, and by the "North Yetti" (see Map 4-1).

Located north of Bir Moghrein, the Zemmour Noir covers a small area (about 2 500 km2) or 2.24% of Mauritania; it has an average altitude of 400 meters.

The Zemmour and Yetti plateaus are carved from sandstone and limestone dating from the primary era. The only water holes are oglats, some of which have an average salinity as high as 5.2 grams/liter; others have salinities lower than 2 grams/liter. These oglats give very little yield : less than 1 m3/day. Most of them are located in oued alluvia. However, the Tirhirt oglats depend on water from sandstone fissures. (Note : there is no permanent population in the Mauritanian Zemmour Noir zone, only nomads who move their camps as a function of the availability of grazing and water.)

4.2 Yields and Problems of Underground water exploitation

4.2.1 Cristalline Rocks : In general, cristalline rocks are not good water reservoirs and are difficult to exploit; they have the least potential for rural development projects.

Finding and exploiting rock contained water is often expensive and the quantities obtained are usually small. This has been the case of the granites in the north of Mauritania (Zone IIB, Map 4-1), which form the Regeuibat Dorsal, and the metamorphic rocks of the Mauritanides Arc (Zone IIa).

In cristalline rocks, the most readily accessible underground water reserves are found in the alteration mantle and the subjacent cracked zones (see cross-section K-L). The thickness of altered rock layers is quite variable. The thickest alteration mantles are found in areas where, in the geological past, climate conditions were more humid and consequently, the rocks were decomposed under the ground. This is the case in certain granite zones in the north (Regeuibat Dorsal). The thickness of the alteration mantle tends to increase in convex areas : mountains, rock outcrops, etc.

According to a USAID study(1), the following yields were recorded for various types of rock formations (Table 4-1) :

TABLE 4-1

Type of Rocks	Well Production (m3/hour)	Depth of Well (m)
Schist	0 to 20	25 to 80
Quartzite	0 to 5	25 to 80
Granites and Granitic Gneiss	0 to 10	30 to 80

Table 4-2 shows the yields for cristalline rocks recorded in Mauritania (2).

(1) this data comes from neighboring countries and must be used with caution, as yields are not necessarily similar to those in Mauritania. Source : Water Supply to Rural Zones and Sanitary Improvements, Preliminary Analysis, African Bureau, USAID, Contract AFR-C-1197, March 1978.

(2) Renforcement du Service des Eaux Souterraines, Mauritanie, PNUD, 1975. Data from table entitled " Classification and Characteristics of Underground Water Resources in Mauritania".

TABLE 4-2

Type of Rock	Exploitable Yield (m3/hour)		Piezometric level (depth in meters)	Location
	Minimum	Maximum		
Schists	0.1	3	6 to 35	Mauritanides Arc
Chlorito-schists	0.1	5	5 to 30	" "
Micaschists	10	20	40 to 50	F'Derick-Zouérate
Quartzites	0.1	5	5 to 30	Mauritanides Arc
Ferruginous Quartzites	20	60	25 to 40	F'Derick-Zouérate
Gneiss Granites		3	5 to 20	Regueibat Dorsal

The reconnaissance of underground water in the rocks of Mauritania is difficult. For 112 exploratory borings (PNUD project)(1) prospecting for underground water in Mauritania, the following results were obtained for sedimentary and cristalline terrains :

- fresh water (2 grams/liter)-30 % of borings
- brackish water (consumable by livestock) (2 to 5 grams/liter)-15% of borings
- salt water (not consumable) (5 grams/liter)-28 % of borings
- unproductive borings - 24 %

Thus, 52 % of the borings were unproductive or produced unusable waters! Most of the unproductive borings occurred in cristalline terrains : Amsaga, Tiris - Zemmour blanc, Tijirit. Of 72 borings, 23 were non-productive (32%) and 49 produced water (68%) of which :

- 15 fresh water (21 %)
- 11 brack water (15 %)
- 23 salt water (31 %)

Wells drilled in cristalline rock are exposed to the risk of non-replenishment during drought cyles and tend to dry up, due to the relatively low storage capacity of the lossened rock.

(1) Renforcement du Service des Eaux Souterraines, Mauritanie, 1975, PNUD - DP/UN/MAU-67-502-2
For more information, see the above reference

During the drought in the West African Sahel, many of these aquifers were dried up. Drilling and exploitation of wells drawing upon these aquifers must be undertaken with care, to avoid the rapid exhaustion of these water resources.

4.2.2 Sedimentary Rock

Sedimentary rocks usually contain much larger water reserves than cristalline rock. However, the older sedimentary rocks (Paleozoic) have been consolidated, due to the settling and compression of the covering strata. These ancient rocks contain water in fissures and between the stratification planes. In Mauritania, dense, consolidated sedimentary rocks are found in the west of the Taoudeni Basin (Zone IIIa - Map 4-1). To the south of this basin, these rocks have been fragemented by fissures and the aquifers are small. A schematic representation of a typical aquifer in ancient sedimentary rock (Assaba region) is given in cross-section M-N, which shows the small extension of these aquifers within the rock bed.

On the basis of data from regions close to Mauritania, one can estimate the yield from wells in consolidated sedimentary rock, but these estimates must, of course, be used with caution(1).

Sandstone is usually the dense rock most likely to contain water, but dolomite and limestone may also furnish good quantities of water, flowing in the spaces formed by stratifications and faults

TABLE 4-3

Type of Rock	Well Production (m3/hr)	Well Depth (m)
Sandstone	1 to 5	10 to 200
Clayey schist and/ or silt	0 to 5	5 to 70
Dolomite and/or limestone	0 to 20	15 to 100

(1) These data concern neighboring countries with identical geographical structures. However, application of these figures may cause considerable error, and they must be applied with caution. Source : West Africa : Water supply to Rural Zones and Sanitary Improvements, preliminary Analysis, USAID, African Bureau, Contract AFR-C-1197, March 1978.

In Mauritania, the following yields have been recorded from aquifers in consolidated sedimentary rocks : (1)

TABLE 4-4

Type of Rock	Exploitable Yield (m3/hour)		Piezometric level (depth in meters)	Location
	Minimum	Maximum		
Quartzite sandstone	0.5	3	0 to 10	Assaba, Tagant
Quartzite sandstone	0.5	3	0 to 10	Center of Adrar
Dolomite	0.1	30	5 to 10	Amogjar Pass
Dolomitic limestones	5	20	20 to 80	Amechtil
Limestone with stromatolites	20	50	10 to 50	Atar

The younger sedimentary rocks of the Senegalo-Mauritanian basin and the east of the Taoudeni basin offer better potential for underground water reserves.

The Continental Terminal sandstones of the coastal basin and the Intercalated Continental sandstones of the Taoudeni basin are less consolidated and therefore more permeable, allowing free water flow within the rock interstices. The approximate yields for this type of rock formation are given below, based on similar geological sites in neighboring countries(2).

TABLE 4-5

	Well Production (m3/hr.)	Well Depth (m)
Continental Terminal	50 to 150	50 to 300
Intercalated Continental	25 to 250	30 to 350

(1) Classification and Characteristics of Underground Water Resources in Mauritania, from "Renforcement du Service des Eaux Souterraines - Mauritanie", PNUD, 1975.

(2) Source : "Water Supply to Rural Zones and Sanitary Improvements", Preliminary Analysis, African Bureau, USAID, Contract AFR-C-1197, March 1978.

The yields furnished by aquifers in permeable rock in the Senegalo-Mauritanian basin are given again here for purposes of comparison :

TABLE 4-6

Aquifers	Type of Rock	Exploitable Yields (m3/hour)		Piezometric Level (Depth in meters)
		Minimum	Maximum	
Trarza	Many-colored clayey sandstones; fine to coarse sands; lenses of clay	15	100	5 to 80
Bennichab		50	70	50 to 60
Tirersioum		10	50	20 to 35
Brakna	Fine sands	15	50	10 to 60

The Maestrichtian deep aquifer (secondary age) of the coastal sedimentary basin is contained in fine to coarse sandy materials with clayey bands. Yields are variable, and often quite high :

To the east of Lake Rkiz : 30 to 50 m3/hour

To the west of Lake Rkiz : 150 to 300 m3/hour

The salinity rates in this aquifer can attain 17 grams/liter (as at Idini (test boring SE 4), which constitutes a serious handicap.

However, drilling in the Lake Rkiz area has revealed water of satisfactory quality : 0.7 to 1.4 grams/liter of salt; this opens new perspectives for the future.

The aquifers in the Intercalated Continental, in the east of the Taoudeni basin, are contained in soft sedimentary rock (aquifers of the Dhar Nēma-Oualata and the Ouartemachet pit). The following table gives yields for these two aquifers.

Table 4-7

Aquifer	Type of Rock	Exploitable Yield (m3/hour)		Piezometric Level (depth/meters)
		Minimum	Maximum	
Dhar Néma, Oualata	Coarse sandstone, more or less clayey	5	30	50 to 75
Ouartemachet Pit	White sandstone, clayey	20	100	40 to 65

Estimation of the reserves of the Trarza aquifer (at Idini)

In 1968, the reserves of the Trarza aquifer exploited at Idini were evaluated at 100 million m3[1], over a borrow area of 180 km2. A yield of 20 000 m3/day during 10 years would be possible using 20 wells, after which salt pollution could attain 2 grams/liter[2]. However, it must be borne in mind that this is only an estimate.

4.2.3 Replenishment of Oued Alluvial Aquifers

Agricultural dams across oueds (as at Oualata) contribute to the replenishment of alluvial aquifers along oueds, and at the same time serve to water herds and for floodland cultivation. At Atar, the Segelil oeud dam plays this same role. By storing runoff, the dam permits better infiltration and minimizes water losses. The water table rises during years of good rains, and the dam sometimes permits increased replenishment due to the subjacent rocks when they are fissured (as in the Atar dolomites). It would be very useful to have precise measurements of aquifer replenishment rates, in order to supervize exploitation.

4.2.4 Cemented Wells and Oglats (by Region)

Of the total of 2169 cemented wells and 6 511 oglats inventoried by the PNUD project[3], the Trarza aquifer has the largest numbers : 500 cemented wells (23%) and 1200 oglats (18%) !

(1) P. Elouard (1973), Recherches d'Eau en Mauritanie depuis 1968.
(2) Ibid, citing Ph. Roussel (1968).
(3) Renforcement du Service des Eaux Souterraines, Conclusions et Recommendations du Projet, Mauritanie, PNUD, 1975.

The following table shows the aquifers having the most water holes (cemented wells or oglats) in Mauritania; these figures reflect the potential of the aquifers, the accessability of the water and the pastoral vocation of these regions.

Table 4-8

Aquifers	Cemented Wells (Total = 2169)	% of Total	Oglats (Total=6511)	% of Total	Oglats + Wells	%
Trarza	500	23%	1200	18.5 %	1700	± 20%
Hodh Pelites	474	22%	292	4.5 %	566	6.5%
Brakna	200	9%	20	0.8 %	220	2.5%
Aouker	150	7%	200	3 %	350	4 %
Amechtil	100	4.6%	10	0.15%	110	1.3%
Chemana-Gorgol	130	6 %	200	3 %	320	3.8%
Freshwater sand-covered aquifers south of 200 mm iso-hyetal line	70	3 %	1200	18.5 %	1270	14.8%
Aïoun sandstone	47	2 %	56	0.9 %	93	1 %

4.3 Conclusions

There are good potential water resources in Mauritania, but they are unequally distributed, due to the geological structure and nature of storage rocks. As far as is known, with the exception of shallow aquifers, most of the aquifers currently exploited to supply large urban centers (such as Nouakchott, Akjoujt, Zouérate, F'Derick, Nouadhibou) contain essentially fossil water. These cities are all located north of the 400 mm isohyetal line and receive limited average rainfall (less than 200 mm). The annual replenishment of these aquifers is not known, but it is estimated as slight.

The Senegalo-Mauritanian basin located along the Senegal River is replenished in part by the alluvial aquifer. In years of high flood, river water invades the Aftout-es-Sahéli and the Lake Rkiz depression, causing much more extense infiltration. These floods play an important part in replenishing the aquifers of the Senegalo-Mauritanian basin. The Diama and Manatali dams, by regulating

the river flow, will decrease floods and may play a negative role in aquifer replenishment. However, these dams will have a very positive effect on agricultural development.

On the overall, Mauritania has fairly large, but fragile, water resources. There do not exist many large fossil aquifers and most of the nation depends on shallow aquifers, which depend on oued floods (which are a function of rainfall). The present trend towards increased aridity imposes rigorous controls of aquifer exploitation to avoid depletion.

North of the 400 mm isohyetal line, all water exploitation must be strictly supervized, so as not to surpass the recharge capacity of the aquifers. Sufficient water reserves must be maintained so that the population may withstand the continuing drought, until such time as rainfall allows substantial increase of aquifer reserves.

It has been noted that there are very high evaporation rates from the soil and from plant transpiration in the arid Saharan regions, towards the east of the country. Evapo-transpiration is such that all infiltrated water is returned to the atmosphere in regions where rainfall is less than 400 mm(1). Efficient infiltration occurs in these regions only when runoff can concentrate in temporary linear flows (oeuds), that is, when there exist impermeable rock surfaces such as in the Adrar and Tagant massifs, and in those sandstone and cristalline massifs which have not been invaded by sand.

A good example of this phenomenon is the Akjoujt aquifer, the size of which has surprized hydrogeologists(2). Only about 90 mm of average annual rainfall is experienced at Akjoujt, in three or four rains. This water runs off from the impermeable cristalline rock in sheet or diffuse flows. As penetration is practically nil, the water concentrates in low areas and forms large linear flows, as the runoff from the 100 km2 catchment basin is received. These linear flows correspond to oeuds (called Khatt) which occur only several days per year. However, this water infiltrates into the sandy alluvium of the bed and penetrates the fissures of the subjacent dolerite.

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(1)and(2) P. Edouard (1973), Problèmes d'Eau et Sous-sol de Mauritanie, Communication au Colloque de Nouakchott, Dec. 17-19, 1973.

To the south of the 400 mm isohyetal line (the southern parts of Administrative Regions 2, 3, 4 and 10), there is less risk of aquifer exhaustion, as rainfall volumes are sufficient to aid aquifer replenishment (average annual rainfall may attain 650 mm in the south of the Guidimaka). However, the southern part of the country has not escaped the effects of the drought, which limit aquifer replenishment. In 1979, rainfall in the south was deficient: Selibabi received only about 50% of normal precipitations (324 mm)[1]

It is certain that rainfall directly affects the shallow aquifers; its actions on deep aquifers have never been quantified. The drought has provoked a decrease in aquifer levels; some shallow aquifers have totally disappeared. The deep aquifers appear to be less directly dependant on rainfall.

The introduction of motor-pumping must be undertaken with caution. The traditional methods of drawing water, using the delou, required effort and limited wastage. Since the motor-pumps require little human effort and do not require supervision, users may be tempted to draw more water than necessary. In addition, motor pumps may be used for agriculture in areas where the water resources are not sufficient. Therefore, all massive use of motor pumps must be rationally conducted.

The growing urban areas of Mauritania (Nouakchott went from 5 807 inhabitants in 1961-62 to 134 986 in January, 1977[2]) and industrial development consume large quantities of water from the fossil aquifers, and risk depleting them over a period of time. Intensive pumping of the underground water in the coastal sedimentary basin will increase salinity and render the water unfit for human consumption. It is clear that economic activities and the well-being of the population can be seriously affected by over-exploiting the aquifers.

In the case of oases exclusively dependant on shallow aquifers (replenished by rainfall), particular care must be taken to protect the aquifer resources.

Intensive prospecting for underground water should be undertaken in those regions where the risk of aquifer depletion is greatest due to population concentrations. In the Trarza,

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(1) The "CHAAB", Saturday 5 and Sunday 6 January, 1980, page 3. Article by Kane Selly.

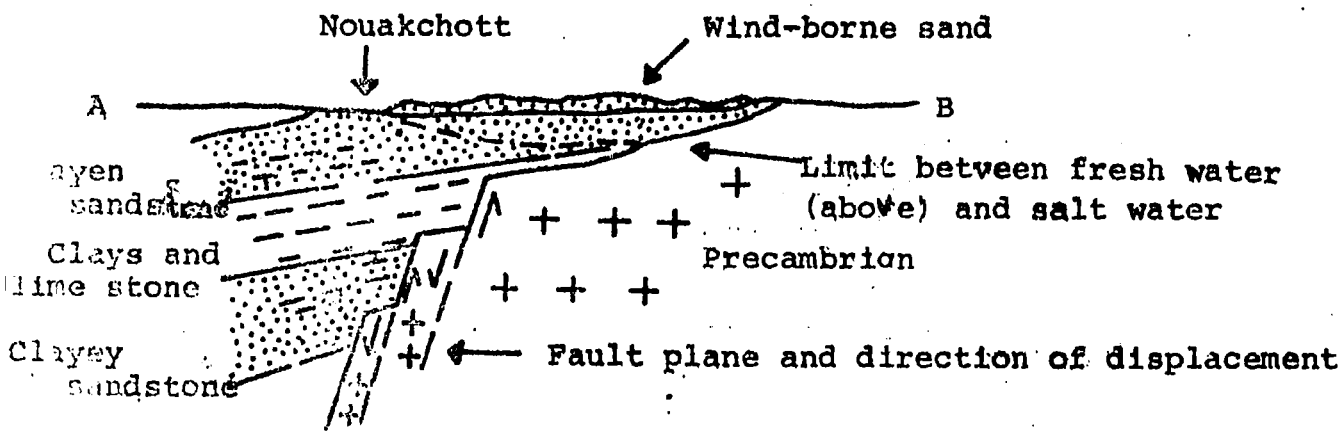
(2) Provisional results of General Population Census. Population as of Jan. 1, 1977. Central Census Bureau, Ministry of Planning and Mines, IRM.

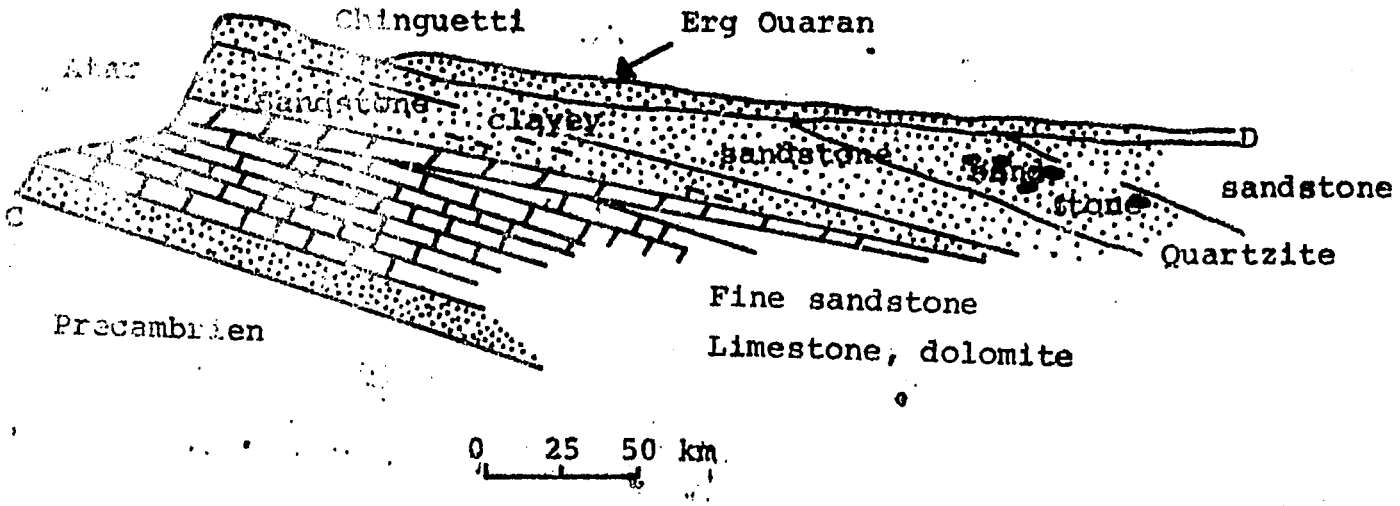
prospections in the Maestrichtian are underway in the hopes of finding resources to replace those currently exploited, once they have been exhausted or become unusable (too salty). However, these prospections do not always give results. While awaiting these hypothetical discoveries, the rythym of aquifer exploitation must be calculated so as to assure the longest possible use of known resources.

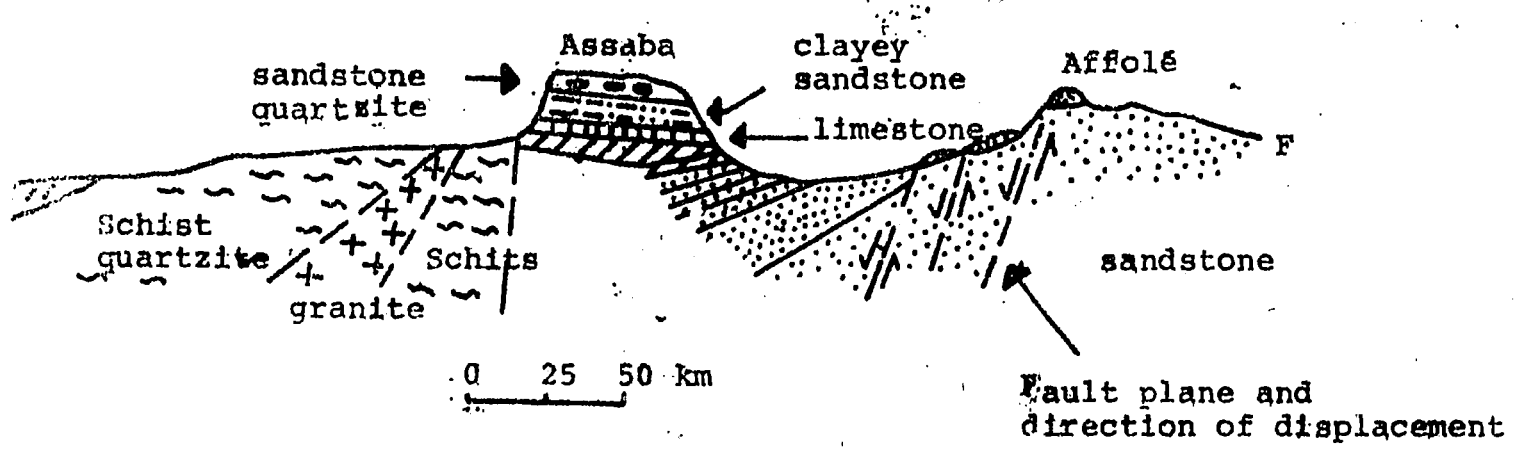
At present, desalinization of sea water to replace aquifer resources is too expensive and cannot benefit the regions far from the ocean. Management of the water resources is thus a vital necessity if Mauritania is to assure the future for its population.

Cross Section of Typical Aquifers in Mauritania

Fig. 4-2





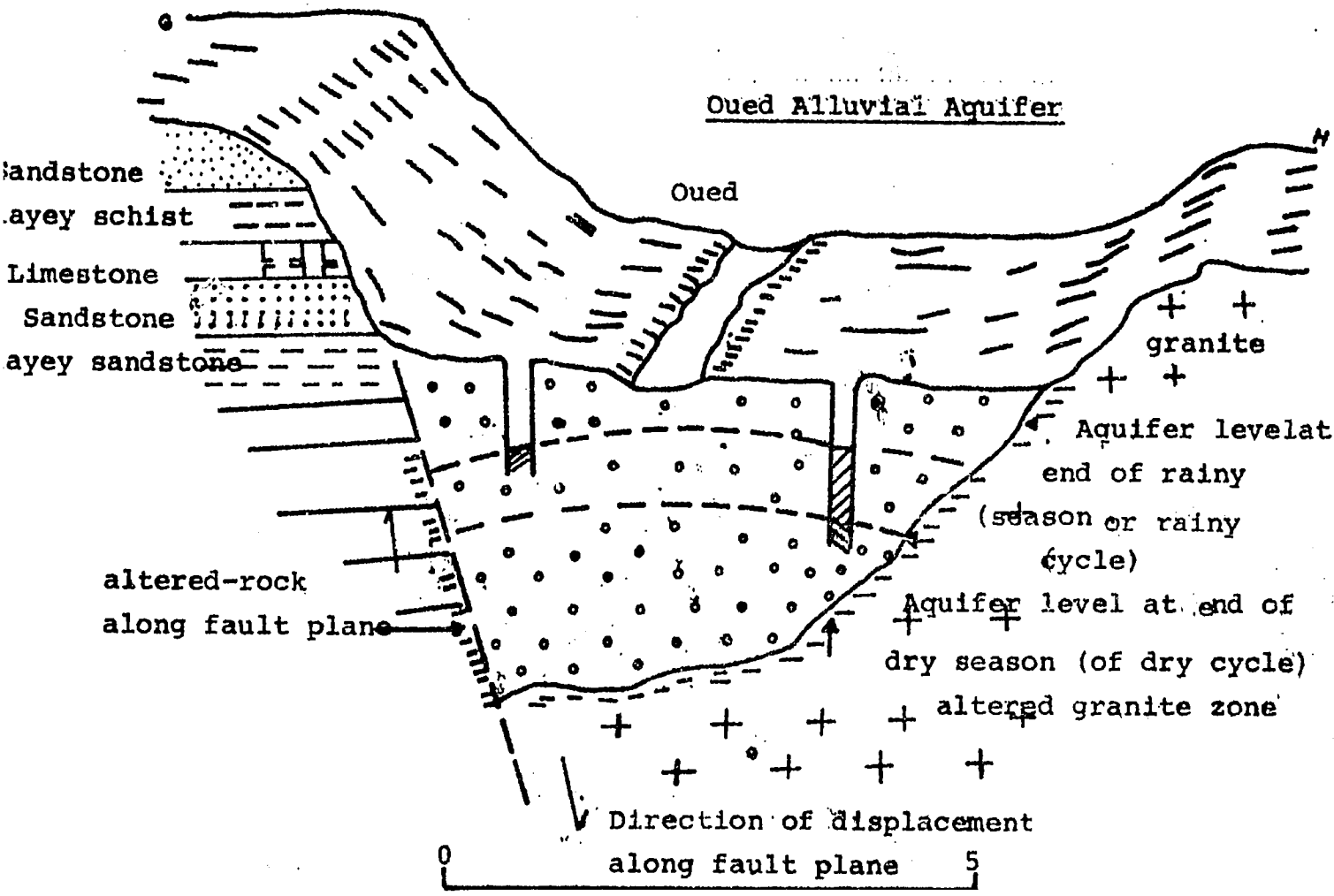


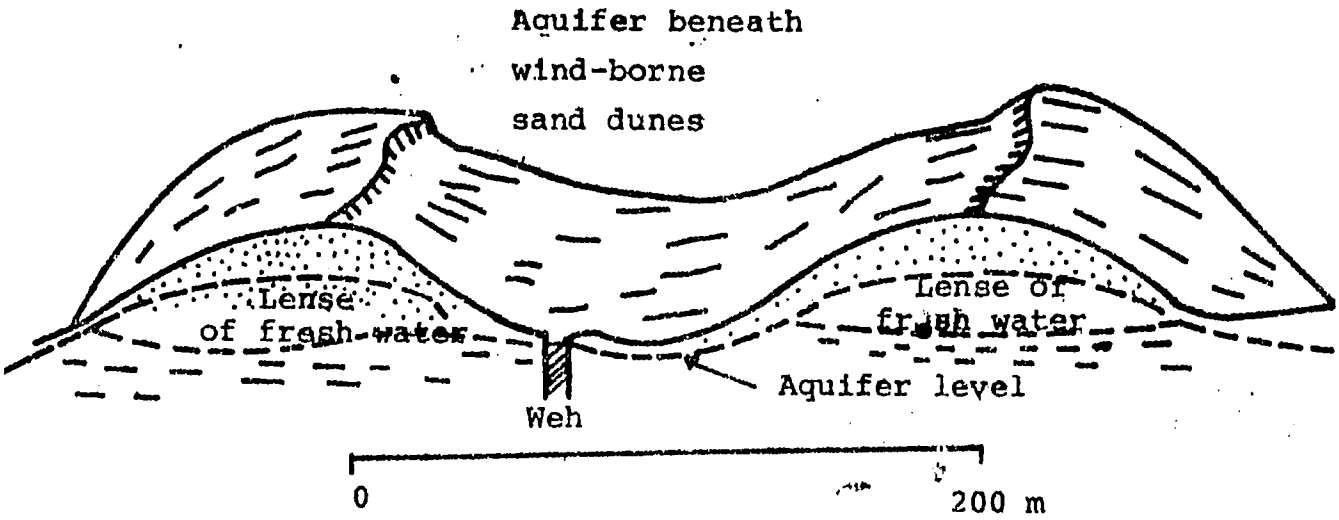
See map n° 4-1 For Location of cross sections

SOURCE: RENFORCEMENT DU SERVICE DES EAUX SOUTERRAINES

Fig. 4-3

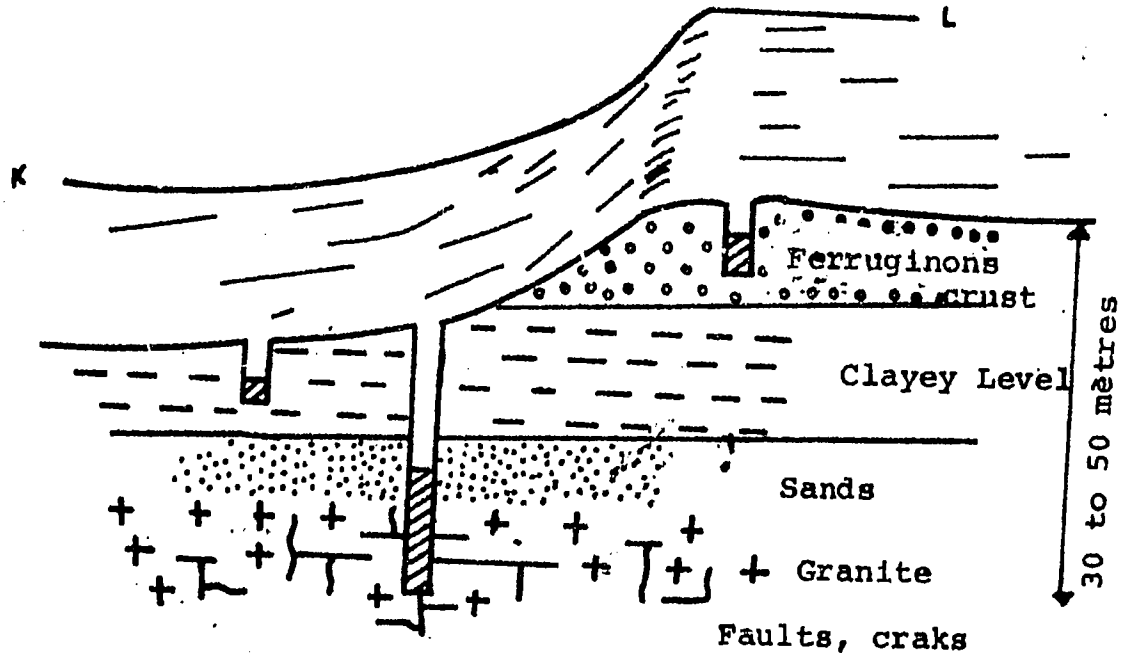
Cross - Section of Shallow Aquifers



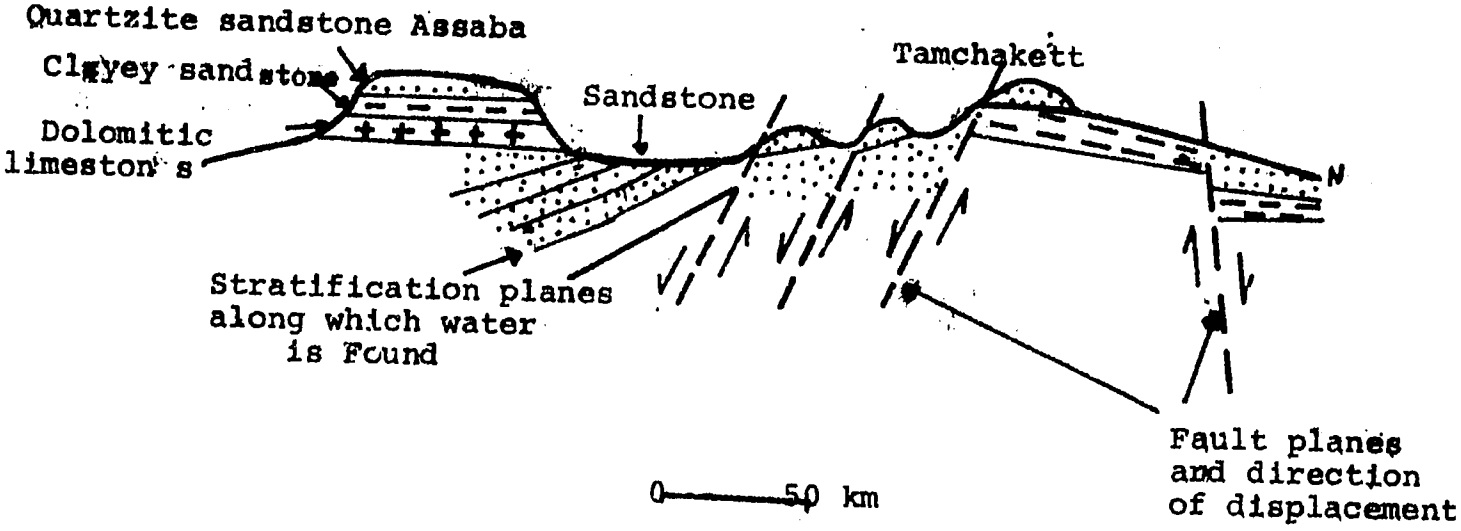


SOURCE : RENFORCEMENT DU SERVICE DES EAUX SOUTERRAINES PNUD 1975.

Cross section of Granite Rock surface



Cross section of the Assaba and Taoudeni Basin
(West-East)



SOURCE : RENFORCEMENT DU SERVICE DES EAUX SOUTERRAINES PNUD 1975.

CHAPTER 5

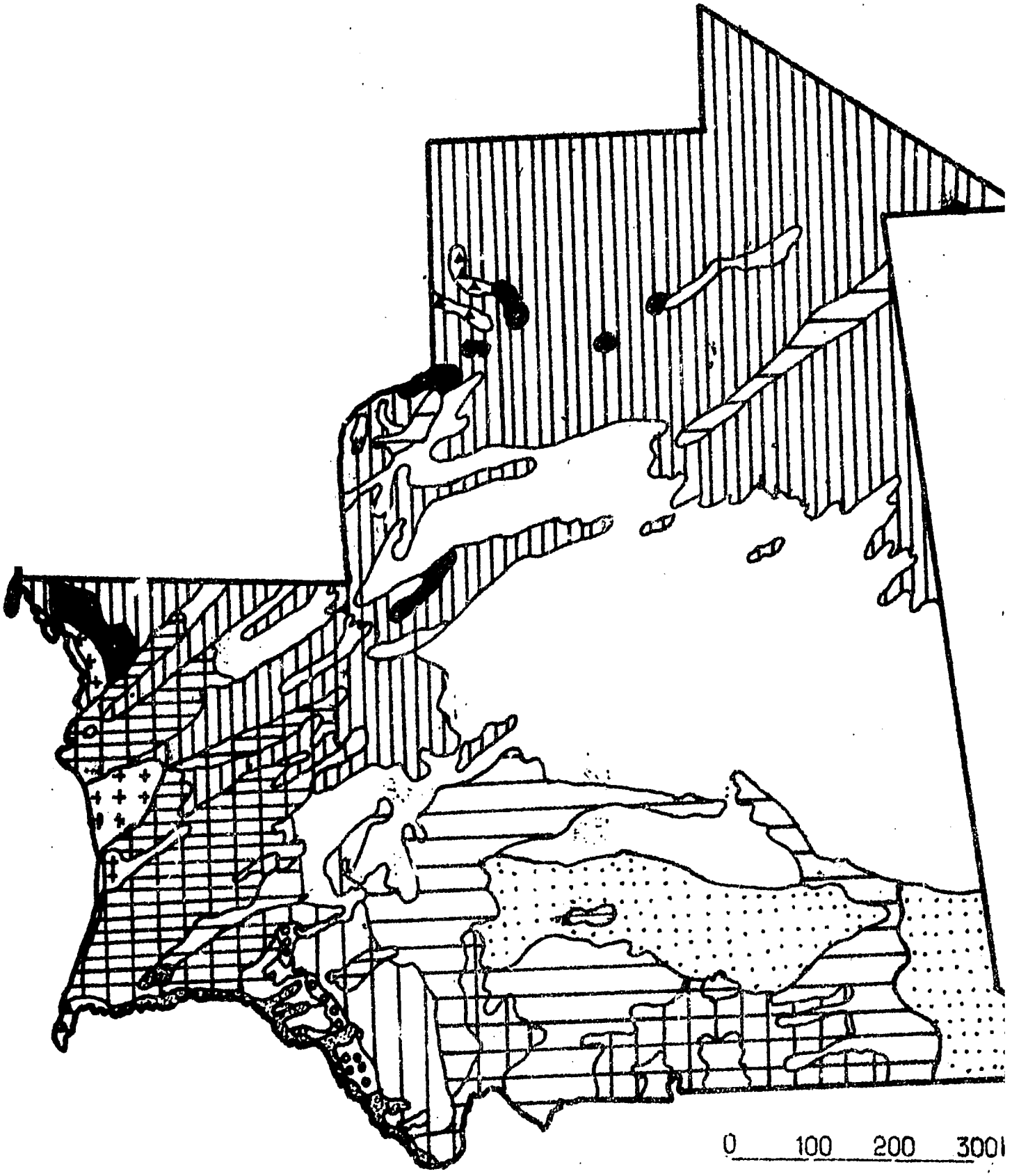
MAJOR SOIL TYPES

(Fig. 5-1)

Legend - Map of Major Soil Types of Mauritiana

- Desert complementary soils on eolian sand
- Desert ablation soils on different rocks
- Raw mineral erosion soils on lithsoils on rocks
- Little evolved zonal soils on differents rocks.
- Little evolved zonal soils on eolian sand
- Complementary soils on eolian sand
- Complementary soils on sandy-clayey and clayey-sandy materials
- Complementary soil on marine or lake deposits
- Brown steppe vertic soils
- Brown-red steppe soils on eolian sand with undifferentiated facies
- Brown-red steppe soil on eolian sands withs modal facies
- Hydromorphic gley soils
- Halomorphic soils

Fig. 5-1



Scale:
Echelle: 1/6 500 000

Mautitania:Distribution of major soil types
arte des principaux types de sol de Mauritanie

ADAPTED FROM A TLAS DE MAURITANIE 1977.

Detailed Legend of Map of Soil Potentialities

(based on O. R. S. T. O. M. Pedological Map, scale : 1/500 000, in the "Atlas International de l'Ouest Africain - O. U. A.")

- Desert and sub-desert soils.

Little evolved raw mineral soils. Few agricultural potentials, unless irrigation of sub-desert soil (high cost). Oasis agriculture.

- Varied halomorphic soils (saline and halic soils)

No agricultural value, without large investments.

- Little evolved complementary soils

Can be used for agriculture only if water and organic matter supplied (high costs).

- Erosion soils, raw mineral (crusts) and little evolved soils.

Extensive grazing. When rainfall permits, cultivation in valleys and on gravelly soils at edge of crusts (2-3 to 5% of surface).

- Isohumic soils - sub-arid soils (steppe). Weak cultivation potential due to sparse rainfall. Varied cultivation possible with irrigation and fertilizers.
- Ferruginous and ferralitic soils (+ hydromorphic soils in low lands, about 5 - 8% of the surface area).

Thick, dense soils of variable chemical richness. Major factor limiting agriculture : rainfall distribution. With sufficient water, good yields for varied cultivation (millet, peanuts, cotton, etc.) if phosphates and organic matter supplied, and land protected against erosion.

- Hydromorphic Soils

Varied chemical richness. Permanently or periodically saturated with water, either surface or deep, requires drainage to be cultivated. Possibility of varied crops and interesting potential for rice cultivation.

Expanding Clays (Black tropical clays)

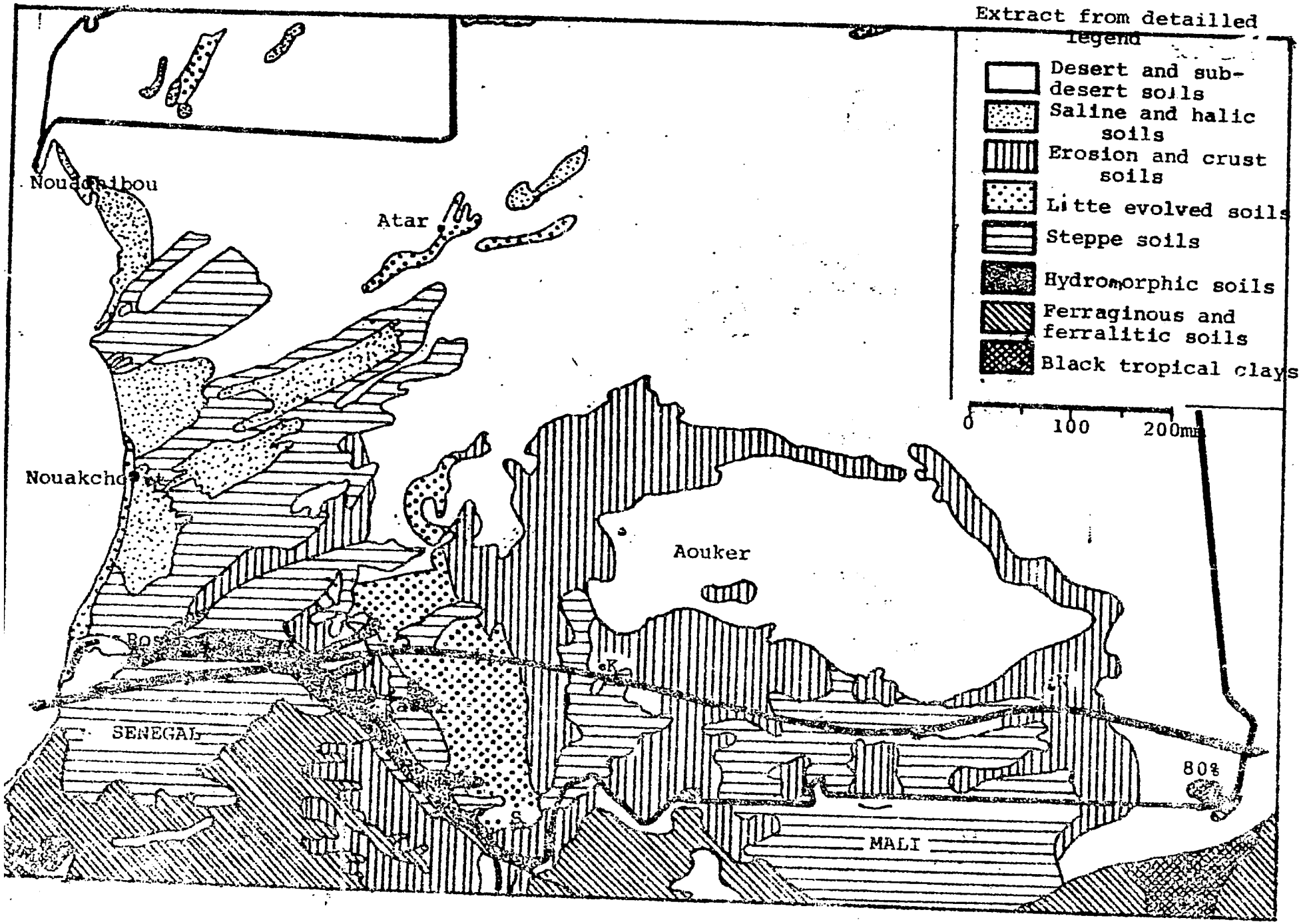
Rich soils, but heavy and requiring water. Difficult to work with traditional methods. Good yields for varied crops (millet, sorghum, cotton, fruits, sugar cane, etc.) if mechanically worked and irrigated.

- Brown tropical soils

The richest soils of the Sahel zone, dense but not deep.

Very sensitive to erosion.

Varied crops possible (cotton, for example).



Source: Cartographie des pays du Sahel Ministère de la Coopération FRANCE

Fig. 5-2

MAURITANA
Soil Potentialities

5. MAJOR SOIL TYPES OF MAURITANIA

5.0 Introduction

Most soil studies in Mauritania have been linked to agricultura development, which explains why they often concentrate on the fertile Senegal River valley, rather than the other parts of the country, which do not have comparable hydro-agricultural potential. Studies of the Senegal River basin were begun by the Inter-State Committee, created in 1963 by Guinée, Mail, Senegal and Mauritania. This committee was replaced in May 1968 by the OERS (Organisation des Etats Riverains du Fleuve Senegal). In March, 1972, the OERS projects were transferred to the OMVS (Organisation pour la Mise en Valeur du Fleuve Senegal), created by the three nations bordering the Senegal River and concerned by the economic development of this zone (Senegal, Mali and Mauritania).

In the Senegal River basin, the annual flood deposits fertile silt and permits extension of cultivation to the oualo floodlands; during drier periods, its permanent flow permits sedentary cultivation.

Although the other zones of Mauritania do not have comparable potential, there are some zones which have been studied for agricultural development (with accompanying pedological studies). These zones are :

- the Gorgol Blanc and Gorgol Noir valleys
- the Boghé plain
- Lake Rkiz (Trarza)
- the Aftout-es-Saheli region
  (these four areas are part of the Senegal River zone)
- the Tamourt en Naaj valley, in the Tagant
- pedological studies in the Guidimaka
- the clayey basins of the Brakna (Aleg region)
- pedological studies of palm groves (Adrar, Assaba, Tagant, Kankossa station).

Certain pedological studies are linked to studies of natural vegetation and inventory of grazing lands in view of developing livestock in the southeast and southwest of the country. At present, there are no detailled pedological maps covering all of Mauritanian territory (average or large scale). There are two small scale maps, which give a general survey of the distribution of major soil types :

- a 1/6 500 000 map, in the Atlas de Mauritanie, which shows the soil types of the country
- a 1/500 000 000 map, in "Cartographie des Pays du Sahel", which shows both main soil types and their potentials.

These two maps, plus a few soils studies conducted in Mauritania, will be reviewed in this chapter, in order to define the main pedological areas of Mauritania and their relative importance.

5.1 Major Soil Types in Mauritania

According to Christian Barbey ("Atlas de Mauritanie", 1979) there are five major soil types in Mauritania :

- raw mineral desert soils
- young soils
- isohumic soils
- hydromorphic soils
- halomorphic soils

5.1.1 Raw Mineral Desert Soils

These soils cover a major part of Mauritanian territory. In areas where the extremely sparse rains and wide temperature variations do not favorize physical modification of the hard rocks, there is no topsoil. There is an almost total lack of vegetation. The raw mineral desert soils are classified as : complementary soils and ablation soils. The first are found in the great ergs, vast zones covered by wind-borne sands (the Mreyé, Ouarane, etc.) Ablation soils have developed on rocks altered in the past. They form regs of coarse sand, gravel or stones. These ablation soils are frequent in the north of the country.

5.1.2 Young Soils

These soils are still evolving and are thicker than the desert soils. Those which are of zonal origin are formed on sedimentary rock or eolian sands. Those which are not of zonal origin develop on the coastal sands or more or less clayey sand zones. One also finds little evolved soils forming on marine or lake deposits, and which are associated with saline soils.

5.1.3 Isohumic Soils

These are found in the semi-arid zones (steppe) and are characterized by a fairly large proportion of humus in the profile. These soils contain enough iron to give them a reddish coloration. They are found in the Trarza, the Akchar and the Azeffal. They are young or little evolved soils.

Some of these soils belong to the expanding clay classification (black clayey soils which form in hot regions during the dry season on ancient sandy-clayey alluvia). Others are found in ancient dunes (of different ages) and have been subjected to different climate conditions (grazing lands may develop on this type of soil).

5.1.4 Hydromorphic Soils

The characteristics of these soils are due mainly to the periodic or permanent presence of water. They are found only in the south of the country, along the Senegal River basin, where they have developed on alluvia, or in the Lake Rkiz region, where they have developed on clayey terrains.

When water is excessive, one finds hydromorphic gleyey soils.

These soils are very compact and impermeable. They are planted with millet and rice (irrigated rice in the Senegal River valley).

5.1.5 Halomorphic Soils (saline and halic soils)

These soils are characterized by the presence of sodium, potassium or other soluable chemical composits. They are found in the coastal region of Aftout-es-Sahéli, in the Delta, and in certain basins without flow to the sea : such as the N'dramcha Sebkha north of Nouakchott. In the interior they are represented in the Chemchane Sebkha to the northeast of the Adrar.

These soils are extremely compact and impermeable. The presence of chemical elements makes them totally unsuitable for cultivation.

5.2 Soil Potentialities

The table on the following page shows the different soil types, their potentialities and the areas where they are located in Mauritania (table adapted from ""Cartographie des Pays du Sahel", 1976).

Table 5-1

SOIL POTENTIALITIES

Type of Soil	Agricultural Potential	Location
Raw and little evolved desert and sub-desert mineral soils	Very low potential; irrigation of sub-desert soils possible, but at very high cost (oasis agriculture)	Northern half of Mauritania; the Aouker and the east (Majabat al Koubra)
Varied halo-morphic soils (saline and halic soils)	No agricultural value, unless high investments	West of Mauritania (Delta, Aftout-es-Sahéli)
Little evolved com-plementary soils	Can be used for agriculture if water and organic matter supplied (high costs)	Southern center of Mauritania (Mauritanides)
Raw mineral erosion soils (crusts)	Extensive grazing. When rainfall sufficient, crops in valleys and on gravelly soils around crusts. (2-3 to 5% of surface area)	Tagant, Assaba, Affolé, East.
Sub-arid Isohumic soils	Cultivation limited by weak rainfall. Varied crops possi-ble with irrigation and fertilizers.	West, Center and South West
Hydromorphic Soils	Varied chemical richness. Soils permanently or periodically saturated; requires drainage to cultivate. Possibility of varied crops and interesting potential for irrigated rice.	Senegal River Valley, Gorgol Valleys
Expanding Clays (Black tropical clays)	Rich soils, but heavy and requiring water. Difficult to work with traditional methods. Good yields with varied crops if mechanical working and irrigation employed.	Rare in Mauritania. Only a small sector in southeast point of country near Malian border.
Ferruginous and Ferralitic soils	Good yields for varied crops with fertilizers and if rains are good (plus protection from erosion)	Miniscule surface area at the border with Mali, in the extreme SW of Region 2 (West of Touil)

An anlysis of these two maps leads to the following remarks

Desert and sub-desert soils are most widely represented in Mauritania. They cover most of the north. They have little agricultural potential, due mainly to the extremely low annual rainfall in these regions.

Water is the limiting factor for almost all the soils inventoried. Insufficient rainfall is a grave obstacle to the agricultural development of Mauritanian soils, with the exception of the Senegal River valley, the oued valleys, the low lands and the rainfed (dryland) agricultural zone. Rainfed cultivation is limited to the north by the 350 mm isohyetal line and is practiced in some years only below the 450 mm isohyetal line (C. Toupet), which confines this type of agriculture to the extreme south of the country.

Improvement of the soils, outside of the zones favored by the availability of water, requires considerable investments for irrigation and fertilizers. Usually, the cost is prohibative.

5.3 BRIEF SURVEY OF SOME PEDOLOGICAL STUDIES IN MAURITANIA

5.3.1 Senegal River Valley(1)

Types of Soils and Crop Aptitudes

Almost all of the soils in the Senegal River valley present the following characteristics :

- they are composed of fine to very fine elements
- their structure is unstable
- they are impermeable or slightly permeable
- their bulk density is high
- they lack phosphoric acid, sulphur, nitrogen and have low organic matter content

These common characteristics do not exclude very marked differences, due to the degree of hydromorphology, and, in the Delta, the type of salinity.

The classification system given below takes into account the ORSTOM system, the FAO classifications and the USDA approximations (7th).

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(1) Based on an OMVS report, conducted by PNUD and FAO, 1977 : "Etude Hydro-Agricole du Bassin du Fleuve Sénégal - Rapport de Synthèse des Etudes et Travaux".

In the Senegal River Valley :

a) Raw complementary soils

Fluvial : bands of sand found mainly upstream from Kaedi. Non cohesive, very filtrating. Their position makes them inapt for continuous cultivation.

Eolian : sands of present and ancient dunes; not cultivable if saline.

b) Little evolved complementary soils

Modal : found in the upper part of levees, which are rarely flooded. Clay content less than 35% and clay + silt content less than 50 %. Good drainage, but settles under rains and becomes very hard when dry. Aptitudes for all crops.

Hydromorphic : Middle zone of periodically flooded levees. Medium texture, only the presence of deep gleys distinguish these soils from the above group. Drainage not as good.

Vertic : These soils are represented only in small lenses. Average texture with 48% clay on surface and less than 54% clay + silt. Low drainage.

c) Topomorphic granular expanding clays

These soils occur in the valley and small levees; they are of fine texture : 55% clay on the average. They are usually expanding clays, having gilgai with small bumps and very large shrinkage cracks. Average thickness of clay is more than one meter. Practically no drainage; large water reserves.

d) Hydromorphic Soils

These are the soils of the low areas, poorly drained, of fine to very fine texture. Both surface gleys and gleys throughout. Very poor drainage.

There are salty gley sub-groups in the Delta. In most of the geomorphic units, there are psuedogley sub-groups, with mottling and concretions, intermediates between the little evolved hydromorphic groups and the gley groups (sufficient drainage, good water reserves).

e) Brown-red isohumic soils (dieri)

These are soils of Ogolian sand dunes (red dunes dating from the dry Ogolian period (-20 000 to -10 000 B.P.) They are 95 % sand. These are good soils for either drip or sprinkling irrigation.

f) Halomorphic Soils

These soils are found in the Delta and in the low valleys up to Podor. This group includes :

- saline soils with superficial salt crusts, found in mud flats and decantation basins
- saline soils with superficial friable horizon, found in almost all geomorphological units in the Delta (salinity greater than 500 micromhos). No agricultural value.
- Saline-acid soils are the largest group. They are found throughout the Delta. They can be desalinized when good subsoil drainage exists.
- Halomorphic soils with degraded structure. These are alcaline soils. They are poorly represented and have no agricultural aptitude.

5.3.2 Soils of the Aftout-es-Sahéli[1]

(see map of major agricultural zones for location of Aftout-es-Sahéli region).

The Aftout-es-Sahéli soils are found on the large Nouakchott marine terrace, extending from the north at the level of Nouakchott to the south a few miles above Chott Boul. These soils are subjected to the influence of winds and the river delta floods. The main types of soils observed in this region are as follows :

a) Raw mineral eolian complementary soils of dunes and coastal belt - not usable for agriculture

These soils cover the zones of shifting sands along the coast or the ancient sands (coastal belt or northern zones) and enter into association, in the form of microdunes, with little evolved complementary and

(1) Source : "Aménagement de l'Aftout es Sahéli" - Interim report, Preliminary studies and Master plan. Annex 3, Pedological Report, IRM, SOGREAH, December 1974.

halic soils. These sandy soils (80 to 90 % sand) present no signs of evolving from materials deposited by the winds. Associations with raw mineral eolian soils are mostly seen in the north. They serve as grazing lands, and if protected against wind erosion, could benefit from limited irrigation projects (sprinkling or drip irrigation).

b) Little evolved complementary soils on marine terrace, texture light to medium, not deep, on sand

These soils cover the marine terrace. They are ferruginous soils, and their profile can be described as follows :

- superficial sandy-silt horizon several cm thick, color : brown-grey
- superficial silty-clay to clayey-sand horizon of from 20 to 30 cm thickness, color : grey-olive, coarse prismatic structure with shrinkage cracks or pockets of white sand.

  inferior horizons of sandy-silt or silty-sand, color : pale olive with brown-yellow ferruginous tubes. The pale yellow sandy to sandy-silty horizons, with ferruginous streaks in the form of brown-yellow tubes, are frequently separated by a level of several cm of arca senilis shells and sometimes by calcareous concretions

Iron content is usually greater than 0.5% and can attain 2 to 3 % in upper ferruginous horizons. This iron appears easily movable, and may block drainage by cementing sandy particles.

c) Halic Soils

These are the most widely represented soils in the study zone and are part of the sub-class with degraded structures. Besides the soils with saline crusts in the Sebkhas, these soils have variable salinity according to surface topography and to their topographic position (depth of salt water table from soil surface).

Conclusions

The common characteristics of these soils are :

- a pH higher than 7.0
- low to medium content of fertilizing materials
- presence of notable quantities of iron.

The base exchange capacity varies from 5 to 20 me/100 kg of soil. Calcium and magnesium are the dominant cations. In saline soils with fine textures, the proportion of sodium can reach more than 15% of the total cation exchange capacity. The hydrodynamic characteristics seem good, in spite of medium values for useful water capacity in the case of sandy-silt to silty-sand textures.

Land use must be based on the soils' aptitude for irrigation, potential and the nature of surrounding environment : topography and drainage. The classification system used is based on the general specifications of the US Bureau of Reclamations and permits classification of 5 Aptitude Classes, of which the largest 2 cover from 14 000 to 15 000 hectares.

These two classes are Class 3, lands which are irrigable after leaching and drainage, and class 5 lands, for which irrigable aptitude depends on the type of improvements planned.

Class 4 (limited aptitude) soils are located in the north of the zone and could be used for small vegetable farming, given major protection against wind erosion.
Part of the non-irrigable soils in the southern zone could be used for floodland pastures in the marl zones, if submersion improvements were undertaken.

5.3.3 Soils of the Boghé Plain(1)

Geographical Location

The town of Boghé is located on the right bank of the Senegal River. The town is separated into two parts by a marigot which runs from the river into the plain. The alluvial plain (surface area : 5000 hectares) is limited on the south and the west by the Senegal River, and in the northwest, north-east and south-east by the sandy highlands (called "diéri") which are never flooded.

(1) "Etude Pédologique de la Plaine de Boghé", J.H. Durand, 1974.

Geology- Geomorphology

The Boghé plain is located in the floodland terrace of the right bank of the Senegal River. To the north, it meets with Ogolian red sands (the "dieri"), parts of which are composed of colluvium ("djedjogol") more or less intermixed with the Senegal River alluvia. These formations date from the quaternary and have not elvolved since. However, the valley itself has seen more recent modifications, which began with the Ouljian transgression. During this period, layers of ferruginous gravel were deposited by continental waters. They are now buried. Since the Dunkerquian, a slight marine depression, accompanied by drying of the climate, has occurred and it is difficult to separate these gravels from older ramparts. In present times, light colored sands are being deposited; they constitute the present flood levees of the Senegal River. However, there are hardly any levees in the Boghé plain.

Types of Soils

Dieri Soils : These are brown steppe soils. They are zonal over all this region.

Dieri soils are of coarse texture, throughout the thickness of the entire profile. Color is a uniform reddish-brown. pH is neutral. Organic matter is not abundant, is poorly decomposed and distributed throughout the profile.

Vegetation is arbaceous, of the steppe type. There is poor aptitude for cultivation; there is little available water.

The topography of these soils (dunes) makes them difficult to cultivate over large areas. In spite of good drainage, they are difficult to irrigate.

Djedjogol Soils

These are soils with deep psuedogleys. Texture is variable, from coarse to medium. As they were formed on the dieri alluvia, their texture should be coarse, but since they have occasionally been flooded, dieri elements have been mixed with flood decantation elements.

There are practically no trees on this soil. Vegetation is of the herbaceous type (mainly vetivers).

These soils are never cultivated and serve as passage-ways between villages. Their pH is neutral or slightly acid, which shows a saturation of the absorption complex. Stability and permeability are relatively good. In spite of the slopes, these soils could serve for irrigated vegetable plots. The internal drainage is mediocre during the rainy season. There are two groups of djedjogol soils :

- djedjogol soils of very coarse to coarse texture, with good permeability and easy to cultivate, although having low water storage capacity, which requires frequent watering
- djedjogol soils with medium texture, less permeable, but having better water storage capacity.

Foundation Soils

Soils with deep psuedogleys.

These soils have the following characteristic in common : the presence of a gley horizon. While floods are too brief to have a determinant action on these soils, they are in contact with the flood-created aquifers, which last until the river waters receed.

"Kola Ouaka" Soils

Soils with deep psuedogley. Texture goes from medium to very fine. In certain cases, pH can attain 8.8 when the content of soluable salts rises in certain horizons. Organic matter is rare. Structure is unstable and permeability weak. These soils support sparse vegetation, herbaceous only. Their hydrological profile in the months of Feb.-March is markedly below the wilting point.

"Holaldé Baléré" Soils (Expanding Clay)

Morphologically, these soils present a well-formed crust with polygonal contours and shrinkage cracks, which are often large. Clay content may attain 87 %. There is little organic matter. pH can attain 8.5 in highly saline profiles of gley horizons, which begin at 70 cm. These soils cover the major portion of the Boghé plain.

Conclusions

The pedological study of the Boghé plain shows that there are a certain number of different soils with varied agronomic aptitudes. When determining the dosage and scheduling of watering, the storage capacity of the soil type must be taken into consideration, as well as the physical relief and the type of crop. If rice cultivation is undertaken, it should be associated with the planting of forage grasses to help regenerate the soil structure and improve fertility.

5.3.4 Pedological Studies of the Brakna Clayey Basins[1]

General Survey

The soils in these depressions include :

- raw mineral soils (soils having only coarse rock debris)
  - regosoils (stoney)
  - lithosoils (slabs and blocks)
- little evolved soils (recent alluvial deposits)
- hydromorphologic soils, which are submerged over more or less long periods
- brown steppe soils : these are zonal soils. They have the following characteristics :

(1) "Etudes Pédologiques des Cuvettes Argileuses dans le Cercle de Brakna", Centre Pédologique de Hann, ORSTOM, Dakar, Jan. 1960.

- diffuse accumulation of organic matter over a thickness of 7.50 cm, organic matter well-decomposed.
- slight individualization of iron-hydroxide, causing brown or reddish coloration of profiles, but not enough to cause formation of aggregates or indurated horizons.
- accumulation, both concentrated and diffuse, of calcium carbonate, between 30 and 200 cm. This characteristic is not seen in all types.

These soils are divided into two groups :

brown soils, characterized by a homogeneous profile, presenting only structural variations

brown-red soils, characterized by two horizons : a humiferous horizon of dark color and a humiferous horizon of reddish color.

This study does not give information concerning the agricultural potential of these soils.

5.3.5 Soils of the Assaba Palm Groves (Kiffa Region)(1)

The palm groves studied are located in the Kiffa Region between the 16° and 17° latitudes north and the 11°20 and 12° latitudes west. This region lies between the Affolé massif in the east and the Assaba massif in the west.

A certain number of palm groves are found at the foot of the Assaba sandstone cliff, between the cliff and the line of sand dunes bordering it. Besides the superficial formations (mostly eolian sands), one finds jasper, schists, sandstone and dolomite-limestone.

General Information

The zonal soils of this region belong to the sub-class of steppe soils, a group of brown tropical sub-arid soils.

Under the palm groves, to the north of Kiffa, the soils belong to the sub-group of brown soils.

(1) F. Dugain, "Prospection des Palmeraies de l'Assaba en vue de leur Possibilité d'Extension", 1960.

In the south, however, the soils become brown-red, the brown soils only developing in areas where drainage is poor. The brown soils of the palm groves, due to their proximity to water, are almost always more or less hydromorphic (as a function of their closeness to the aquifer).

Due to evaporation, the surface holds a certain number of soluable salts; while they do no change the soil's appearance, they confer certain chemcial properties. When the aquifer is quite close, hydromorphic soils are found; they are not suitable for palm cultivation.

Near the Assaba cliffs, colluvial soils are found, of heavy texture and very compact.

Properties of the main soil types

Brown soils :

- typical brown soils : these soils are not frequent because of the topography. A fairly dark brown horizon, with less than 1% organic matter. Texture is sandy and the proportion of fines (clay and silt) is not more than 10%. The absence of colloidal fractions causes very low exchange capacity. There is little calcium, but notable magnesium content. There is generally little sodium; potassium content is quite variable.Given this "over-saturation", it goes without saying that pH is always higher than 7 and often attains 8.
- deep hydromorphic brown soils : They are differentiated from the above soils by the presence of a more clayey horizon, which is a little more compact. The colloidal fraction is a little higher, giving exchange capacity and higher water characteristics; however, their properties are essentially the same as the typical brown soils.

Saline soils (alkaline soils):
In the field these soils do not show particular characteristics, but analysis reveals that the pH attains extremely high values (up to 10). Organic matter is quite dispersed, making percolation difficult. These soils are not very fertile and seem to have little aptitude for cultivation.

According to the soils observed in the palm groves, those soils valid for agriculture are the soils where :

- the aquifer is not less than 4 meters away
- hydromorphy is not too accentuated

5.3.6 Soils of the Kankossa Palm Groves (1)

The station of Kankossa (covering about 75 hectares) extends over one of the plains on the edge of the Kankossa pond. The valley is dominated on the west by sandstone cliffs of the Assaba range, which is the southern prolongation of the Tagant massif.

The petrographic nature of the rocks in this catchment basin and the hydrologic regimen of the Karakoro control the nature of the sediments which give rise to the soils of this date cultivation station. The geology of the region can be summarized as follows :

- at the base, an eruptive hardpan from the PreCambian age, represented by granite and gneiss outcrops in the Loudeye oued course to the southeast of Kankossa.
- a layer of phtanites
- a layer of schistoid jasper outcropping under the Dreha dunes. This series begins by a schist-dolomite conglomerate visible 8 km to the south of the station.
- a very large sandstone complex forming the Assaba and Tagant massifs. These are more or less ferruginous siliceous sandstones from the Devonian age.
- a very sandy quaternary cover.

(1) R. Maignieu : "Les sols de la Station I.F.A.C. du palmier-dattier à Kankossa", 1955.

Numerous borings at this station have shown that the water table has a low salt content.

Soil Types

The soils observed were very homogeneous. They are steppe soils, characterized by accumulations of little-decomposed organic matter and the beginnings of iron individualization. These two factors give the general brown-red coloration of the soils. In low areas, where water drains poorly and flows only partially during the rainy season, brown-black hydromorphic soils develop.

According to the zonal classification of these soils (action of atmospheric climate), the evolutionary trend of the well-drained soils of the Kankossa region make them typical brown-red soils. The horizon is grey-brown to reddish-grey, with humerous partially decomposed vegetable debris. The thickness of this horizon can attain 80 cm. Following, there is a very characteristic brown-red to reddish horizon, 5 to 200 cm thick, and then the mother-rock, which in this case is an essentially quartz sand of yellowish-white. There is slight ferruginous rise accumulation directly beneath the humiferous horizon, which renders the horizon slightly hardened by dessication. The phenomenon of leaching during the rainy season and that of rise during the dry season partially cancel each other out, with a very slight predominance of leaching.

Hydromorphic soils are only found on the edge of the station and widely along the Kayes road. They are located in the more depressed areas, where water accumulates during the rainy season. Vegetation is almost purely Balanites egyptiaca. These soils are characterized by a brown-black or grey-brown horizon (horizons are little differentiated by color). The profile whitens suddenly upon contact with the water table, which is never very deep (100 to 150 cm), due to the oblique leaching created by the water. Large roughly cubic clods form, moving in the direction of the slightly inclined surfaces.

Between the brown-red silts and the hydromorphic soils, there is another category, which are morphologically brown soils.

Their position near the hydromorphic soils has strongly influenced their evolution. Humidity from the hydromorphic soils permits the rise of solutions from the brown soils well into the dry season. The result is a soil identical to brown steppe soils, usually situated in dryer zones.

Soils are not only a function of the climate, but depend on a total of factors. For sub-arid regions, these factors are :

- climate
- water
- chemical richness of mother-rock
- texture

For this region in general, and this station in particular, there exists a regular succession of well individualized soils; from high to low, according to topographic position and drainage :

- well-drained brown-red soils, characteristic of the region
- brown soils, where leaching and rise cancel each other
- hydromorphic soils, water dependent

To these three types of soils must be added the saline soils. However, they are very sporadic in this region, and none were found in the station itself.

5.4 General Conclusions

These different pedological studies are quite unequal in size and quality. Many of them do not provide information concerning crop aptitudes, which is necessary if they are to be employed for agriculture.

As has already been mentioned, there is an unequal distribution of soils studies between the Senegal River valley and the rest of the country. (All the studies conducted in Mauritania were not discussed in detail, as the objective of this chapter is to provide a rapid pedological survey of Mauritania.)

Given the present lack of information, a pedological survey concerning all of Mauritania should be undertaken, to provide knowledge of the distribution of soil types suitable for cultivation. This pedological inventory should preferably be of scale : 1/200 000,based on the IGN topographical maps of the same scale, and indicate the hydrographic network, which is one of the major factors for the development of agriculture in Mauritania.

This chapter would not be complete without mentioning the problem of the degradation of Mauritanian soils. Almost everywhere in the country, one can find shifting sand dunes. On the Akjoujt road, for example, the barkhanes (crescent-shaped dunes) impede traffic. On the Nouakchott-Kiffa axis, dune invasions are frequent. In the Trarza, red dunes which were formerly fixed by vegetation are beginning to shift again. Other examples abound.

This increasing wind deflation is explained by the prolonged drought, which has killed a great number of trees.(The situation is particularly acute in the Trarza region) and considerably reduced the herbaceous carpet during the rainy season (many annual grasses stopped growing from lack of water, never matured and produced no seed). In addition, massive over-grazing and cutting of branches occurred. The impact of the drought was much worse in zones with high human and animal propulations.

As the drought is continuing, the situation shows signs of worsening. Winds blow across the bare land and rip up fine soil particles from the surface; wind force is such that considerable masses of sand can be moved.

In many regions, the A Horizon (humiferous) has completely disappeared (Trarza, Brakna, etc.), revealing the B Horizon (accumulation), which is quite indurated and tampered on the surface. The volume of wind deflation can be noted particularly around trees, many of which have their roots exposed to the air. This demonstrates the large quantities of soil torn away by the winds.

Rain water erosion is also increasing as the soils become progressively more barren.

Between the winds and the rains, immense volumes of soil are eroded each year.

These soils are a precious resource for agriculture and livestock. If actions are not taken to arrest soil degradation, an irreplacable part of the national patrimony will progressively disappear.

CHAPTER 6

MAJOR VEGETATION GROUPS AND GRAZING LANDS

6. MAJOR VEGETATION GROUPS AND GRAZING LANDS

6.0 Introduction

The latitude and the major geomorphological features determine the distribution of natural vegetation in Mauritania.

The density of the vegetable cover decreases from the south to the north, in direct relation to the volume of annual rainfall. In the extreme south (Guidimaka) and southeast, where annual rainfall is from 650 mm to 450 mm, the savanna is studded with trees and shrubs, and one finds Soudanian species such as Adansonia digitata (Baobab) and grasses such as Andropogon. Farther north, the savanna is progressively transformed into Sahelian steppe, where only shrubs may grow; finally, in the Sahara, the land becomes desert steppe.

Locally, geomorphological conditions may change the composition of vegetation groups and may even modify the physionomy of plants.

Within the major climate zones (limited by the isohyetal lines) and geomorphological units, natural vegetation constitutes pastures, of which the extension and quality are variable as a function of

- topography
- rock in situ
- soils
- human activities (cultivation, livestock, wood cutting, etc.
- population density
- local rainfall (perturbed during drought)
- micro-climates (shelters)

The Drought and Vegetation

The drought which began in 1968 has had severe repercussions on the vegetation of Mauritania, on several levels :

- Due to insufficient rainfall over several years, trees have died, completely withered. This is the case of Acacia senegalensis, of which more than 50 % of the individuals have died, especially in the Trarza (as was seen during a RAMS visit to this region, June 17-19, 1979).

  For the Guiera senegalensis, 63% of the trees may have died[1]. 20% of the Balanites aegyptiaca died in 1972-73 on the Karakoro dunes[2]. The 1972-73 drought was the most destructive for vegetation.

- Other destructive effects of the drought on the vegetable cover were :
  - delayed leafing
  - shortened flowering
  - frequent absence of fruit and seeds

- The massive cutting of branches in order to feed livestock (due to lack of grasslands during the drought and dry season) finished off a number of trees that were already in very poor condition.

- The concentration of herds around a reduced number of water holes (certain having been dried up by the drought) provoked excessive over-grazing, degrading the vegetable cover even further.

- The herbaceous cover (composed mostly of annuals, with Cenchrus biflorus dominant) was less affected. It was reduced, especially in 1972-73, in localized areas of the southwest, which received very deficient rainfall (60% at Kaédi, 80% at Rosso and Boutilimit).[3]

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(1) H. Poupon : "Influence de la Sécheresse de l'année 1972-73 sur la Végétation d'une Savane Sahélienne du Ferlo Septentrional (Sénégal)" - Nouakchott Colloquium, 1973.

(2) J. P. Hervouet : "Stratégies d'Adaptation Différenciées à une Crise Climatique - L'exemple des Eleveurs Agriculteurs du Centre Sud Mauritanien", 1969-1974, page 79.

(3) J. Rotert Pitte: "La Secheresse en Mauritanie", Table p. 645, Rainfall Deficit 1971-73, Nouakchott Colloquium, 1979

The drought shattered the already precarious equilibrium between the environment and the herds of livestock, which had increased due to vaccination programs and a long period of clement years. The effects of the drought on the environment were more or less severe depending on the burden of men and animals in a given region.

The southwest was affected more severely, due to high rainfall deficits and the large concentrations around water holes in the Trarza and the Brakna. (This problem will be discussed in the chapter concerning livestock - See map of wells in this chapter).

Given the above observations, one can see that the pasture lands of Mauritania are quite fragile and that the potential for exploitation is quite variable.

6.1 Major Vegetation Groups

The major vegetation groups identified in Mauritania correspond to specific environments :

- the Senegal River valley
- the Sahel
- the salt lands
- the Sahara

6.1.1 The Senegal River Valley (see sketch in Chapter : Major Cultivation Zones)

There are four subdivisions :

- the Oualo : in the Senegal River valley, the Oualo vegetation is dominated by the presence of a forest (very degraded) composed of a sole species of tree : *Acacia nilotica*, which populate the depressions of the major river bed, covered each year by floods (Oualo).
- the Falo : the willow groves (*Salix colutëoides*) along the banks of the minor river bed (Falo)
- the Fondé : a mixed marginal forest of the non-flooded zones (transition area from Oualo to Diëri.)
- the Diëri: this zone is not flooded and is a zone of rainfed cultivation. Downstream appears tree-studded steppe and upstream, dense shrub-covered savanna.

The inundatable Oualo forest is a well-developed high forest composed exclusively of Acacia nilotica, the leaves of which joint to form a continuous green canopy. The trunks are black; tanin is extracted from their bark.

These trees have the characteristic of being able to withstand total immersion of their roots, and often their trunks, every year during several months.

In cleared zones, the forest has been replaced by grasslands, almost exclusively composed of Vetiviera nigritana.

Exploitation of Gonakié trees (Acacia nilotica)

The Acacia nilotica forest in the Senegal River valley is the major source of wood charcoal in Mauritania. This tree furnishes an excellent wood for charcoal; this situation has led to intense degradation of the Gonakié forests due to over-exploitation. The Acacia nilotica populations are found in all the middle and lower valley of the Senegal River, from Gouraye to the Delta. However, due to the stricture of the valley immediately downstream from Gouraye and the excessive salinity of the Delta water, one only finds real Gonakié forests between Waoude and Rosso (about 400 km).

Extensive clearing has almost supressed all forest vegetation on the left bank (in Senegal) between Matam and Saldé, and on the right bank (in Mauritania) around Boghé and downstream from Podor.

Classified forests (surface area): in 1972, according to forestry expert R. Perraudin[1], there were about 20 000 hectares of classified forests in the Senegal River valley. The cutting of wood and the extension of floodland agriculture have seriously reduced the Gonakié forests. Those that have subsisted are found mainly in the depressions unsuitable for cultivation.

Gonakiés are also found outside the Senegal River valley : in the Gorgol valley, in the Brakna, in the Tagant (Tamourt en Naaj), at Tamchakett (where a large 25 km long classified forest is found in the Tamourt Tamchakett), and elsewhere when conditions are favorable : around the temporary ponds of the Sahel (up to the 200 mm isohyetal line in the north) and in oued lowlands.

(1) R. Perradin, "Rapport sur les Missions Effectuées en Mauritanie, au Sénégal, au Soudan".

However, the real "forests" are located in the Senegal River valley. Elsewhere, the Gonakié trees form only small groves.

The degree of degradation may be appreciated by remarking that in Mauritania, 500 000 tons of Gonakié wood are used each year for fuel or to produce wood charcoal(1). In the Senegal River valley most degradation of vegetation is the result of population density (which can surpass 20 inhabitants/km2 around Kaédi)(3). These are mostly sedentary farmers.

6.1.2 The Sahel

Located on the edge of the desert, the Sahel extends from the 600 mm isohyetal line in the south to the 150 mm isohyetal line in the north. In the extreme south of the courtry (600 mm to 450 mm rainfall), one finds "Sahelo-Soudanian" savanna, with large trees sticking out from a carpet of high grasses. Farther north, groves of Acacia and some tufts of grass compose the steppe landscape, the vegetation becoming more and more sparse as one approaches the Sahara.

The different vegetation groups of the Mauritanian Sahel cover about 300 000 km2(3), from the northern limit of the 200 mm isohyetal line, which corresponds roughly to the northern limit of cattle raising, which may attain the 150 mm line.

According to Mame Seck Diack(4), four vegetation groups are found in the Mauritanian Sahel (see map of vegetation groups).

6.1.2.1 The Combretum glutinosum Group

This group runs along the Malian border in the southwest of the Guidimaka; its northern limit is located below the 16° latitude. The tree stratum is dominated by Combretum glutinosum, and includes some Soudanian species such as Adonsonia digitata (Baobab), Sclerocarya bierra , and many acacias, of which

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(1) "L'Elevage et les Forêts en Mauritanie" - Situation actuelle, Recommandations, Propositions de Projets - FAO, Rome, 1975, P. 20 (5-2)
(2) Atlas de Mauritanie, 1977, p. 35
(3) "Elevage et les Forêts en Mauritanie", op. cit., p. 13
(4) Atlas de Mauritanie, op. cit., p. 24

Acacia senegalensis (gum tree). The herbaceous strata are formed of dense carpets of high grasses, such as Andropogon gayanus, which often grow higher than 1.50 m in the rainy season.

6.1.2.2 The Acacia senegalensis Group

This group exists mainly in the dune regions of the Sahel, from the Trarza up to the Tilemsi, in the Hodh, and to the east of the Dhars Néma, near the Malian border. To the west, this group reaches the 20° latitude north (or just under the 150 mm isohyetal line). To the east, it reaches 18° latitude north, between the 200 mm and 150 mm isohyetal lines.

Acacia senegalensis dominates, acompanied by Balanites aegyptiaca, Leptadenia pyrotechnica, and the herbaceous carpet is composed of grasses, in particular, Cenchrus biflorus ("cram-cram"), which dominates, and Chloris prieuri.

The disappearance of Gum Trees (Acacia senegalensis)

As mentioned above, the Acacia senegalensis has been severely affected by the drought, especially in 1972-73. According to our estimates(1), for the Trarza region more than 50% of individuals died from drought.

H. Poupon(2) estimates the loss at 53.2% in the Senegalese Sahel (northern Ferlo region).

The decrease in gum arabic production reflects this situation(3) summarized in the following table :

Table 6-1

Year	Production (tons)	Price (UM/ton)	Value (millions UM)
1968	4 670	14 770	69.0
1969	5 324	16 990	90.4
1970	7 318	21 840	159.8
1971	5 364	20 880	112.0
1972	5 738	18 940	108.8
1973	885	35 800	31.7

(1) RAMS Mission to the Trarza, June 19-21, 1979

(2) "Influence de la Secheresse de l'Année 1972-73 sur la Végétation d'une Savane Sahélienne du Ferlo Septentrionnal", Nouakchott Colloquium, 1973.

(3) "Elevage et les Forêts en Mauritanie", op. cit., p. 4

The spectacular regression of 1973 production was due to the drought and even lower levels may be reached before energetic measures are taken to protect the gum trees[1].

At present, there are 53 000 hectares of classified gum tree forests[2], but they are poorly supervized by the Nature Protection Service, due to insufficient means and personnel.

The Balanites aegyptiaca, on the other hand, have fairly well withstood the drought. They are omnipresent in suitable areas, and in the Trarza, it has become the dominant tree in zones where Acacia senegalensis has practically disappeared.

6.1.2.3 The Commiphora africana Group

This group occupies only clayey soils :

- the the west, in the Brakna rag
- in the east, in the Hodh pellites and the colluvium glacis below the Dhars Nema and Oualata.

Its northern limits attain almost 17° latitude and the southern limit is a little below the 16° latitude.

Note : To the east of Akjoujt, one finds islets of Commiphora africana, up to the 20° latitude north.

Boscia senegalensis and Capparis decidua often accompany Commpihora africana on clayey soils.

6.1.2.4 The Ziziphus mauritiana (Jujube tree)

This group is found on clayey soils between M'Bout and Magta-Lahjar and Moudjeria, between 16° and 19° latitude north. The jujube tree dominates, associated with a small acacia, Acacia seyal.

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(1) "L'Elevage et les Forêts en Mauritanie", op. cit.,p. 4

(2) Ibid., p. 18

6.1.3 The Salt Lands

Salt lands form a narrow coastal strip from the Senegal River Delta to Cap Blanc (Nouadhibou) and are represented in the interior of the country by numerous Sebkhas.

The salt lands are characterized by flat relief. Between the Delta and Nouakchott, separated from the sea by a coastal belt, the Aftout-es-Sahéli salt lands are characterized by heavily saline soils. They are populated by specifically halophytic species, such as Tamarix senegalensis (a favorite food of camels). The low lands are populated by tufts of halophytes : Salsola baryosma, Salicornia senegalensis, etc. (these plants are also appreciated by camels).

The coastal dune belts support Euphorbia balsamifera bushes. (Projects for the improvement of the Aftout-es-Sahéli and Senegal River Delta regions will be discussed in paragraph 6.2.5.)

6.1.4 The Desert

The Sahara desert is essentially a "mineral" world, where vegetation is very sparse. The transition zone between the Sahel and the Sahara occurs roughly between the 100 mm and 200 mm isohyetal lines (1). In this zone, stunted and sparse vegetation exists only in sheltered areas, having a little humidity : in dune hollows, the flanks of guelbs and along fossil oueds.

The presence of sand substratum or rocky substratum influences vegetation. Aristida pungens (a grass) grows on sand, while Aristida pappose (a grass) grows in the rags. There are quite a few Sebkhas in this zone, from the Ndghamcha Sebkha to those of Chemchane and Ej-jill: they are surrounded by halophytic steppe plants, dominated by Salsola foetida.

Vegetation becomes poorer as one goes from the coast towards the interior. In the heart of the desert, the most extreme degree of vegetation poverty is attained in the immense Majabat al-Koubra (central eastern Mauritania), where Professor T. Monod calculated a vegetation richness rate of 4, one of the lowest in the world(2)

(1) "La Mauritanie", Collection "Que sais-je?", page 9, PUF; 1977, Charles Toupet and Jean-Robert Pitte.

(2) Number of vegetable species over a surface area of 10 000 km2.

In Mauritania, two vast vegetation groups occupy the Sahara

6.1.4.1 The Stipagrostis pungens Group

This group occupies sand-covered regions. It is found essentially in the Majabat al-Koubra and is characterized by large scattered tufts of "shatt" (the Hassanya word for Stiagrostis pungens, a hardy grass).

6.1.4.2 The Acacia tortilis s. s. raddiana Group

This group extends over all the Regeibat Dorsal and the Atlantic Sahara to the north of the Akchar and Azzeffal dunes. Along the Atlantic coast, the maritime alizé winds, frequent fogs and dews maintain scattered growth of trees, in spite of the extremely sparse rainfall. The Acacia raddiana dominates by far. Herbaceous cover is represented mainly by Panicum turgidum.

6.2 Pasture Lands

The distribution of major vegetation groups discussed above will serve as a basis for the study of Mauritanian grazing lands. "Grazing lands" (or"pasture") in this intertropical environment include both grasses and ligneous forage (trees and shrubs), of which the anmials eat the leaves and fruits during the "hungry gap" at the end of the dry season. These ligneous forages are called "aerial pastures".

Major Pasture Units :

Most grazing lands are found in the Sahelian and Sahelo-Soudanian areas (i.e., roughly about the southern third of the country). In the Saharan areas which cover most of the country, one finds only "spontaneous pastures" (Acheb), which spring up after a rare rainfall, and rarely at the same place from year to year.

Only the pastures below the 200 mm isohyetal line can be exploited in a rational manner. Annual rainfall is the characteristic which determines the main pastoral vegetation groups, within which pastures have different potentialities according to geomorphological criteria. Productivity varies from year to year according to rainfall. In Mauritania,(and in the Sahel in general), there are five major pastoral units :

- the sub-desert Sahel
- the typical Sahel
- the Sahelo-Soudanian border
- the Senegal River valley
- the salt lands (Aftout-es-Sahéli)

These pastoral units will be examined below : (see Table 6-1, "Sahelian Pastures in Mauritania").

6.2.1 The sub-desert Sahel

This region is characterized by an insignificant period of active pasture. The climate is Saharan, with annual rainfall of less than 200 mm (variation coefficient close to 30%). The 200 mm isohyetal line for normal rainfall over the last 30 years corresponds roughly totthe southern limit of this sector. In Mauritania, the sub-desert Sahel covers a narrow strip from Nouakchott in the west to Tidjikja in the center. In the east, the Majabat al-Koubra is a vast empty zone, a desert, which cannot be included in this category.

The southern limit of this zone is around the 17th parallel in the west, rising to the 18th parallel in the center of the country.

Productivity of Pastures (1)

In the sub-desert Sahel, productivity for an average year is relatively low. On sandy dunes with a vegetable cover of 5 to 10%, and a tuft height from 15 to 30 cm, potential production is about 400 kg/hectare of dry matter. On the sandy and silty peneplains, potential production can reach 500 kg/hectare of dry matter.

6.2.2 The typical Sahel

This region is characterized by Sahelo-Soudanian sub-desert climates, with an active pasture period of about one month (August), and a rainy season which lasts from 2 to 2 and 1/2 months.

The average annual rainfall varies from 200 mm in the north to 400 mm in the south.

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(1) "Les Systèmes Pastoraux Sahéliens", FAO, Rome, 1977.

The southern limit is roughly along a axis from Kaëdi to south of Kiffa and Abdel Begrou in the east.

Productivity of Pastures(1)

On sandy dunes, the herbaceous carpet can attain 50 cm height and coverage of 40%. However, the carpet is not continuous, barren plains occupy more than 30% of the land. The potential production is estimated to be an average 1000 kg/hectare of dry matter. In some areas, production may attain 2 tons.

In the shady inter-dune hollows, production may attain 3 tons.

On the sandy peneplains, the herbaceous carpet can be 50 cm high with 50% coverage, giving a potential production of 1200 kg/hectare of dry matter.

On silty and clayey peneplains, potential production is variable; it can attain from 1 to 3 tons.

On skeleton soils, more or less covered with sand or silt, the herbaceous carpet is discontinuous. Bare soil beaches may represent 75% of the landscape. Potential production varies from 0 to 1800 kg/hectare of dry matter; average production is estimated at 800 kg.

6.2.3 The Sahelo-Soudan Border

This is characterized by a dry tropical Sahelo-Soudanian climate. The active pasture period is about 3 months. Rainfall varies from 400 mm in the north to 500-600 mm in the south. In Mauritania, this zone covers the southeast below the 400 mm isohyetal line (including the Guidimaka).

Productivity of Pastures(2)

On sandy dunes, potential production varies from 1300 to 2000 kg, with an estimated average of 1500 kg/hectare of dry matter. On sandy peneplaines, potential production varies from 900 to 1500 kg; the estimated average is 1200 kg/hectare of dry matter. On silty-clayey depressions, potential production varies from 2 to 5 tons/hectare of dry matter; the estimated average is 3000 kg/ha. On skeleton soils, potential production is quite variable; an average estimate gives 800 kg/ha of dried matter.

(1) "Les Systèmes Pastoraux Sahéliens", FAO, Rome, 1977.

(2) Ibid.

6.2.4 The Senegal River Valley

There are few floodplain pastures in Mauritania. They are found mainly in the valleys of the Senegal River and the Gorgol Rivers, in the Oualo, the part inundated by yearly floods.

Productivity of Pastures

We do not have any information concerning natural pastures. However, irrigated plots are envisaged in the Senegal River valley, which will permit an increase of forage production, while avoiding climatic risks, by the practice of double or triple crops each year.

Table 6-2

FORAGE	YIELD PER SEMESTER (Tons/hectare)	UF/kg[1]	UF/hectare
Forage Sorghum	90 - 100	0.13	11 700-13 000
Forage Corn	65 - 75	0.22	14 300-16 500
Forage Niébé	60 - 66	0.20	12 000-13 200
Rice Straw	5 - 5	0.35	1 750
Sorghum Stalks	4 - 4	0.25	1 000
Corn Stalks	3 - 3	0.25	750

(For purposes of comparison, a pasture in Normandy produces an average of 30 000 UF/hectare/year.

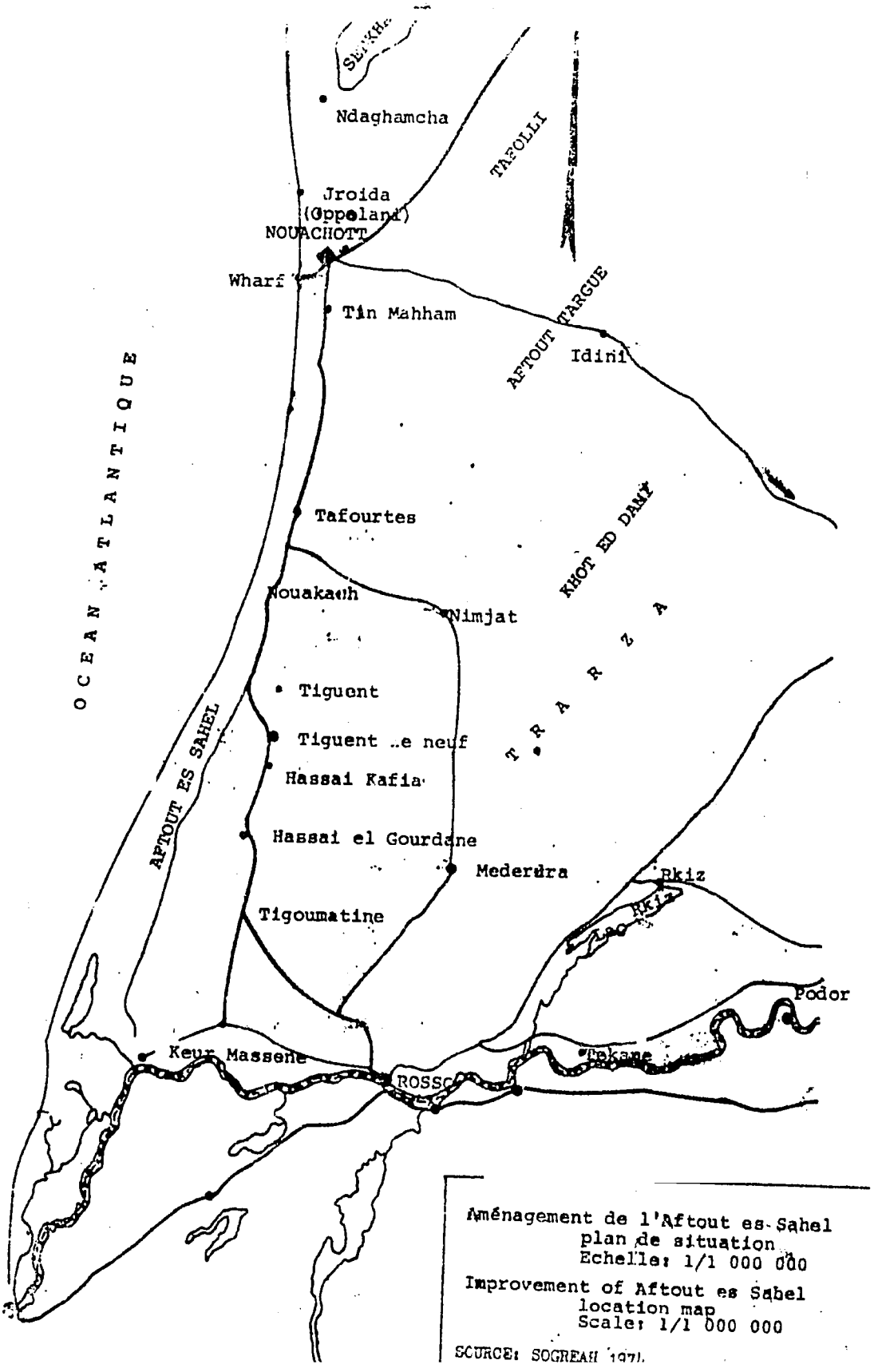
6.2.5 Salt Land Pastures (Aftout-es-Sahéli)

(see location map)

The Aftout-es-Sahéli is a long depression extending from the Senegal River Delta to Nouakchott, between a belt of coastal dunes and the Trarza dunes. It is about 170 km long; width is from 4 to 10 km, and it covers a surface area of about 1 000 km2.

The climate is sub-Canarian, relatively temporate due to the proximity of the ocean. Annual rainfall is about 120 mm in the north and 300 mm in the south of the Aftout, distributed over 4

(1) Energy value of forage expressed in "Unités Fourragères" (Forage Units). One UF is the equivalent of 1 kg of grain barley, which provides 1650 calories to ruminants.



Aménagement de l'Aftout es-Sahel
plan de situation
Echelle: 1/1 000 000

Improvement of Aftout es Sahel
location map
Scale: 1/1 000 000

SOURCE: SOGREAH 1971.

months (July to October) Potential evapo-transpiration is 2000 to 2800 mm.

Various studies have been conducted in this zone, especially by the Mission d'Aménagement du Fleuve Sénégal (MAS)[2]. One problem studied was the desalinization of the soil, in order to improve pasturelands, by flooding about 50 000 hectares.

The Sebkhas (depressions having high salt content) cover about 30 000 hectares in this region (they support no vegetation). Alluvial terraces cover about 50 000 hectares (of which 15 000 are of good to average suitability for irrigation).

Hydrology[2]

The Aftout-es-sahéli is inundated very irregularly by high floods from the Senegal River, during the rainy season. Complete floods occur only 4 or 5 years out of 100 (inundation depth = 1 to 3 meters).

At present, the Aftout-es-Sahéli has a few floodland pastures, (and a little pisciculture). A SOGREAH improvement project envisages the creation of floodland pastures over 15 000 hectares (first phase) to be extended by 8 000 more hectares (second phase). The projected production of these pastures[3]: at the beginning, 300 UF/hectare. The project envisages an eventual production of 7 780 00 UF, which would permit the supply of meat and milk for Nouakchott.

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(1) Besides the MAS study, other studies meritting mention :

- "L'Aftout es sahéli mériodional et ses bordures (Région de Keur Macene, Mauritanie)". Etude géomorphologique, Université de Dakar, July 1977, by Amadou Tidiane Ly.

- "Aménagement de l'Aftout es sahéli. Rapport Intermédiare, Etudes préliminaires et schémas directeurs d'aménagement", IRM, Min. de Developpement Rural, SOGREAH, Dec. 1974, Contrat ET. 1-74 SAR.

(2) Fiches de Projets d'Aménagements Hydro-Agricoles en Mauritanie, CILSS, Equipe des Cultures Irriguées (court et moyen terme)

(3) Third Economic and Social Development Plan (p.154), 1976-1980, Ministère du Plan et des Mines, IRM.

Table 6-3

SAHELIAN PASTURES IN MAURITANIA

(Total surface area : 300 000 km2)

Sahel Sub-Divisions	Rainfall	Production Potential of Pastures	Location
Sub-desert Sahel	150 to 200 mm Variation coefficient around 30%	Relatively low. Average year: 100 kg/ha dry matter on sand dunes and 500 kg/ha dry matter on sandy-silty peneplain.	Limit around 17th parallel in west rising to 18th parallel in center near Tidjikja. The Majabat al Koubra is desert.
Typical Sahel	Average annual rainfall varies : 200 mm north 400 mm south Rainy season : 2 - 2 1/2 months.	Active pasture about 1 month (Aug). 1000 kg/ha dry matter on sandy dunes, can attain 2000 kg locally, 3000 kg/ha in shady hollows, 1000 - 3000 kg/ha on silty-clayey peneplain, 0-1800 kg/ha (average:800) on skeleton soil covered by sand or silt.	Southern limit roughly along axis Kaédi - south of Kiffa - Abdel Begrou in south east.
Sahel-Soudanian Border	400 mm in north to 500-650 in south	Active pasture period : about 3 months. 1300 kg/ha to 2000 on sandy dunes, 900-1500 kg/ha of DM (estimated average:1200 kg) on sandy peneplain, 2000-5000 kg/ha on silty-clayey depressions (average : 3000 kg/ha), 800 kg/ha of DM on skeleton soils.	Southern part of southeast Mauritania, including Guidimaka.
Senegal River Valley			
-Oualo floodland Pastures	300 mm in north to 650 mm in south (Senegal and Gorgol Rivers)	No information on productivity of natural pastures.	Oualo of Senegal and Gorgol Rivers. Very small areas. Lake Rkiz : 5000 to 6000 ha floodland pastures. Project for 10 000 ha.
-Irrigated Pastures		Example : 90-100 t/ha/semester for forage sorghum to 3 t/ha/semester for corn stalks.	Few irrigated pastures : -Kaédi ranch -Rosso center

SAHELIAN PASTURES IN MAURITANIA
(continued)

Sahel Sub-Division	Rainfall	Production potential of pastures	Location
Coastal Salt Lands	120 mm in north to 300 mm in south. PET : 2500 to 2800 mm.	Project for creation of floodland pastures : 300 UF/hectare.	Narrow coastal strip from the Senegal River Delta to Nouakchott.

6.3 Study and Cartography of Pasturelands

There exists a very large study financed by the FED, entitled "L'Elévage au Sud-Est Mauritanien"(1), in four tomes. The first tome is entitled "Pastures, Climate and Forage Production". An 8-color polychrome 1/200 000 map of the pastures in the south was established.

Pasturelands are divided into 5 major categories, relative to forage values :

1. Good pasturelands
2. Average to good pasturelands
3. Mediocre pasturelands
4. Mediocre to very poor pasturelands
5. Very poor pasturelands

These categories correspond to geomorphological units. The different types of pasturelands will be discussed later in the text.

This study also divides the southeast into 4 major botanical zones, on the basis of average annual rainfall. The following table shows the dominant grasses, shrubs and trees within the major botanical zones (see map of major botanical zones in southeast).

(1) "L'Elévage au sud-est Mauritanien, Pâturages, Situation Actuelle, Programme de Développement"; Tome 1 : "Pâturages, Climat et Production Fourragère", FED, IRM, SCET International, July 1976.

Table 6-4

Botanical Zones	Annual Rainfall (mm)	Vegetation - Grasses	Dominant Species - Trees and shrubs
I	200 to 300	Cenchrus biflorus Panicum turgidum Aristida mutabilis	Acacia raddiana Leptadenia sptartium Commiphora africana Acacia senegalensis
II	300 to 400	Cenchrus biflorus Artistida mutabilis Schoenefeldia gracilis	Acacia raddiana Acacia senegal Balanites aegyptiaca Combretun aculeatum Maenua crassifolia
III	300 to 500	Schoenefeldia gracilis Aristida mutabilis Eragrostis tremula Cenchrus biflorus	Combretum glutinosum Acacia senegal Acacia seyal Balanites aegyptiaca Guiera senegalensis Grevia bicolor Adansonia digitata
IV	400 to 600	Schoenefeldia gracilis Aristida mutabilis Eragrostis tremula (Loudetia togoensis) (Cenchrus biflorus) (Andropogones)	Comretum glutinosum Acacia seyal Acacia senegal Balanites aegyptiaca Adansonia digitata (Piliostigma reticulata) (Sterculia setigera)

The main characteristics of the pasturelands are inventoried in the following table : (1)

Table 6-5

PASTORAL CHARACTERISTICS

DEFINITION OF STRATA	CLASSIFICATION OF MAIN PASTORAL CHARACTERISTICS			
	Discontinuous and sparse	Discontinuous and dense	Continuous and sparse	Continuous and dense
Aptitude for conservation of un-cut forage	Poor to None	Poor	Average	Good
Resistance to propogation of brush fires	None	Poor	Average	Good
Valorization of rains at beginning or end rainy season	Poor to None	Poor	Average	Good
Presence of shade and density of herbaceous stratum	Poor to None	Poor	Average	Good
Presence of small temporary ponds in rainy season	None	Rare	Fairly Frequent	Frequent
Resistance to over-grazing	None	Poor	Average	Good

(1) Taken from Tome I "Elevage au sud-est Mauritanien, page 13, July 1976.

The Physical Environment (1)

"Given the variability of rainfall distribution over time and space and the influence of the physical environment on pastoral potential and its aptitude for regeneration, the choice of taxonomic units was based on the one permanent factor of the pastoral ecosphere : the physical environment."

Four major categories of physical environment were selected :

- environments linked to the presence of sandy soils: dunes and sandy plateaus.
- those linked to rags : flat clayey or rocky plains, characterized by shallow soils and the discontinuity of covered zones.
- those linked to the rocky massifs, usually sandstone
- those linked to a particular water network, whether oueds, ponds, or lowlands.

The following table, from "L'Elèvage au Sud-Est Mauritanien", summarizes this information.(2)

(1) "L'Elèvage au Sud-Est Mauritanien", Tome I, July 1976, p. 10

(2) Ibid., p. 33

TABLE 6-6

	Physical Environment	ForageValue	Main Botanical zones concerned	Average production tons/Dry matter/hectare	WF/kg of dry matter average production: Rainy season	WF/kg of dry matter average production: Dry season
SAND DUNE FORMATIONS	Shifting and semi-fixed dunes	None	I	0 to 0.1	0.43 To 0.48	0.35 To 0.40
	Massive dune belts separated by large inter-dune depressions	Mediocre	I	0,5 to 1.1	0,42 To 0,60	0.35 To 0.40
	Dune belts, oriented NW-SE, separated by narrow interdunes	Average to good	I II III	0,5 to 0,9 0,5 to 1 00,8 to 1,3	0,42 to 0,60	0,35 to 0,40
	Aklé-Joined Crescent-shaped dunes, forming an aveolar network	Mediocre	I	0,3 to 0,8	0,40 to 0,50	0,30
	Dune massifs without preferential orientation localiced narrow inter-dunes	Good	I II-III IV	1 to 1,5 1 to 2	0,35 to 0,50	0,30 to 0,45
	Dune undulations with out preferential orientation; large inter-dunes	Good	II-III	1,5	0,35 to 0,50	0,30 to 0,40

Source : "Elevage au Sud-Est Mauritanien", 1976

RIM-Fed - Scet international

TABLE 6-6 (continued)

	Physical Environment	Forage Value	Main Botanical zones concerned	Average production Tons/Dry Matter/hectare	WF/kg of dry matter average production. Rainy season	Dry season
SAND COVER	Plain or plateaux sand covered with micro-relief	Average to good	I II-III IV	0,8 to 1,2 1 to 2	0,10 to 0,50	0,35 to 0,45
	Tayaret : sand covered fossil valleys, micro-relief, localired hydromorphism	Good	I II-III	1,5 to 2	0,40 to 0,60	0,30 to 0,40
	Sand cover on rags or rock outevops	Mediocre to good	I II-III IV	0,2 to 2	0,40 to 0,50	0,35 to 0,40
STONEY OR CLAYEY RAGS	More or less croded rag-plain associated with jasper, pettites schists	Mediocre to none	I-II III IV	0,1 to 0,5 0,[illegible] to 0,5	0,35 to 0,50	0,30 to 0,40
	Rag-plain or plateau associated with sandstones or lateritic fossil crusts	Mediocre to none	I II-III IV	0 to 0,5 0,5	0,35 to 0,45	0,30 to 0,40
ROCKY MASSIFS	Rochy relief and lateritic buttes	Mediocre	I-II III IV	0,1 to 0,2 0,4	0,35 to 0,45	0,35 to 0,40
[illegible] ZONES	Beds of water course and depressions temporarily floded	Good	I II-III IV	1 to 2,5	0,40 to 0,55	0,35 to 0,40
	Fonds flooded during long periods	Good	[illegible] I-III IV	0,[illegible] to 3	0,45	0,40

The afore-mentioned study shows that the best pasturelands are found mainly on the sandy substrata, with the exception of shifting dunes. Sandy formations cover more than two-thirds of the study zone and concern more than 80% of pastoral potential.

These are eolian sand formations, characterized by :

- the extension of several coastal belt systems, oriented North-South (Tamchakett) or Northeast-Southwest in the northern part of this sector (Dahr Nema), or East-West in the southern part (Djigueni),
  the presence of dune formation following an aveolar network (Aklé),
  the existence of eolian sand formations with practically no relief.

In general, these sands, the texture of which includes more than 85% sand (fine sands dominant), are very permeable to both water and root systems and thus favor germination and rapid growth of grasses and the regeneration of the herbaceous cover. However, their water retention capacity is low and the distribution of rain storms during the rainy season plays a fundamental role in pastoral production of the herbaceous strata. These soils provide ample depth for deep roots, which explains the extension of trees, inspite of the weak rainfall (300 mm).

Good pasturelands are still found on alluvial soils, but cover a reduced surface area due to the weakness of the hydrographic network.

Poor pasturelands are found on stoney or clayey rags, on rocky reliefs and lateritic buttes, where the soils are not very developed (or absent, exposing bare rock)

On sandstone rock formations and ancient laterite crusts, the soils are shallow (raw erosion soils and rock outcrops totally devoid of soils). The result is a very weak and localized vegetable cover on sand covers (herbaceous) and in fissured zones or deep sand covers (trees and shrubs).

On rock formations such as schist or pellite (Hodh), which are characterized by great sensitivity to water erosion and alterations which lead to the formation of clayey-silty textured soils, degradation leads to formation of tampered crusts, which discourage germination. Therefore, regeneration of these zones is much slower and more difficult (clayey or schist rags).

6-4 Conclusions

In a country that experiences extremely irregular rainfall, the surface area of herbaceous pastureland varies considerably from one year to another. Estimates of productivity of pasturelands must be considered with caution, as the primary factor in production of vegetable cover is rainfall.(1)

The severe degradation of the pasturelands by men and animals added to the harsh years of drought, has resulted in a decrease in the density and quality of the vegetable cover; vast bare plaques have appeared, due to sheet or gully water erosion and especially due to wind erosion, causing the advance of the shifting dunes. Due to insufficient means and personnel, the Nature Protection Service cannot efficiently control the cutting of wood and the brush fires which further degrade the vegetable cover.

According to many experts, the most efficient and economical solution to combat degradation is to favor natural regeneration by forbidding the use of areas which have been over-exploited, especially as this leads to progressive desertification, worsened by the drought.

The Southwest of Mauritania (Trarza, Brakna, Gorgol) has been particularly affected by degradation of the vegetable cover, due to the large concentration of water holes in this area and the corresponding numbers of animals (over-grazing). This has created intolerable pressure on the environment, the consequences of which were revealed and exacerbated by the great drought of 1972-73.

The major livestock zones of Mauritania will be discussed hereafter in the light of the above context.

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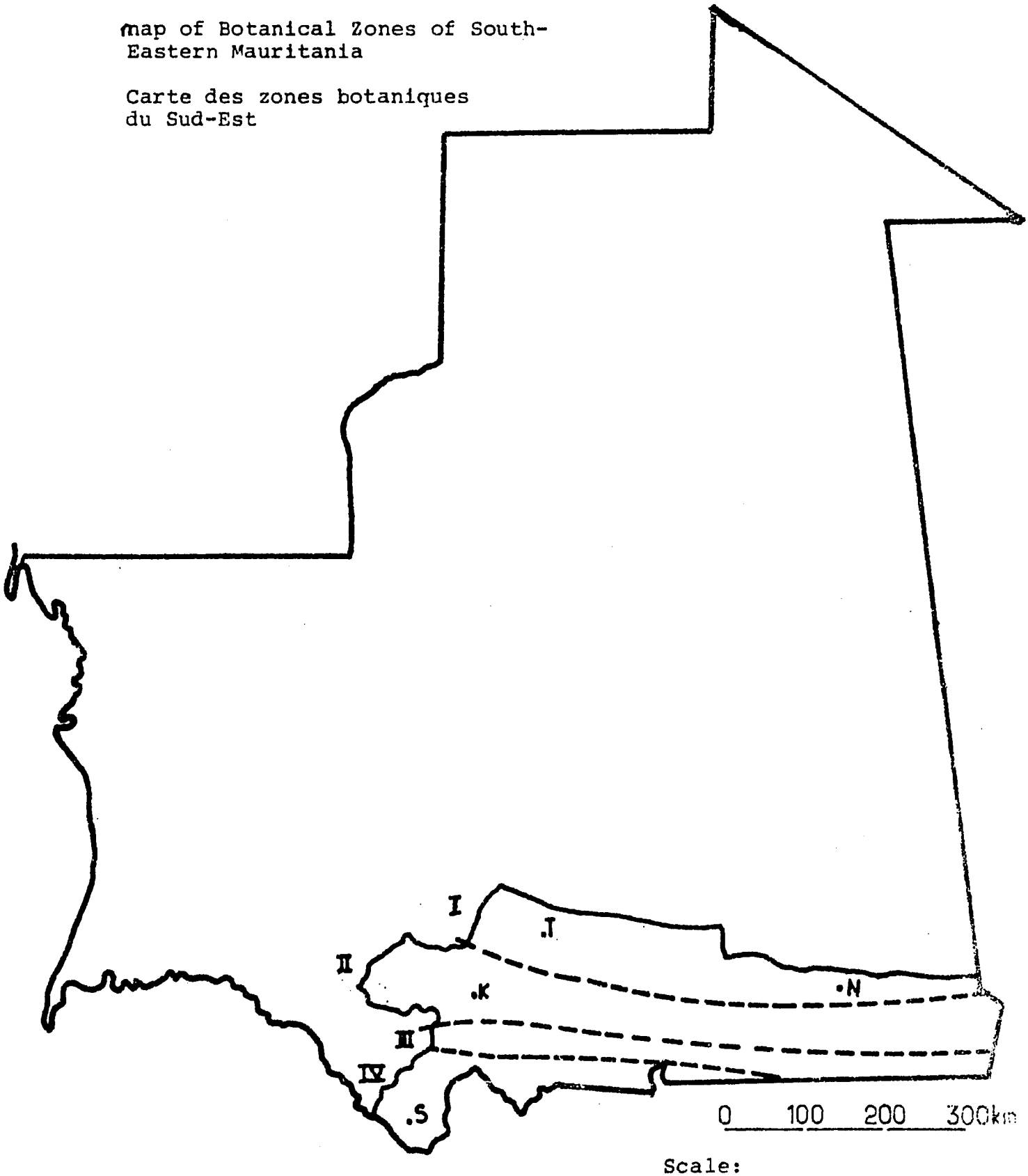
(1) "Les Systèmes Pastoraux Sahéliens", FAO, Rome, 1977, P. 174

map of Botanical Zones of South-Eastern Mauritania

Carte des zones botaniques du Sud-Est

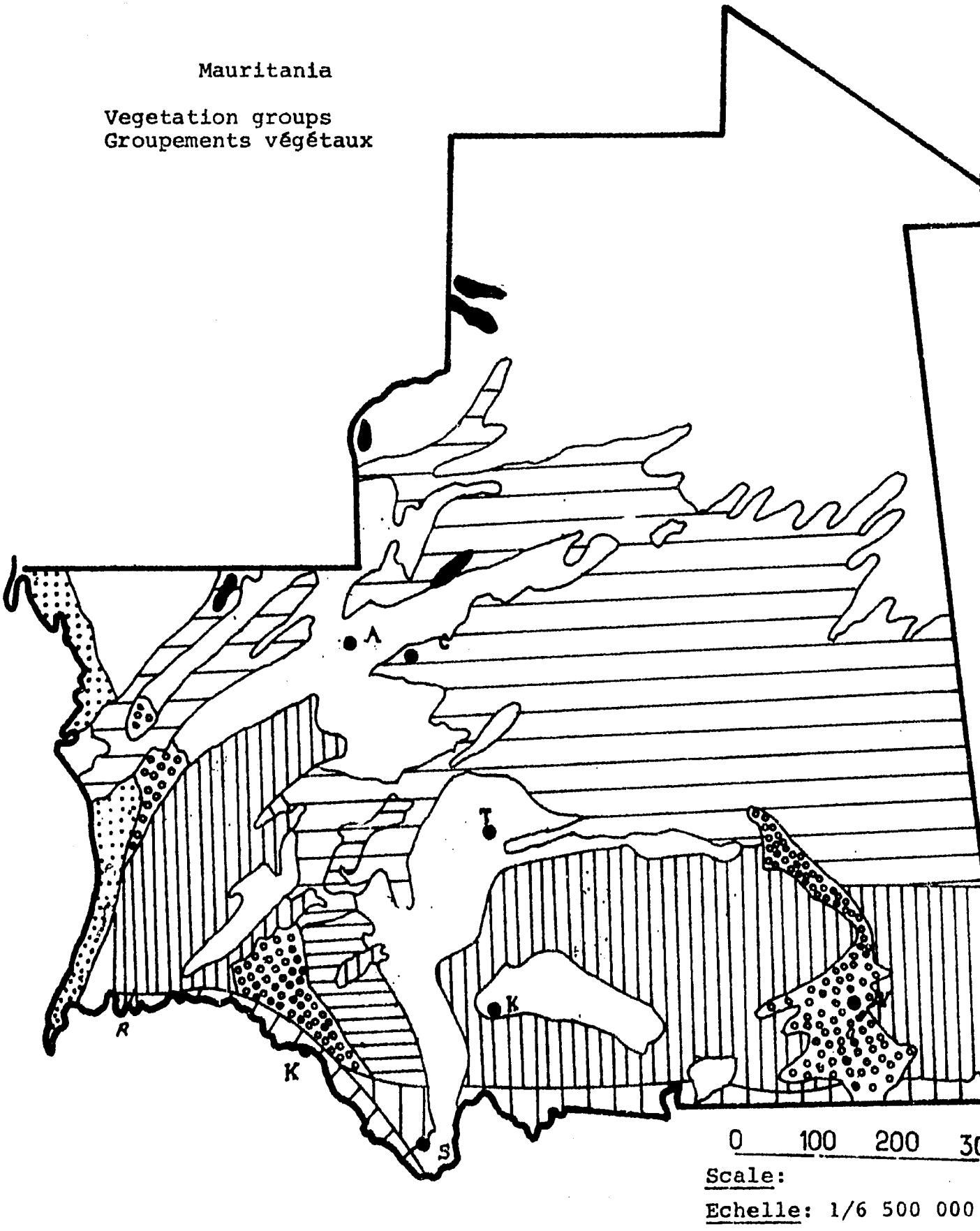


Scale:
Echelle: 1/6 500 000

Pour la légende voir le texte
For legend, see texte

SOURCE: L'ELEVAGE AU SUD EST MAURITANIEN 1976.
R.I.M. FED. SCET INTERNATIONAL.

Fig. 6-3



ADAPTÉD FROM ATLAS DE MAURITANIE 1977.

(Fig. 6-3)

Legend of map of vegetation groups in Mauritania

Légende de la carte de la Mauritanie sur les groupements végétaux

Acacia nilotica group

Combretum glutinosum group

Acacia Sénégal group

Commiphora africana group

Zizyphus mauritania group

Tamarix sénegalensis group

Stipagrostis pungens group

Acacia tortilis S. S raddiana group

Sebkha

Average location of isohyetal line
(adapted from "atlas de Mauritanie")

CHAPTER 7

MAJOR LIVESTOCK ZONES

7. MAJOR LIVESTOCK ZONES

7-0 Introduction

Livestock raising in Mauritania is concentrated mainly in the southern third of the country, where grazing is available during the rainy season. In spite of the development of the industrial sector and the ravages of the catastrophic drought, livestock remains the fundamental activity of this nation.(1) This is demonstrated by :

- the size of herds(2), which to the herdsman represent : capital, a source of food and a means of transport.
- the extension of the nomadic way of life, adapted to the harsh ecological conditions of Mauritania
- the volume of livestock marketed (mainly for butchering) : sales of live animals represent about 80% of the revenues of Mauritanian herdsmen, and about 60% of the revenue for all of rural Mauritania(3).

Livestock raising is a risky enterprise in the Sahel in general, and in Mauritania in particular. This has been seen during the drought-provoked disasters, beginning in 1968. Cattle herds were the most affected, and in some zones more than others (this will be discussed further in the text). For the whole of Mauritania, cattle herds decreased by 45% during 1972-73, according to Livestock Service estimates(4).

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(1) Charles Toupet and Ndiawar Kane, "Atlas de Mauritanie", p. 41, 1977.

(2) See Tables 7-1 and 7-2

(3) Charles Toupet and J. Robert Pitte, "La Mauritanie", Collection "Que Sais-je", PUF, 1977, p. 88.

(4) From "Etude socio-économique de l'élèvage dans le Delta et la basse vallée du Fleuve Sénégal", Part 1, Technical and Economic Aspects, OMVS, SEDES, Paris 1976., p. 6.

According to the FAO, for the period 1970-74, cattle losses in Sahelian countries were as follows :[1]

- 41 % for Mauritania
- 39 % for Niger
- 33 % for Chad
- 31 % for Mali
- 10 % for Senegal
- 8 % for Upper Volta

Thus the drought affected the productivity (and often the existence) of pasturelands in certain regions, with corresponding repercussions on livestock dependent on this grazing.

As noted by J. Robert Pitte[2], the estimates of cattle losses for 1968-69 correspond closely to the rainfall deficits in these different regions. Two examples demonstrate this :

- at Nema; the rainfall deficit was 18 % and the cattle losses were 12% (for Region 1).
- at Kaédi, the rainfall deficit was 58 % and the cattle losses were 60 %.

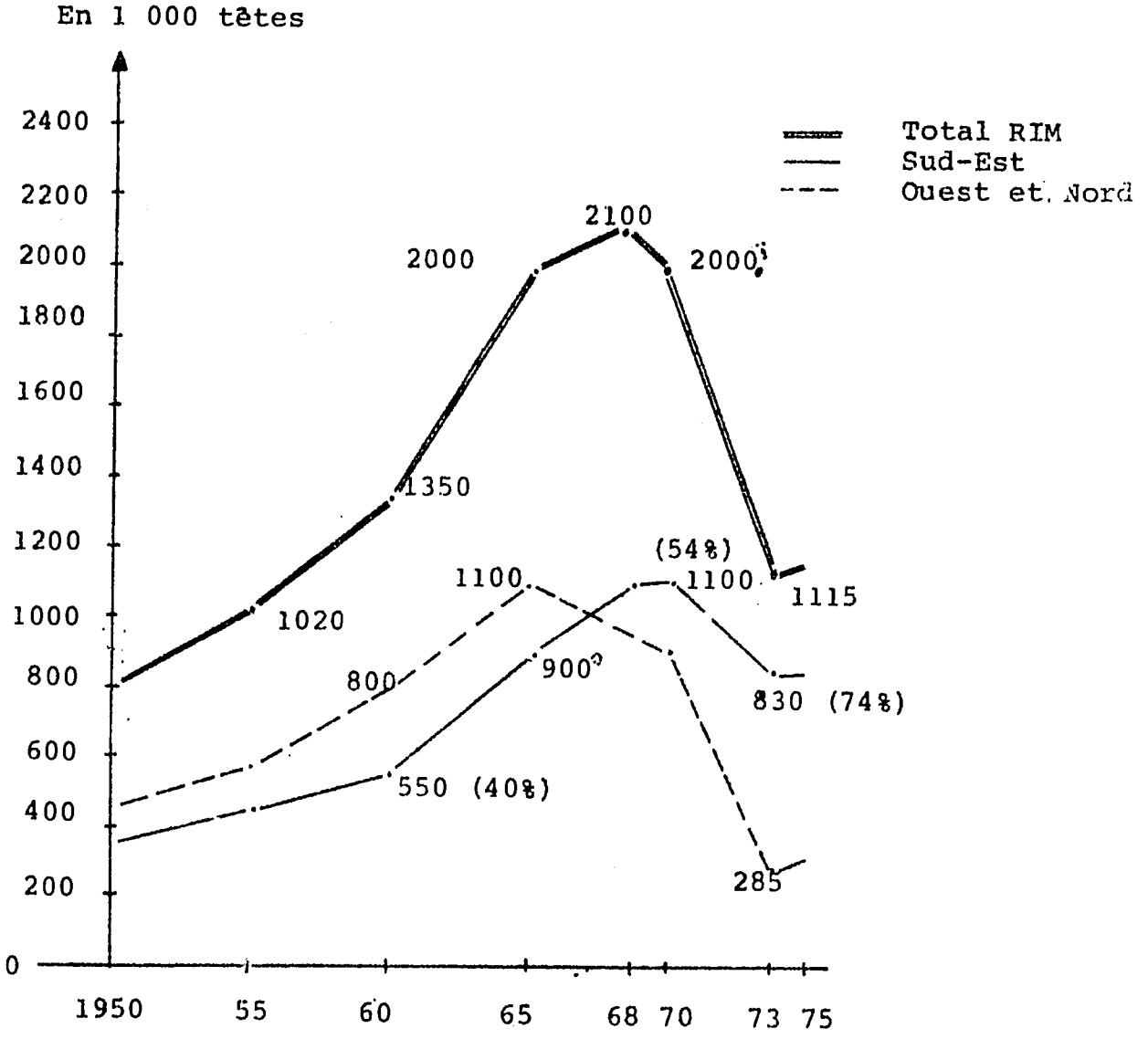
The drought sequence and consequent over-grazing have caused a catastrophic over-grazing of the vegetable cover in several regions of Mauritania, making the raising of livestock extremely difficult.[3]

Given the fragility of the pastoral environment, in order to survive most herds are forced to practice nomadism or extensive transhumance.

(1) According to "Le Modèle Technique de l'Elevage au Sahel", in French document "Problèmes Economiques" N° 1546, P. 25

(2) In "La Sécheresse en Mauritanie", Annales de Géographie N° 466, Nov.-Dec., 1975, p. 650.

(3) This was especially the case in the Trarza zone.



Estimation of cattle population during the period 1950-1975

Evolution des estimations du cheptel bovin su 25 ans (1950-1975).

Effets de la sécheresse (1968 et 72-73

Effects of drought (1968 et 72-73)

SOURCE: L'ELEVAGE AU SUD-EST MAURITANIEN 1976.
R.I.M. FED|SC INTERNATIONAL.

7.1 The Nature of Mauritanian Livestock

By order of economic importance, Mauritanian livestock consists of : cattle, sheep, goats, camels, donkeys and horses.

Cattle :

Cattle are represented by two races in Mauritania :

- the Moor Zébu and the Peulh Zébu (also known as the Gobra Zébu

  - the Moor Zébu : 85% of the country's cattle herds are Moor Zébus[1]. Of reddish-blond to pied light red in color, they are medium-sized animals, measuring 1.20 to 1.30 meters and weighing 330 to 380 kg. They are short-horned. The female is a fairly good milk producer. These cattle need to drink water only once every two days.

  - the Peulh Zébu : of a washed-out grey or dirty white, sometimes black (Baleri) or spotted with black (Tiouri Baleri)[2], these cattle are characterized by long lyre-shaped horns, pronounced sexual dimorphism and larger size than the Moor Zébu. The male measures 1.40 to 1.54 meters and weighs 350 to 500 kg. These cattle must drink every day. They are better for meat than the Moor Zébu, but the female produces less milk.

Crossbreeding between the two types of Zébu is rare, as the Peulhs refuse to crossbreed their animals. In the southern center of Mauritania, 60% of cattle herds are Zébu Gobra[3]

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(1) "Atlas de Mauritanie", 1977, P. 43

(2) "Elèvage au Sud-Est Mauritanien- Tome II", July, 1976, p. 38.

(3) J. P. Hervouet, "Type d'adaptations sahéliennes: l'exemple des éleveurs de la Mauritanie Centrale méridionale", 1977, p. 91.

Sheep

There are three races (all having hair instead of wool).

- Two are Moorish :
  - the short-haired sheep, which is white, sometimes spotted with black or reddish-brown. It is a large sheep : 70 to 80 cm high. Weight can attain from 60 to 80 kg. This animal is not a good walker, but is appreciated for its meat. Of this type, the Ladem (Tintane Region) is considered in the southeast as the best meat producer.
  the long-haired sheep, which is black and much smaller (the male's height is from 50 to 60 cm and weight is from 25 to 35 kg). This type produces less meat, but is appreciated by the nomads because it is a good walker and furnishes hair for the fabrication of tents.

The Peulh Sheep is reddish and closely ressembles the large, short-haired Moor Sheep.

Goats

One type is dominant : the Sahel goat (also called the Moor Goat), which has a grey or two-colored coat. This is a long-legged animal, having fine short hair, weighing 25-35 kg ; it is an excellent producer of milk and meat for the poorer herdsmen.

Camels

They are represented by the dromedary (Camelus dromadairius), incorrectly called "camel". The Sahel Dromedary dominates ; it is a large animal, which can attain 2.10 m to the whithers. The Saharan camel is a bit smaller.

Donkeys

These are Sahelian donkeys. Small animals, they weigh 80 to 100 kg, are short-haired (grey with a black crucial band). They are good carriers and can bear from 50 to 100 kg.

Horses :

There are few horses in Mauritania (16 000 in 1977)[1]. Two types are noted :

- the Barbe Horse[2], of size varying from 1.42 to 1.82 m and usually of grey coat.
- the Arabian Horse, which is small (average 1.40 m) and also has a grey coat.

7.2 Pastoral Areas

Grazing ranges cover about 300 000 km2[3], corresponding to that part of the country between the 200 mm isohyetal line and the southern border with Senegal and Mali.

To the north of the 200 mm isohyetal line, rational exploitation of the ranges becomes difficult due to the scarcity and increasing irregularity of rainfall.

Cattle raising (for the Moor Zébu) may reach the 150 mm isohyetal line, but Charles Toupet points out that it is rapidly impeded towards the north by increasing dryness, which decreases the number of watering holes and the herbaceous carpet. Beyond the 150 mm isohyetal line, cattle raising is impossible.

Map 7-1 illustrates the distribution of cattle, expressed in number of heads/km2 (in 1975)[4]. This map shows the heavy concentration of cattle in the southern center of the country (Guidimaka Gorgol, and south of the Brakna), which attained more than 5 heads/km2 in 1975.

(1) FAO - Questionnaire pour l'annuaire de la production, 1978.

(2) Source : Mémento de l'agronomie, Ministère de la Coopération, 1974.

(3) "Les aménagements sylvo-pastoraux", Equipe Ecologique Sylvo-Pastorale, CILSS (year not mentioned).

(4) Map adapted from the Third Economic and Social Plan of The Islamic Republic of Mauritania, 1976-1980.

The Gorgol (Region 4) and Brakna (Region 5) were greatly affected by the drought, which reduced the surface area and quality of pasturelands. The pressure of livestock on the environment, added to that of the drought, created extreme overgrazing (and trampling of the ground), degrading the soil-protecting vegetable cover.

The figures for 1972-73[1] show that cattle losses were -50% in the 4th Region and -80% in the 5th Region, demonstrating the severity of this drought. Field observations by the RAMS team permitted evaluation of the major degradation of these regions[2]. The southeast of Mauritania contains the majority of cattle herds, although density is less.

Sheep and Goats are distributed throughout the country; their hardiness allows them to range everywhere (except in the Majabat al-Koubra).

However, higher densities are found in the southeast (up to 13 heads/km2), as shown by Map 7-2 of the Distribution of Sheep and Goats in Mauritania in 1975.[3] Most of the herds are located in the southeast.

Camels are almost always nomadic to the north of the 400 mm isohyetal line. They are excluded from the southern regions, which are infested by a fly which is a vector of camel trypanosomiasis.[4] (Tabourit)

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(1) J. Robert Pitte, "La Sécheresse en Mauritanie", Annale de Géographie N° 466, Nov.-Dec., 1975.

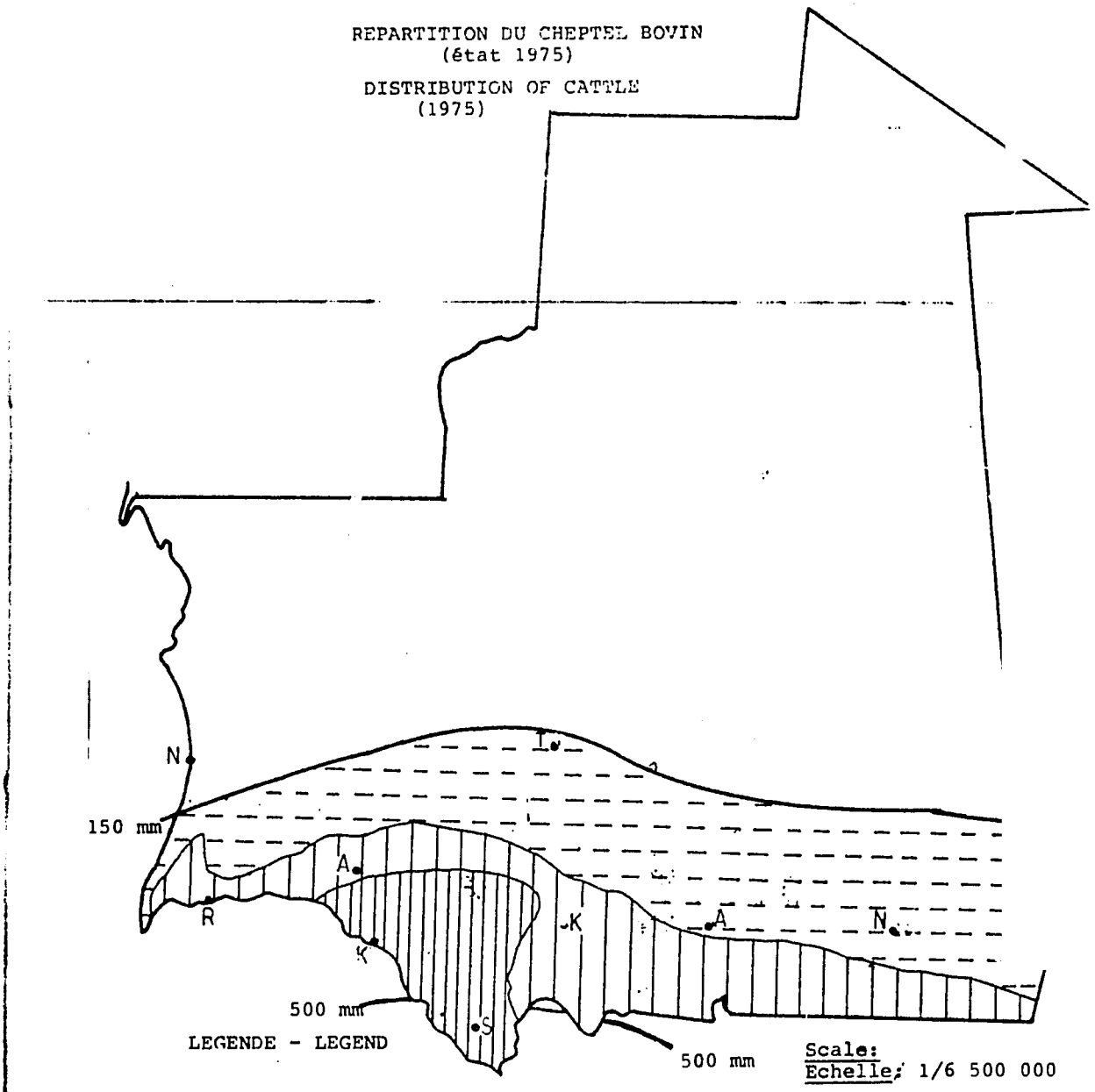
(2) RAMS missions of June 9-10 and July 11-19, 1979.

(3) Third Economic and Social Development Plan, IRM, 1976-1980.

(4) "La Mauritanie", Collection "Que Sais-je?", PUF, 1977, p. 85

REPARTITION DU CHEPTEL BOVIN
(état 1975)

DISTRIBUTION OF CATTLE
(1975)



LEGENDE - LEGEND

Scale:
Echelle: 1/6 500 000

0 100 200 300km

150mm Limite septentrionale de l'élévage bovin

150mm Northern limit of cattle raising

Nombre de têtes au km2 - Number heads/km2

Moins d'une tête - Less than 1 head

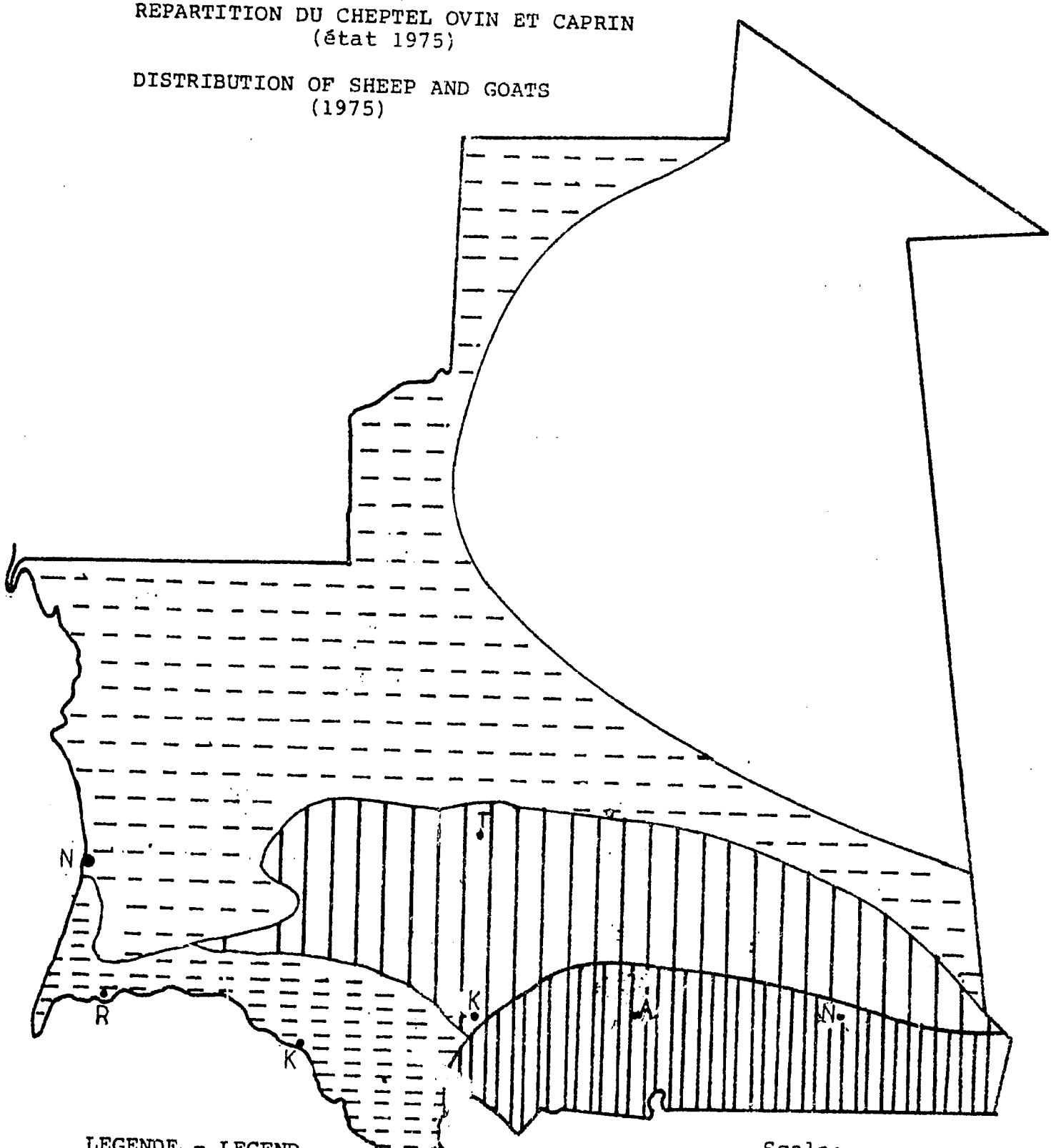
De 1 à 5 têtes - 1 to 5 heads

Plus de 5 têtes - More than 5 heads

Source: adapté du IIIe plan de développement 1976 - 1980
adapted from IIIe plan of development.

REPARTITION DU CHEPTEL OVIN ET CAPRIN
(état 1975)

DISTRIBUTION OF SHEEP AND GOATS
(1975)



LEGENDE - LEGEND

Nombre de têtes au km2 — Number heads/km2

Zone vide - Empty zone

Moins de 2 têtes - Less than 2 heads

De 2 à 9 têtes - 2 to 9 heads

De 9 à 13 têtes - 9 to 13 heads

Plus de 13 têtes - More than 13 heads

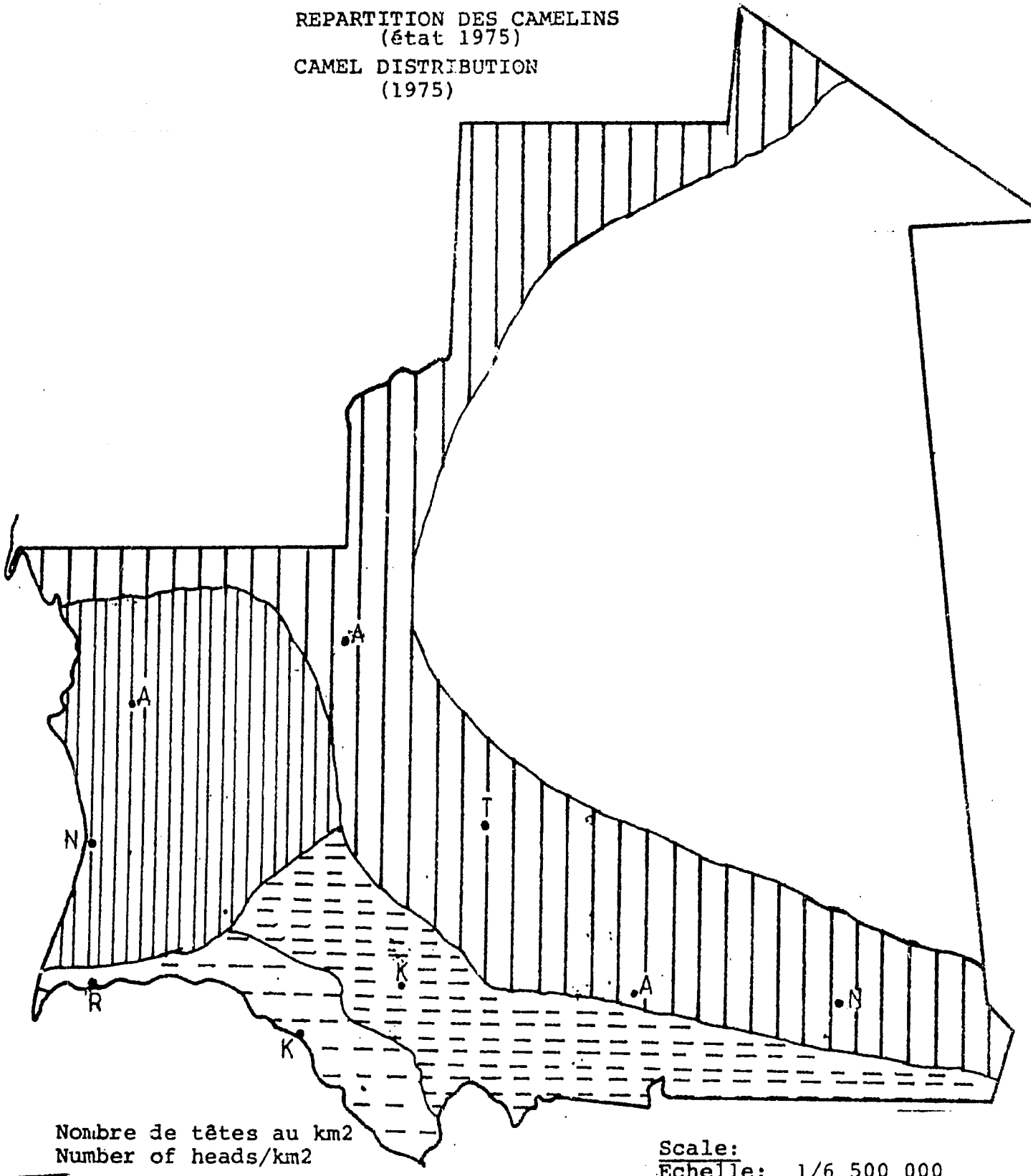
Scale:
Echelle: 1/6 500 000

0 100 200 300km

Source du IIIe plan de développement 1976 - 1980

REPARTITION DES CAMELINS
(état 1975)

CAMEL DISTRIBUTION
(1975)



Nombre de têtes au km2
Number of heads/km2

- Zone vide / Empty zone
- Moins d'une tête / Less than 1 head
- De 1 à 2 têtes / 1 to 2 heads
- De 2 à 3 têtes / 2 to 3 heads
- Plus de 3 têtes / More than 3 heads

Scale:
Echelle: 1/6 500 000

0 100 200 300km

Source: Adapté du IIIe plan de développement 1976 - 1980

Adapted from IIIe plan of development

Map 7-3 shows the distribution of camels in Mauritania, by number of heads/km2[1]. The higher densities (more than 3 heads/km2) are found in the west of the country (Region 6 (Rosso)and Region 12 (Akjoujt)), where are found the salt pasturelands relished by camels. This map shows that the camels are usually distributed in the drier Sahelo-Saharan and Saharan regions.

Donkeys :

They are found throughout the Sahel (in villages and towns). In the Sahara, they are found only in urban centers (oases). They are used mainly for transport.

Horses :

Horses have negligeable economic importance. According to a 1974 Agronomic Memo, the Barbe horse is found in the Trarza, the Brakna, the Aouker and the Hodh.[2]

7-3 Size of Livestock Population in Mauritania

Livestock pupulation has varied over the years due to the drought. (Regional disparities due to drought will be examined later in the text.)

There was very low rainfall in the years 1913, 1941 and 1942, but the drought that began in 1968 has been the worst of the last 50 years[3]. Rainfall deficits during the period 1968-75 are evaluated at more than 40% of average.[4] One of the most severe effects of the drought was the major decrease in livestock, as demonstrated by the table "Evolution of Livestock for the Period 1964-75"[5]. Cattle herds suffered heavy losses, as they required more water and pasturage than goats and sheep.

(1) Third Economic and Social Development Plan, 1976-1980, IRM.

(2) Ministère de la Coopération, 1974.

(3) Third Economic and Social Development Plan, IRM, 1976-1980.

(4) Ibid.

(5) Ibid.

TABLE 7-1

EVOLUTION OF LIVESTOCK HERDS FROM 1964-1975 (IN THOUSANDS OF HEADS)

LIVESTOCK CATEGORIES	1964	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
CATTLE	2000	2000	2275	2500	2000	1850	1550	1500	1115	1150	1185
SHEEP + GOATS	4600	5900	6650	2700	7000	6750	6500	6500	5850	6300	6800
CAMELS	500	700	710	720	720	710	705	700	670	680	685
DONKEYS + HORSES	250	270	280	300	300	295	280	265	250	255	260

Sources : "3e plan de Développement Economique et Social" RIM 1976-1980.

TABLE 7-2

Evolution of livestock for period : 1975-1978

	1975	1976	1977	1978
Cattle	1.236.000	1.311.272	1.400.000	1.500.000
Sheep	4.200.000	4.500.000	4.700.000	5.000.000
Goats	2.500.000	3.000.000	3.100.000	3.200.000
Camels	680.000	690.000	700.000	?
Donkeys	160.000	170.000	180.000	?
Horses	16.000	15.000	16.000	?
TOTAL	8.790.000	9.686.272	10.096.000	?

Sources : FAO - "Questionnaire pour l'annuaire de la production 1978" RIM

Note : These are provisional figures. A statistical annuary is being prepared within the context of the RAMS project and will furnish statistical information on the numbers of livestock in Mauritania.

Table 7-1 shows that cattle progressed until 1968 (from 200 000 000 heads in 1966 to 2 500 000 heads in 1968, an increase of 25%). In 1969, a sharp regression was noted (-25%) due to the 1968 drought. This regression continued regularly until 1973, when it attained its maximum : 1 115 000 cattle in 1973, as compared to 2 500 000 in 1968, or a decrease of 1 385 000 heads (55.4%). The year 1972-73 was the harshest for all livestock.

Another table, based on an FAO report(1), shows the progressive rebuilding of livestock herds after the 1972-73 drought (Table 7-2). These figures show that for sheep+goats, camels, donkeys and horses, the herds have been reconstituted since the 1972-73 drought and have even gone beyond the size of herds existing before the drought began in 1968.

On the other hand, cattle herds took longer to recuperate from the drought :

- in 1978 (10 years later), the number of heads had still not reached that of 1968 and was about 1 500 000 heads, as compared to 2 500 000 heads before the drought.

However, the interpretation of national livestock decreases must be undertaken with caution, as these losses do not necessarily reflect the mortality rate. A large number of animals left Mauritanian territory during the drought, in search of grazing (even when water was still available). Some of the migrant herds did not return to Mauritania(2).

In addition, according to the Third Economic and Social Development Plan of Mauritania, 1973 was characterized by excessive slaughtering and export of meat, due to the lack of sufficient pasture. Thanks to good grazing lands in 1974 and 1975(3), Mauritanian livestock was able to return to the number of heads before the drought.

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(1) Based on "Questionnaire pour l'annuaire de la production", 1978.

(2) Report of Mission for "Développement de l'Elévage et des forêts en Mauritanie", July 2-31, 1975, FAO, Rome, 1975.

7.4 - The Southwest and the Southeast

There are two major livestock zones in Mauritania : the Southwest and the Southeast. Formerly, the Southwest dominated, but it has lost its place to the Southeast because :

- of the 1968-73 drought, the severity of which killed a great number of animals in the Southwest, whereas in the Southeast, livestock was less affected. During this period, in the 5th and 6th Regions (Trarza and Brakna)(1), the livestock losses were about 65%, as compared to 15-20% in the Southeast (Regions, 1, 2 and 3).
- the presence of a relatively dense network of wells (see Map 7-4) in the Trarza and Brakna provoked concentrations of men and animals beyond the bearing capacity of the environment. The sedimentary Senegalo-Mauritanian basin which supplies most of the Southwestern wells was not greatly affected by the drought. The result was considerable destruction by over-grazing of the pastoral ranges, which depend directly on rainfall. These ranges had already been over-exploited before the drought began, precisely because the dense water holes permitted maintenance of an excessive number of animals

The disequilibrium that already existed between the availability of water and the lack of natural forage was sharply exacerbated from 1970 on(2), which lead to severe destruction of the vegetable cover, followed by high mortality in the herds of this region. These animals did not die of thirst, but of hunger.(3)

It must be noted that the Southwest is less isolated than the Southeast, due to a relatively greater number of means of communication (including the Senegal River). This region tended to be oriented towards the large cities such as St. Louis and Dakar, which polarized economic activities in the region.

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(1) "Rapport de Mission sur le Développement de l'Elèvage et des Forêts en Mauritanie", FAO, Rome, 1975.

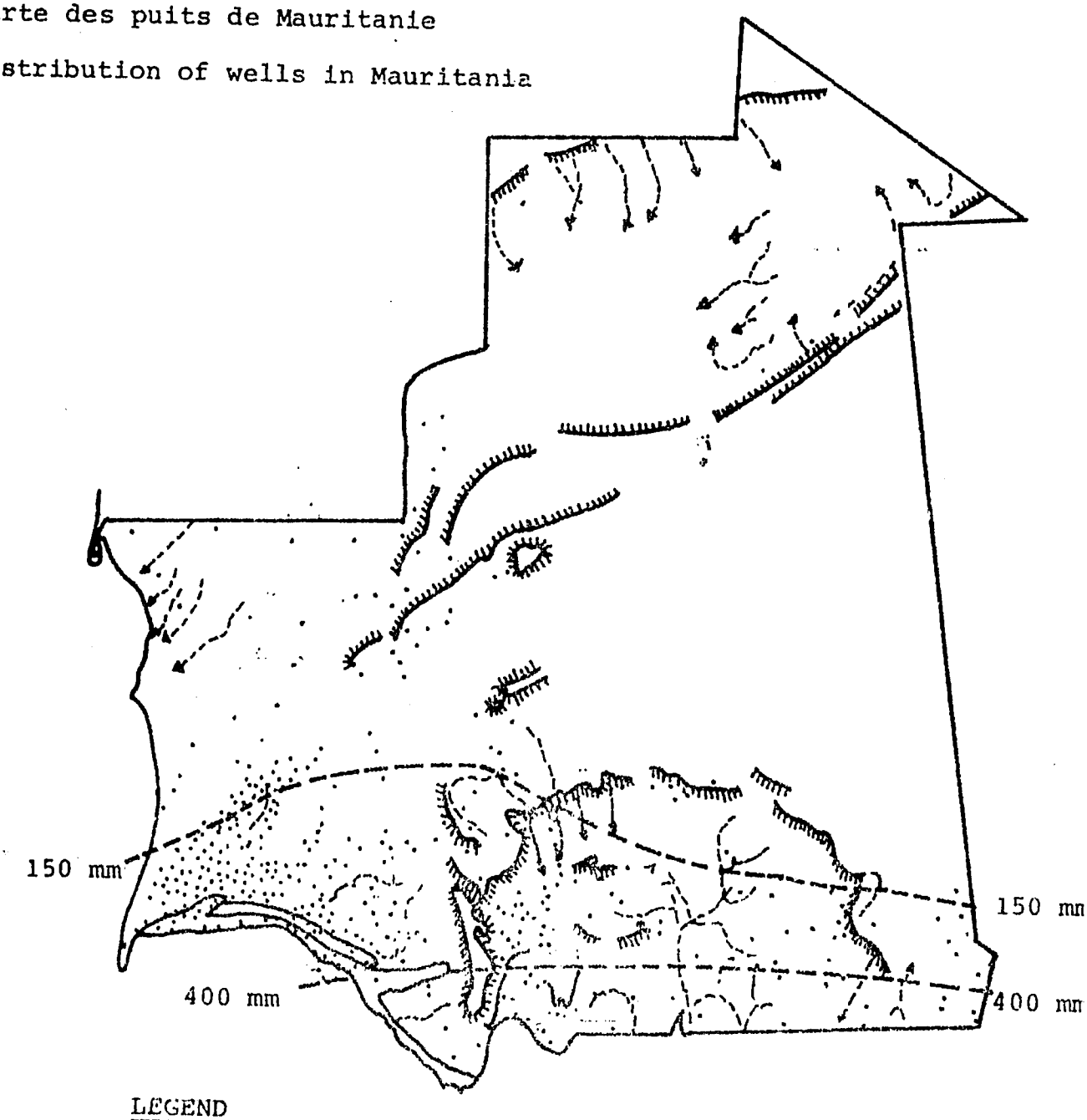
(2) Ibid, July 2, 1975.

(3) Ibid.

Fig. 7-5

Carte des puits de Mauritanie

Distribution of wells in Mauritania



LEGEND

	Escarpments	Escarpements
	Wells	Puits
	Water cours;	Cours d'eau
	Isohyetal lines	Isohyètes

Source: R + D USAID 1979

TABLE 7-3

Regional variations of rainfall Deficits for period 1971-1973

REGIONS	NORMAL AVERAGE RAINFALL (mm)	1971	1972	1973	ANNUAL AVERAGE 1971-1973	DEFICIT AS COMPARED TO NORMAL RAINFALL
REGION 1 NEMA	315.0	237.5	267.9	220.4	241.9	23 %
REGION 2 AIOUN	315.9	146.0	144.5	141.0	143.8	54,5 %
REGION 3 KIFFA	352,5	163,7	119,7	176,1	153.1	49 %
REGION 6 ROSSO ~~BOUTILIMIT~~	287,4	125,6	53,0	166,1	114,9	60 %
DISTRICT OF NOUAKCHOTT	135,5	17,9	72,2	79,9	56,6	58 %

Source : J. Robert Pitte - "La Sécheresse enMauritanie" - November - December, 1975.

Thus, due to the accessibility of markets, the Southwest developed more than the isolated Southeast, which is far from the coast, and attracted men and livestock. Livestock was excessive for the bearing capacity of the environment, resulting in disaster during the 1968-73 drought. This is not to say that the Southeast was spared by the drought (which was generalized in Mauritania for the years 1972-73). However, in 1968, the drought was much more severe in the Southwest.

Table 7-3 shows the regional variation of rainfall deficits for the period 1971-1973(1). This table shows that rainfall deficits were greater in the Southwest.

According to a FAO report in 1975(2), the sparse rainfall reduced simultaneously the availability of water holes and forage in Regions 1, 2 and 3. However, many herds had migrated in time to the south of Mauritania and to Senegal and Mali, which explains the smaller losses in the Southeast, which did not experience the excessive degradation of the 5th and 6th Regions (Trarza and Brakna). This degradation was observed by the RAMS field mission of Oct. 4, 1979.

In the Southeast (Regions 1, 2, 3 and 10), the percentage of Mauritanian cattle herds was :

40 % in 1960
54 % in 1970
74 % in 1973(3)

Thus, this region has become an important livestock zone, for the reasons explained above. Other statistics confirm this(4); At the end of 1974, the Southeast (1st, 2nd, 3rd and 10th Regions) had :

75 % of the cattle in Mauritania
72 % of the sheep in Mauritania
68 % of the goats in Mauritania

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(1) J. Robert Pitte, "La Sècheresse en Mauritanie", November-December, 1975.

(2) Report of the Mission on "Développement de l'Elèvage et des Forêts", July 31, 1975.

(3) "L'Elèvage au Sud-Est Mauritanien", Tome II, Situation Actuelle, FED, July 1976.

(4) Ibid.

Figure 7-1 shows the evoluation of cattle herds over 25 years (1950-75). It shows the preponderant change from the Southwest to the Southeast during the drought period 1968-73.

Tables 7-4 and 7-5 show, for the Southeast and Southwest respectively, the regional differences in Mauritanian livestock distribution during the 1968-1973 drought.(1)

The Southwest lost a high percentage of cattle :

84 % in Region 6 (Rosso)

80 % in Region 5 (Aleg)

50 % in Region 4 (Kaédi)

Losses were less in the Southeast; the 1st Region (Néma) lost only 33% of cattle, the 2nd Region (Aïoun) 44% and the 3rd Region (Kiffa) even shows an increase of 21%.

Losses of sheep and goats were highest in Region 4 (Kaédi).

The number of camels decreased by 45% in Region 5 (Aleg) and by 20 % in Region 6 (Rosso). Elsewhere, the number increased, often by enormous proportions. Some of these excessive increases or decreases are due to the migrations of herds between 1971 and 1973 as well as to losses. For this reason, it is necessary to be cautious in interpreting these statistics. It should also be pointed out that a certain number of animals died of illnesses, which affected the weakened individuals.

(1) J. Robert Pitte, "La Sècheresse en Mauritanie". Nov.-Dec. 1975.

TABLE 7-4

Evolution of livestock during he drought in the southwert of Mauritanie, by region.

LIVESTOCK	REGION 4:KAEDI	REGION 5:ALEG	REGION 6 : ROSSO
CATTLE			
12-31-71	300.000	400.000	250.000
12-31-73	150.000	80.000	40.000
Evolution	- 50 %	- 80 %	- 84 %
SHEEP + GOATS			
12-31-71	456.000	920.000	517.000
12-31-73	250.000	700.000	400.000
Evolution	- 45 %	- 23 %	- 22 %
CAMELS			
12-31-71	8.000	175.000	326.000
12-31-73	50.000	80.000	260.000
Evolution	+ 525 %	- 54 %	- 20 %

Source : J. Robert Pitte . "La Sécheresse en Mauritanie" in Annales de Géographie n°466, p.651 - Nov. - Dec.1975, citing : sources from Direction de l'Elevage.

TABLE 7-5

Evolution of livestock during drought in Southeast of Mauritanie, by region

LIVESTOCK	REGION 1: NEMA	REGION 2: AIOUN	REGION 3: KIFFA
CATTLE			
12-31-71	400.000	300.000	330.000
12-31-73	270.000	170.000	400.000
Evolution	- 33 %	- 44 %	+ 21 %
SHEEP-GOATS			
12-31-71	2.275.000	2.400.000	977.000
12-31-73	1.900.000	1.800.000	650.000
Evolution	- 16 %	- 25 %	- 33 %
CAMELS			
12-31-71	80.000	70.000	41.000
12-31-73	100.000	80.000	100.000
Evolution	+ 25 %	+ 14 %	+ 124 %

Source : J. Robert Pitte - "La Sécheresse en Mauritanie" - Annales de Géographie n°466 ; p.651 - November - December 1975 - citing Sources from : la Direction de l'Elevage.

7-5 Pastoral Migrations : Transhumance and Nomadism :

In this environment, where pasturage and water are scarce, animals cannot survive unless they undertake to migrate with the seasons.

Transhumance is practiced by the Peulhs[1]. In this type of migration, the human community does not accompany the herd, which is confided to a shepherd. The herd owners remain in their village and practice cultivation.

Nomadism implies that the entire human community[2], living in mobile camps, follows the herd in its migrations. It is practiced by the Moors.

The Peulh transhumance rarely goes beyond the 450 mm isohyetal line; therefore, it is essentially located in the southern center (Guidimaka) and Southeast of the country, and covers the rainfed cultivation zone. Most of the Peulhs' livestock consists of cattle (Gobra Zébus). According to J.P. Hervouet[3], the Peulhs in the southern center of Mauritania possess more than 80% of the regional livestock, which is to say that the Peulhs are the major ~~livestock~~ owners south of the 450 mm isohyetal line.

Moorish nomadism covers a much larger surface area, as it concerns :

- camels, which are distributed throughout Mauritanian territory to the north of the 450 isohyetal line. The Moors have a monopoly of camel raising.
- cattle : the Moor Zébu attains the 200 mm isohyetal line in the north, and at times, the 150 mm line.
- goats and sheep, which are found just about everywhere in Mauritania (and are owned in large majority by the Moors).

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(1) Charles Toupet and Ndiawar Kane, "Atlas de Mauritanie", 1977 p. 43

(2) Ibid.

(3) "Stratégies d'adaptation différenciées à une crise climatologique - L'exemple des éleveurs-agriculteurs du Centre-Sud Mauritanien" 1969-1974, p. 84.

Pastoral migrations are linked to rainfall distribution. The Sahelian herdsmen (both Moors and Peulhs) spend the dry season in the south, moving north in the summer to benefit from the pasturelands created by the monsoon rains[1]. During the rainy season (July to September), the herds move north, passing through regions where rainfall is sufficient to provide green pastures and provide water holes. In October and November, the dry season begins, and the ponds around which the animals have gathered begin to dry up. At this time, the herds begin to migrate back towards the south, in stages as a function of the water holes available. Around the month of December, all pastures are found around permanent water holes (wells or water courses).

The herds will remain at the permanent water holes until the next rainy season, spending the driest months at pastures composed of dried grasses and stubble, some rare leguminous plants and a few trees, which furnish a useful supplement to their diet.

The length of migrations varies according to region; certain herds go as far as Mali or Senegal, and herd movements are extremely regular if nothing opposes them[2]. In general, herdsmen tend to return to the same pastures, following the same transhumance route, each year, and it is frequent that certain wells or water holes come to be considered as belonging to certain families or groups.

The "external factors" which may modify this pattern are the lack of water (when wells along the route have dried up) or lack of grazing (due to insufficient rainfall or brush fires). When over-grazing occurs in the dry season around a water hole, it may be abandonned, as it is no longer of any use to the herds.[3]

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(1) "Atlas de Mauritanie", 1977, p. 43

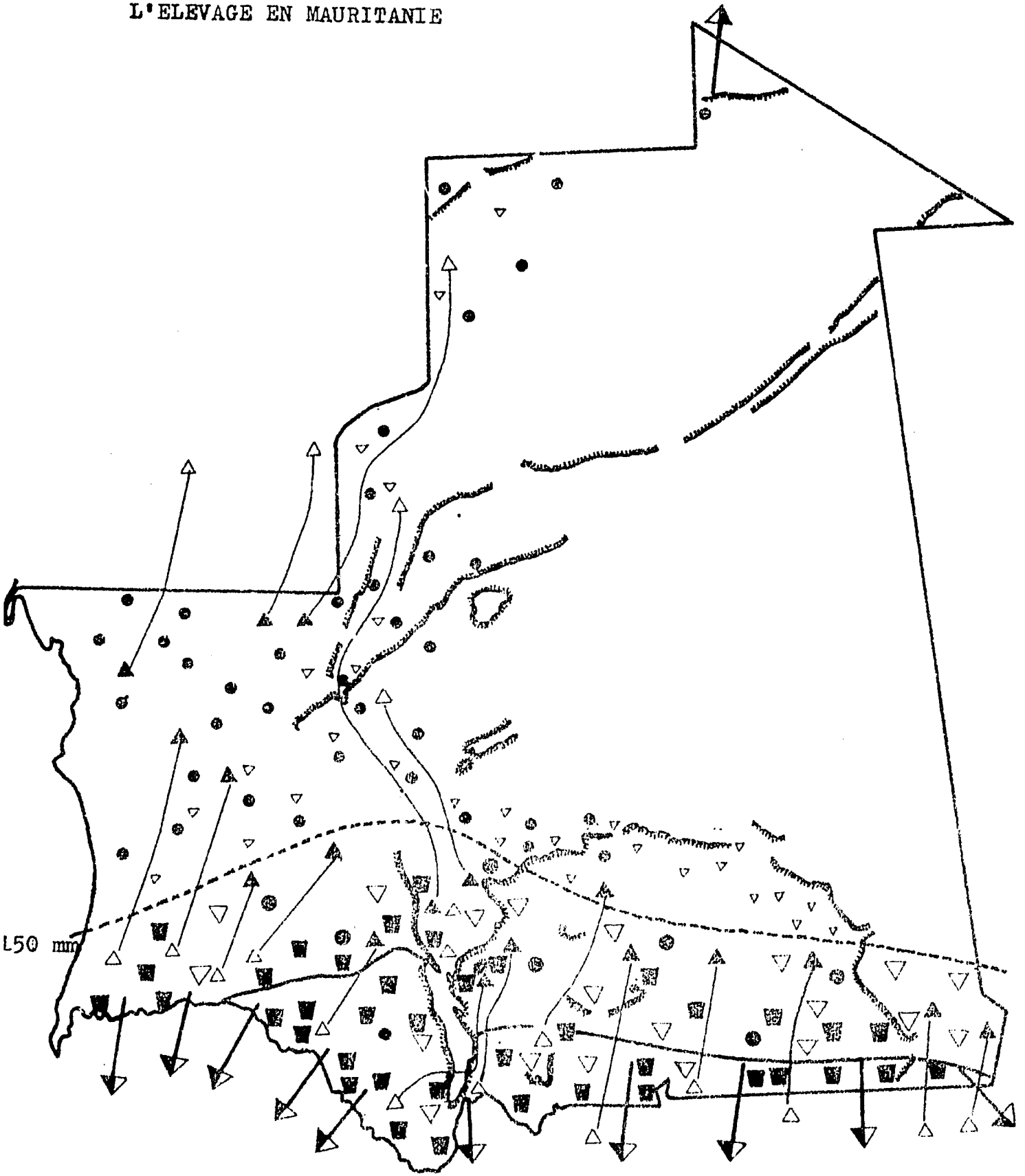
(2) "Situation et Perspectives de l'Economie Mauritanienne", IRDB, Volume II, 1971.

(3) A case frequently observed in the Trarza (RAMS mission 6/19/79 to 6/21/79).

FIG. 7-6

LIVESTOCK RAISING IN MAURITANIA

L'ELEVAGE EN MAURITANIE



SCALE 0 100 200 300km

ECHELLE: 1/6 500 000

ADAPTED FROM ATLAS DE MAURITANIE 1977.

The Moorish herdsmen on the edge of the Sahelo-Sahara region and the Sahara practice inverse migrations : they remain much farther north in the dry season to benefit from the winter rains and move southwards towards the Sahel during the summer rains[1].

Since the beginning of the 20th century, the nomads have tended to buy or plant palm groves or to have their former slaves cultivate fields of millet and sorghum. Thus, they have begun to remain for longer periods near the oases at the period of date harvest or near their fields at the period of cereal harvests. In fact, they have become semi-nomads. For example, with the Ahel Boulobat nomads, it is possible to distinguish two groups : the camel herders, who follow the rainfall but stop at their palm groves for the harvest, and the cattle raisers, whose migrations are more restricted, as a function not only of grazing but also of their cultivated fields.[2]

7-6 The Livestock Raisers and the Drought [3]

During the recent drought, many herdsmen found their livestock decimated and were forced to abandon their activities and sedentarize in the towns. According to J.P. Hervouet[4], the reactions to the climatic crisis were quite different for different ethnic groups and can be seen quite clearly at the level of animal losses, where only the Peulhs (Foulabé and Foulbé Walo groups) were able to save their herds by adaptation in the central southern portion of Mauritania.

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(1) Atlas de Mauritanie, 1977, P. 43

(2) Ibid.

(3) For more information, see the following studies : B 5 : "Profils Sociologiques - La Mauritanie Négro-Africaine" section on the the Peulhs, and F 2, "Changements Socieux en Mauritanie : le devenir du pastoralisme en Mauritanie"

(4) "Stratégies d'adaptation différenciées à une crise climatique L'exemple des éleveurs-agriculteurs du Centre-Sud mauritanien" 1969-1974

While the Moor groups abandonned their traditional way of life, the Peulhs attempted to adapt to the crisis conditions. Traditional use of the land was changed, due to the lack of labor and the social separation between the livestock raisers and cultivators; this forced the Moors to change from nomadism to a semi-sedentary life style where the inerests of the animals were often sacrificed to those of the herders, transhumance now being practiced towards areas of cereal production rather than towards the better pasturelands. The losses of the Moors reflect their difficulties in adapting to new situations, a problem severely aggravated by the drought.

According to Hervouet, only the agro-pastoral Peulhs, who consider their livestock as other than a purely economic resource, were able to resist the drought period. Those groups which practiced transhumance towards less populated zones and maintained strict control of their herds during migration (often to the temporary detriment of the herdsmens' well-being) were able to incur relatively low losses of livestock.

The attitude of the herdsmen towards the environment is extremely important during herd migrations.(1) A herd which is left to itself instead of being controlled wastes enormous amounts of potential forage, especially cattle which consume only part of the pasture,but trample a great deal during their constant ranging. On the other hand, a herd which is guided and controlled by the herdsman progresses much more slowly, but avoids wastage by maximum exploitation of the pastures along the route selected. The herdsman who controls his animals thus acts as a "protector of nature", in that over-grazing is reduced because wastage has been avoided.

However, given the present crisis situation, it is becoming more and more rare to find herdsmen walking in front of their animals; more and more frequently, one finds herds foraging without a guardian. This decrease in control of herds has led to an exacerbation of the consequences of drought on the vegetable cover, and an intensification of desertization., which in turn has a direct affect on the survival and increase of future livestock herds.

(1) J. P. Hervouet, "L'Attitude du pasteur et la désertisation" - Notes africaines N° 140, 1973.

7-7 Conclusions

The recent drought has over-burdened the environment, with catastrophic consequences when the equilibrium between the number of animals and the availability of pasturelands has been broken, which is what occurred in the Southwest. Although the Mauritanian herds are beginning to reconstitute themselves, it is to be feared that another climatic crisis may cause dramatic situations such as occurred during the last drought.

Heavy concentrations of livestock around watering holes have long term negative effects on the pasturelands; hydraulic programs for the future must take this into consideration in order to avoid the errors such as occurred in the Trarza.

Surface areas planted in forage are still too modest to meet the present needs of the livestock at the end of the dry season (Centre de Rosso and Ranch d'Embouche de Kaédi). According to the conclusions of a FAO report in 1975(1), large-quantity production of forage on irrigated perimeters could theoretically protect Mauritanian livestock from new famines, but not before 10, or possibly 15, years, and only on the condition that some link exist between extensive livestock raising and intensive agriculture ((by means which have yet to be defined). The development of irrigated forage cultivation is not planned and does not exist in the Senegal River valley. Were they to exist, of what help is this to those areas located far from forage production centers?

In the traditional pastoral milieu, which is far from permanent water courses, water control can only be attained by small dams, wells and more or less deep borings. According to the FAO report(2), it is impossible that the present or planned wells and borings could permit forage production in sufficient quantities and at reasonable costs to assure, even minimally, enough forage for herds during a famine period. Water control in the pastoral milieu can solve only problems of watering herds. If rational systems are not adopted rapidly for the use of water holes, their extension along migration routes may have negative effects on the productivity of natural pastures(3).

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(1) "Rapport de la mission du développement de l'élèvage et des forêts en Mauritanie", July 1979
(2) Ibid.
(3) Ibid.

TABLE 7-6

DEPARTMENTS DECLARED "DISASTER-AREAS" FOR PERIOD 1979/80 (1)

DEPARTMENTS	NUMBER OF HEADS	
	CAHLE	SMALL RUMINANTS
- Oualata, Néma	85.000	520.000
- Tamchakett	58.000	250.000
- Boumdeit, Kiffa, Kankossa	270.000	900.000
- Tagant	30.000	200.000
- Magta-Lahjar, Boghé	200.000	1.200.000
- M'Bout	150.000	250.000
- Boutilimit	10.000	100.000
- Inchiri, Adrar	1.000	100.000
TOTAL.....	804.000	3.520.000

(1) Source : "Evaluation de la Situation Agro-Pastorale Campagne 1979/80"
Ministère du Développement Rural-RIM.
Mission conjointe Multidonateurs/Gouvernement, November 1979.

CHAPTER 8

MAJOR CULTIVATION ZONES

8. MAJOR CULTIVATION ZONES[1]

8.0 Introduction

After livestock, agriculture is the next main activity of the rural sector in Mauritania[2]. It employs most of the rural labor of the country (about 85% of the Mauritanian population is rural).

A traditional and sedentary activity, agriculture is dependen on the availability of water, and thus, is very localized. Rainfa conditions and the degree of water control determine and strictly limit the distribution of crops.

Crop Distribution :

There are five different zones where cultivation is possible in Mauritania :

The Senegal River valley zone, where irrigated and floodlan cultivation are practiced in the floodable major bed (Oualo) of the Senegal and Gorgol rivers.

The rainfed cultivation zone, which extends essentially from south of the 450 mm isohyetal line along a thin strip on the border with Mali, covering the Guidimaka region in the west (along a West-East axis from south of Kaédi to M'Bout, north of Kankossa, to Timbedra, Amourj and Bassikounou.)

The floodland cultivation zone, along the oueds, which are mainly concentrated in the highlands and on surfaces favorab to rainwater runoff (See Chapter "Surface Water").

The palm groves (oases), which occupy a vast triangle in the highlands (Adrar, Tagant, Affolé, Grand Dahr). This zone is often intermixed with the floodland cultivation zone.

the new sector of urban gardens, where vegetables are cultivated using purified waste water (example : Nouakchott)

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(1) For more information, see the work of Research Group N° 3, Revenues and Agricultural Production (Study B 4 and sub-sector studies P1, P2 and P3).

(2) See Table 1 - PIB - Secteur Rural
Source : Ministère du Plan et des Peches.

Constraints of the Ecological Milieu

The sparse rainfall and its irregularity have a negative effect on crops; for rainfed cultivation, the surface areas planted vary considerably from year to year, and some years, there is no production at all

Table 8-2, "Evolution of Agricultural Production for the Period 1962-1973", clearly shows the effects of drought years on agricultural production. For example, for millet and sorghum, production decreased from 90 000 tons in 1967 to 50 000 tons in 1968 (a very dry year, especially in the southwest). In 1972, production decreased to 12 000 tons, due to the severe drought conditions of this year.

Other sources show the regression and stagnation of the surface areas cultivated in cereals and the corresponding production variations from 1948 to 1974[1].

In addition to the climatic variations, crops are attacked by numerous predators : locusts, rats and weaver-birds ("mange-mil").

Human Constraints

The survival of customary land tenure (where the land belongs to an absentee minority in the oases, or to a village oligarchy in the Chemana) hinders all attempts to restructure land use. In addition, the technological level of the rural population is usually fairly low.

Agricultural production is rarely high, and varies from year to year (See Tables 8-2 and 8-3). The major crops are millet and sorghum; however, even during good years, Mauritania must import additional tonnages of these cereals from Senegal and Mali. The following figures demonstrate that cereal imports are steadily increasing in Mauritania : (From FAO Trade Yearbooks)

1969	36 492 tons
1970	60 800 tons
1971	78 000 tons
1972	80 000 tons
1973	88 000 tons

(1) See Table 8-3, "Evolution of Agricultural Production (Cereals)" Source : "Equipe des Cultures Sèches", CILSS, March 1977.

TABLE 8-1

Gross national product by type of economic activity (1970-1978) at current prices (millions UM)

	1970	1971	1972	1973	1974	1975	1976	1977	1978
RURAL SECTOR	3.514	3.491	3.328	2.932	4.078	5.207	6.271	6.195	6.286
AGRICULTURE	820	750	420	281	379	366	477	351	326
LIVESTOCK	2.200	3.200	2.380	1.832	2.756	4.004	5.074	5.060	5.143
FISHING	450	395	480	770	890	730	650	685	70
TREE CULTIVATION AND FOREST EXPLOITATION	44	46	48	49	53	57	60	64	67

Source : Ministère du Plan et des Pêches R.I.M.

TABLE 8-2

Evolution of agricultural production (Tons) from 1962- to 1973

YEAR	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Millet + Sorghum	90.000	90.000	90.000	100.000	90.000	90.000	50.000	100.000	82.000	-	12.000	37.000
Corn	3.400	3.700	4.000	4.000	3.000	2.000	4.000	4.000	[illegible]	400	-	-
Wheat and Barley	200	200	200	300	300	200	200	300	200	-	200	250
Niébé	5.300	5.800	6.600	7.300	8.000	8.300	500	1.100	10.000	-	400	2.000
Vegetables	400	400	500	600	700	400	300	400	700	-	450	1.000
Dates	11.370	10.500	9.500	9.100	9.600	10.900	11.700	11.400	14.600	-	9.800	9.320

Source : Ministère du Plan et des Pêches R.I.M.

TABLE 8-3

EVOLUTION OF SURFACE AREAS CULTIVATED AND AGRICULTURAL PRODUCTION (CEREALS)

YEARS	TOTAL PRODUCTION	SURFACE AREA CULTIVATED
1940-52	50.000 t	83.000 ha
1952-56	58.000 t	83.000 ha
1961-65	98.000 t	261.000 ha
1967-68	90.000 t	187.000 ha
1969-71	93.000 t	272.000 ha
1972-74	41.000 t	187.000 ha

Source : CILSS - "Equipe des cultures sèches", March 1977.

8.1 The Senegal River Valley

Three types of cultivation are practiced in the Senegal River valley :

- floodland cultivation, in the Oualo (major bed of the river and its tributaries : the Gorgol, Lake Rkiz and Oued Gorfa, which are inundated by annual floods.
- irrigated rice cultivation
- rainfed cultivation on diéri, the banks of the river which are not inundated by annual floods.

8.1.1 Oualo Floodland Cultivation

The Senegal River Valley has considerable surface water resources, but they are very irregularly distributed over time, going from several thousand /s during the flood period to less than 10 m3/s during slack water.

The volume of annual floods determines the cultivable surface area in the Oualo. In the middle valley of the Senegal River, a weak flood in 1944 permitted the cultivation of 80 000 hectares, an average flood in 1947 permitted cultivation of 120 000 hectares, and a high flood in 1950 permitted cultivation of 180 000 hectares(1)

However, often more surface areas are flooded than can be cultivated, due to lack of labor.

During drought years, the flood is weak, which severely reduces the surface areas that can be cultivated and thus, agricultural production:

- In 1972, the flood deficit was enormous. This is demonstrated by observations made at Bakel : whereas the average annual flow at Bakel is 24 billion m3 and the flood volume is, 9 years out of 10, greater than 13 billion m3, in 1972, the annual flow was only 8.33 billion m3. The normal rate of maximum flow is 4 700 m3/s; during 1972, it was only 1 428 m3/s(2).

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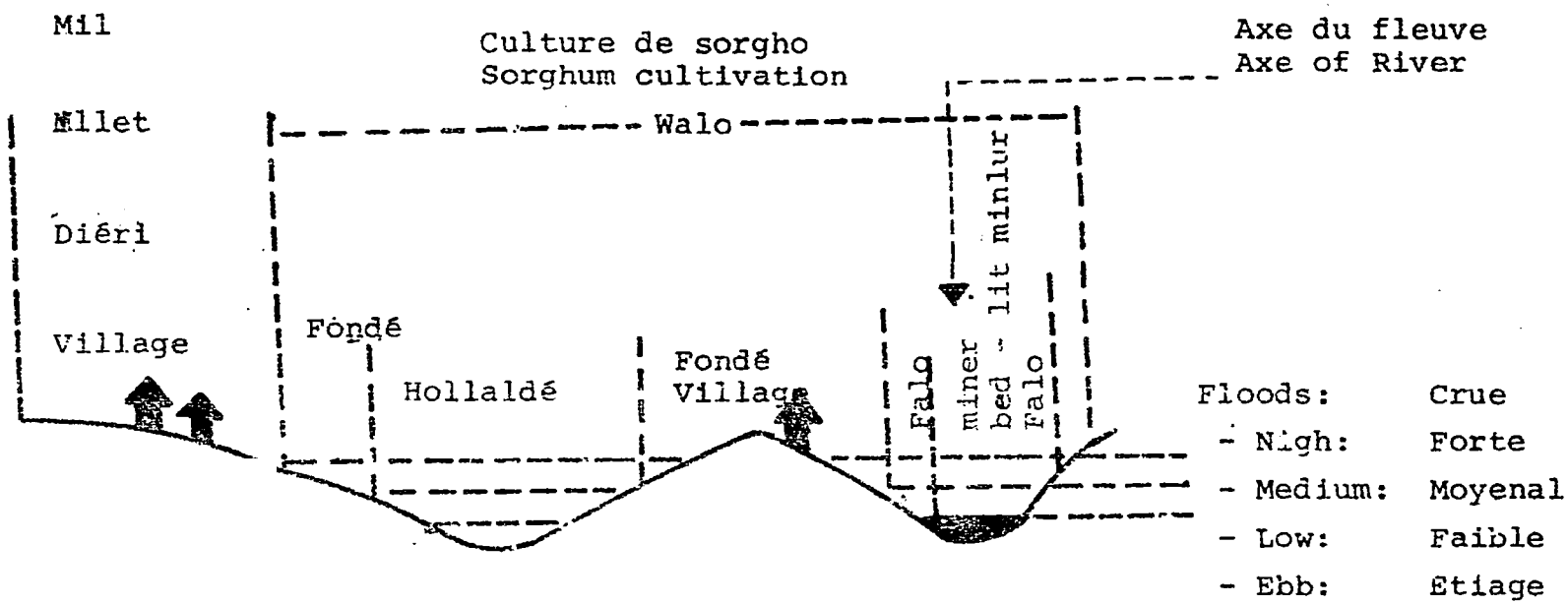
(1) Charles Toupet, "La Mauritanie", 1977

(2) André Lericollais, "La Secheresse et les Populations de la Vallée du Sénégal", Nouakchott Colloquium, Dec. 17-19, 1973, Nouvelles Editions Africaines.

Fig. 8-1

Cross Section of Terraines in Senegal River Valley

Coupe schématique des terrains de la vallée du fleuve Sénégal



Walo: Floodland cultivation (sorghum) - Cultures de décrue

Falo: Floodland vegetable cultivation - cultures maraîchères à la décrue

Diéri: Winter millet cultivation - Culture d'hivernage du petit mil

See annex for explanation of the following local terms:

Voir en annexe la signification des termes locaux utilisés

Walo - Diéri - Fondé - Hollaldé - Falo -

SOURCE: PERRAUDIN 1972.

Since the flood in 1972 was practically non-existant, the rural populations were able to plant only a narrow strip of the Oualo 15 000 hectares, according to FAO estimates. The probable production for total Oualo crops did not attain 10% of the normal figure.[1] The deficit for cereal harvests in this year (millet sorghum and rice) was about 90% in the oualo and diéri.[2]

In 1979, the Senegal River flood was inferior to that of 1972. The flood hardly inundated the Oualo[3] and attained a maximum elevation of 6.20 meters. In addition, the flood was very rapid, the level falling to 3.20 meters at the end of October (elevations measured at Bakel). Only 8 000 hectares of Senegal River valley Oualo were cultivated and yields will be very low[4]. However, the Gorgol and Oued Gorfa oualos were cultivable over 20 000 hectares and an average yield of 300 kg/hectare to 350 kg/hectare is expected.

Gross production is estimated at 2 000 tons of millet and sorghum, which is very low[5].

As the surface area cultivated depends on the flood level, in a good year, floodland cultivation can cover up to 60 000 hectares; for a very weak flood, only 3 000 hectares may be cultivable. Yields will be from 3 to 5 quintals as a function of soils and the period of the flood. Floodland cultivation in the river valley supplies three-fourths of total production in Mauritania[6].

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(1) André Lericollais, "La Sécheresse et les Populations de la Vallée du Sénégal", Nouakchott Colloquium, Dec. 17-19, 1973, Nouvelles Editions Africaines.

(2) Jean Robert Pitte (1975), "La Sécheresse en Mauritanie", Annales de Géographie N° 466

(3) "Evaluation de la Situation Agro-Pastorale, Campagne 1979/80", Ministère du Développement, Mission Conjointe Multidonateurs/Gouvernement, IRM.

(4) Ibid.

(5) Ibid.

(6) Equipe des Cultures Sèches, Club des Amis du Sahel, CILSS, IRM, March 1977

Distribution of Oualo crops (see Figure 8-1)[1]

Sorghum (sorghum cernuum) is the basis of Mauritanian diets and dominates cereal crops. According to Charles Toupet, sorghum occupies 98.5 % of hallaldé fields, 62.8 % of fondé fields and 50 % of falo fields[2]. (See Annex for definitions of these terms as used in literature concerning the Senegal River valley). Corn, niébé, and sweet potatoes are also cultivated; in recent times, vegetables are seen more and more often, especially in the Falo.

8.1.2 Irrigated Rice Cultivation

The cultivation of irrigated rice has recently been introduced; it is practiced with more or less sophisticated water control on small plots :[3]

small village perimeters : 196 hectares in 1976 with a total production of 956 tons.

the M'Pourié pilot perimeter : 802 hectares cultivated in 1975-76 giving a total production of 3 472 tons

the Gorgol pilot perimeter (for which work was finished in July 1977), which possesses 567 hectares of rice fields, of which only 371 were exploited in 1978.[4]

Other units are being completed (such as Boghé). Table 8-4 gives rice production figures for 1975[5]

TABLE 8-4

PERIMETERS	Surface Area (ha)	Yields(T/ha)	Production (T)
Tiékane	23.0	2.91	67.0
Dar el Barka	62.0	1.20	72.4
Leboudou	35.0	1.55	54.5
Bakao	16.0	0.1	2.0
Vinding	38.0	3.95	150.0
Rindiao	23.0	3.8	87.4
Diovol	25.0	2.7	67.3
Sorimale	10.5	1.6	16.8
Ngorel/guidale	14.0	6.6	92.4
M'Pourié	792.0	4.4	3 450.0
TOTAL	1 038.5	-	4 059.6

(1) Final Report of R. L. Perraudin, Forestry Expert (Points II and III), "Etude Hydro-Agricole du Bassin du Fleuve Sénégal", AFR/Reg/61, April 1972.
(2) "La Mauritanie", Collection "Que Sais-je?", PUF, 1977.
(3) Club des Amis du Sahel, Equipe des Cultures Sèches
(4) "Réalisation d'un périmètre pilote dans le Gorgol", Report on 1978 winter campaign, SONADER, IRM, Dec. 1979.

This table shows that the surface areas cultivated are fairly small, as is the total production.

It is hoped that the extension of rice plots in the Middle Valley of the Senegal River will help, in the future, to decrease Mauritania's rice imports, which are currently on the order of 32 000 tons per year[1].

8.1.3 Diéri Cultivation

Cultivation on diéri lands is rainfed. It is practiced along a narrow strip on the banks of the Senegal River between Rosso-Keur Massène and Kaédi, roughly. To the south of Kaédi, the river penetrates a rainfed zone bordering the west of Littam and the Guidimaka; in this area diéri cultivation is intermixed with other rainfed cutlivations below the 450 mm isohyetal line.

The main crop is millet during the rainy season, with occasional niébé, peanuts and beref. Yields are very low.

The so-called "diéri villages" are located on these lands; although they are permanently inhabited, a part of the population emigrates during the flood season towards the Oualo, where homologous "oualo villages" exist.

According to a CILSS study, 30 000 laborers can cultivate 40 000 hectares of millet. Depending on rainfall, production can vary from 0 to 12 000 tons.

It is difficult to evaluate the cultivation of diéri lands in the Senegal River valley, as surface areas vary so greatly from year to year as a function of rainfall.

In 1972, rainfall deficits in the Senegal River valley were considerable, (see Table 8-6), attaining 81% at Rosso and 75% at Dagana. During this year, diéri cultivation was severely affected (especially "little millet" or Pennisetum, which usually occupies 85% of diéri fields.)

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(1) Charles Toupet and Jean-Robert Pitte, "La Mauritanie", PUF 1977

(2) Club des Amis du Sahel, Equipe des Cultures Sèches, CILSS, IRM, March 1977.

TABLE 8-5

Rainfall from June to October 1972 (from ASECNA-DAKAR) (mm)

STATIONS		JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	TOTAL	DEFICIT
SAINT-LOUIS	1972	22	10	33	80	7	152	55 %
	Mean	6	44	161	97	29	337	
ROSSO	1972	18	1	1	25	8	53	81 %
	Mean	8	47	119	74	32	280	
DAGANA	1972	33	2	22	11	10	78	75 %
	Mean	17	56	128	88	25	314	
PODOR	1972	4	10	58	8	25	105	68 %
	Mean	16	68	133	84	23	324	
BOGHE	1972	25	-	87	-	-	112	65 %
	Mean	15	73	131	76	22	317	
KAEDI	1972	27	9	60	22	10	128	68 %
	Mean	29	87	166	95	20	397	
MATAM	1972	24	11	47	56	33	171	67 %
	Mean	51	129	202	122	22	526	
BAKEL	1972	44	45	130	124	15	358	48 %
	Mean	68	177	234	178	38	695	
SELIBABY	1972	70	10	63	72	68	283	53 %
	Mean	70	133	217	151	35	606	

In 1979, the entire Senegal River zone, with the exception of Rosso and Keur Massène, registered large rainfall deficits : Kaédi received only 63 % of normal rainfall, and Boghé only 58%.

8.2 The Rainfed Cultivation Zone

The rainfed cultivation zone is found in the southeast of the country, below the 450 mm isohyetal line, which is the northern limit for this type of cultivation (see map). To the north of the 450 mm isohyetal line, rainfed cultivation is only occasional.

Satellite documents from December 1972 show that in the Hodh[1] region, rainfed cultivation may attain the 350 mm isohyetal line, in the form of a "pioneer front".

In general, rainfed cultivation occupies a narrow strip along the Senegal River on diéri lands, between Kaédi and Rosso-Keur Massène to the north of the 450 mm isohyetal line. It varies considerably from year to year.

Certain attempts at rainfed cultivation have been made above the 450 mm and 350 mm isohyetal lines (for example, at Aleg and Magta-Lahjar), as was seen by the RAMS Geographical Research Unit in the beginning of September 1979. These crops are usually "little millet".

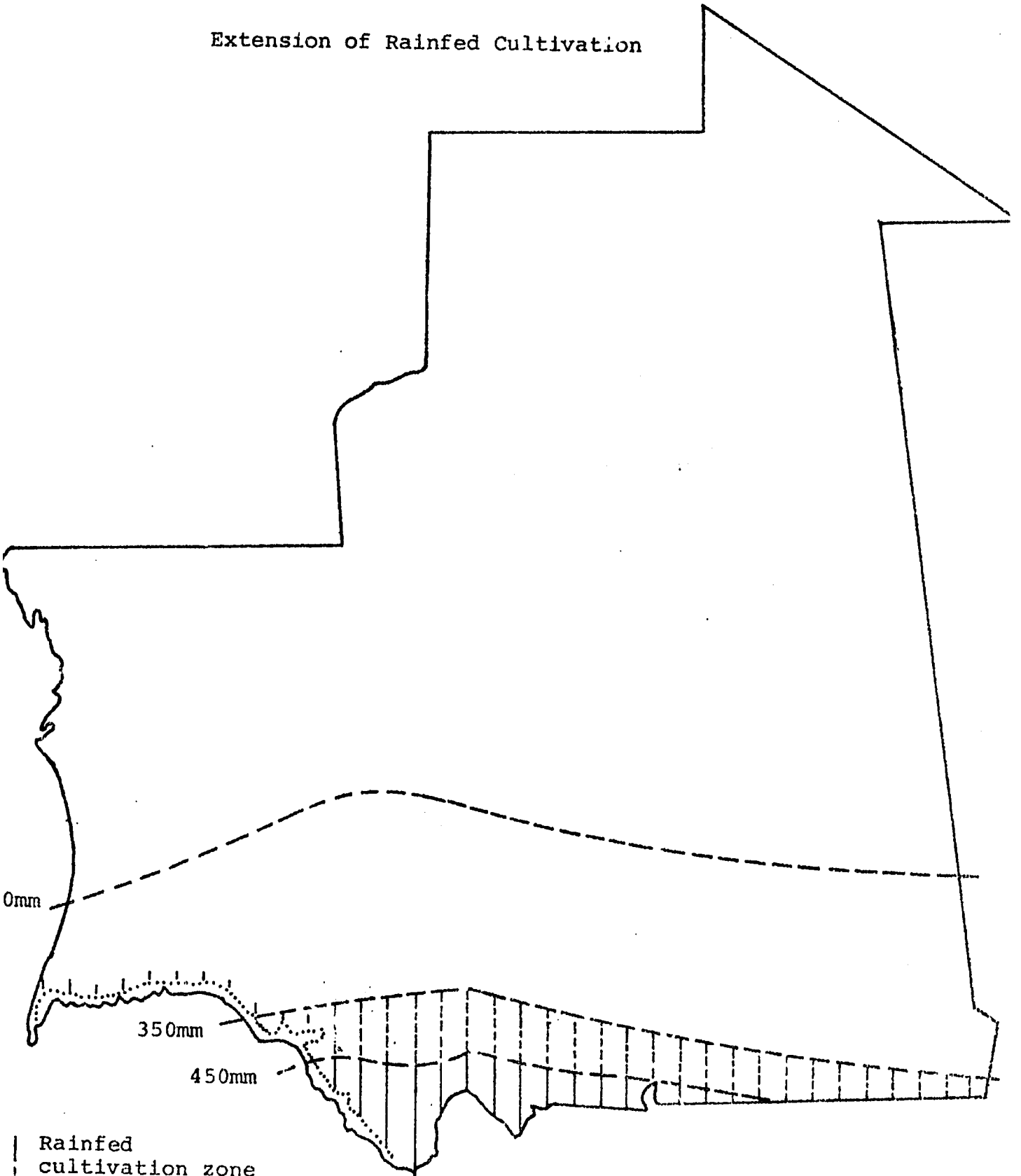
However, the real rainfed cultivation zone is distributed as follows

Region Number	Regional Center	Rainfed Cultivation
4	Kaédi	South of the region
10	Selibabi	Guidimaka
3	Kiffa	South of the region
2	Aïoun	South of the region
1	Néma	South of the region

(1) Author's observations, see chapter on Surface Water.

Fig. 8-2

Extension of Rainfed Cultivation



Rainfed cultivation zone

Zone where rainfed cultivation is occasional

Isohyetal lines

Limit of alluvial plain of Senegal river and diéri cultivation.

0 100 200 300 km

Map By Author DAMS 1979.

According to a CILSS study[1], the southeastern rainfed cultivation zone covers about 110 000 hectares, but not all of the arable land is cultivated at present. This report estimates that 50 000 laborers cultivate 110 000 hectares with a yield that varies, as a function of rainfall, from 1 to 3 quintals/hectare (or a production of from 11 000 to 35 000 tons).

The integrated development project for the southeast of Mauritania should permit the improvement of about 45 000 new hectares for cultivation of millet and sorghum, with diversification of crops and the introduction of animal traction (the use of animals for cultivation has practically disappeared in Mauritania).

8.2.1 Main Cereal Crops and Cultivation Practices[2]

Sorghum and millet are by far the major crops; in 1967 they represented about 80% of the surface area cultivated (and even more, if the niébé cultivated in association with them is not taken into account).

Corn represented in 1967 about 2% of the surface areas cultivated in the southeastern rainfed zone.

Niébé (vigna sinensis or "bean") is cultivated in association with millet and sorghum. It represented 10 to 20 % of the surface areas cultivated in 1967 in the Hodhs and the Assaba.

Peanuts : although the sandy soils of the southeast of Mauritania are theoretically very favorable for peanut cultivation, the weak rainfall of this region practically forbids peanut crops, with the exception of the wetter Guidimaka zones. In 1967, less than 10 % of the surface area was planted in peanuts.

Rainfed rice is cultivated in certain flooded zones of the Guidimaka and concerns only very small surface areas ("floating rice").

(1) Club des Amis du Sahel, Equipe des Cultures Sèches, CILSS, IRM, March 1977.

(2) "Cultures Vivrières dans la Zone Pluviale du Sud-Est Mauritanien-Possibilité de Développement", BDPA, Opération 1.06.67.

Cutlivation methods in the southeast are traditional, of the extensive type, and appear, given the present state of techniques, well adapted to the soils and climate of this region. The extension of surface areas cultivated compensates for low yields(1), mediocre soils, and insufficient and irregular rainfall. All agricultural work is manual (daba, hoe, etc.).

Millet and sorghum crops are never pure; the different varieties cultivated in the region are frequently mixed in the same field. In this manner, the farmers hope to obtain maximum production, even in the case of drought or attacks by parasites or predators. Niébé is practically always associated with these cereals unless the soil is too depleted.

Ancestral techniques are employed : clearing, sowing, harvesting and battues against monkeys and warthogs are the work of the men; the women and children try to preserve the harvest from the attacks of weaver-birds ("mange-mil" - Quelea quelea). Rotational fallow is the rule.

The Soninkés, Peulhs and Harrantins are the ethnic groups that practice rainfed agriculture in the area under consideration (as well as a few Bambaras in the extreme southeast of the country, below Néma).

8.2.2 Rainfed Cultivation and Climate

Rainfed cultivation depends directly on rainfall conditions, which, unfortunately, are not improving in Mauritania.

Drought years considerably reduce the surface areas cultivated. In 1979, the rainfall was poor, affecting the crops. All the Regional Agriculture Departments of the south of the country describe the poor state of the crops, linked to insufficient and poorly distributed rainfall.

In the Guidimaka area, 60 to 70 % of the 1978 crops were registered. In the Gorgol, only a third of the rainfed cultivable land was cultivated (about 20 000 hectares out of 60 000). At Kaédi, the rainfall deficit was about 63% of normal.

(1) "Cultures Vivrières dans La Zone Pluviale du sud-est Mauritanien - Possibilités de Développement", BDPA, Operation 1.06.67

8.3 Floodland Cultivation Zones

The floodland cultivation discussed here concerns the oueds and not the oualo of the Senegal River valley. Cultivation is practiced along the oued banks which have been submerged; the land is planted as the waters recede. The surface areas cultivated depend on the amount of rainfall, and vary from year to year. The construction of a dam across a favorable site along the oued allows water storage and an increase of the surface areas to be cultivated upstream.

The main crop is floodland sorghum. The area of extension of this type of cultivation has already been discussed in the chapter concerning surface water; it corresponds to the highlands : the Adrar, Tagant, Assaba and Affolé Massifs, of impermeable rock (mostly sandstone), which is a particularly favorable surface for the runoff of rainwater (see map of main dams in Mauritania).

To the west of the country, the large sand dune-covered zones are not favorable for floodland cultivation, as surface runoff is negligeable due to infiltration of the rain water (absence of hydrographic network).

In the Hodhs, the extension of the Aouker sands causes the northern limit of floodland cultivation to descend towards the south. On the other hand, in the southern center of the country (Traab el Hajra), the northern advances of the Tagant and Adrar Massifs allows floodland cultivation along oueds at higher latitudes.

The southern limit of the floodland cultivation zone corresponds very roughly and irregularly (in a saw tooth fashion) to the 450 mm isohyetal line. North of the 450 mm isohyetal line, rainfed cultivation is quite risky, due to insufficient rainfall. However, floodland cultivation is possible north of the 450 mm isohyetal line, because even relatively weak and poorly distributed rainfall concentrates in the catchment basin's hydrographic network and finally arrives at the main oued, which collects all the water that has fallen upstream.

Thus, floodland cultivation extends over the zone where rainfed cultivation is risky, as it depends directly on the localization of rainfall (precipitation becomes weaker and more irregular towards the north).

Floodland cultivation is also practiced along the banks of ıds, which appear during the rainy season, and in the flow zones the oueds (called "graïr"). Graïr cultivation is occasional, ly about 1 year out of 5, and yields are usually negligeable, ew stalks of sorghum and a few handfuls of black beans ("dolic").(1) of the main Graïrs is at Yagref, at the mouth of the Seguelil l El Abioud oueds, at the foot of the first escarpments of the ar massif.

Due to ecological conditions, there are two separate floodland ıes, roughly separated by the 150 mm isohyetal line(2):

- the southern and central zone south of the 150 mm isohyetal ıe, which includes the Assaba, Affolé and Regueiba (region north Kiffa).
- the northern zone, which includes the eastern Tagant and the ar (north of the 150 mm isohyetal line).

To the south of the 150 mm isohyetal line, floodland cultiva- ın represents a considerable supplement to the nomads' diet. hough yields are quite variable, it is possible every year.

To the north of this theoretical limit, floodland cultivation subjected to increased climatic variations.

icultural Dams(3)

Agricultural dams are constructed so as to control the very egular floods. The advantages are obvious : an increase of the ıgth of submersion and an increase of surface areas flooded. ditionally, certain tribes put up these dikes in order to culti- e sorghum upstream.

Charles Toupet, "La Mauritanie", PUF, 1977.
Charles Toupet, "La Sédentarisation des Nomades en Mauritanie Centrale Sahélienne", 1977.
Ibid.

After the Second World War, the Mauritanian administration decided that by multiplying these dams, it would be possible, if not to hasten the sedentarization of the nomads, at least to assure their periodic settling, while providing a dietary supplement. For the past twenty years, the technical services (first the Génie Rural, and much more recently, the SONADER) undertook the constructi of modern dams; considerable investments have been devoted to this project.

However, the results obtained are far from those expected. Some of the reasons for the disappointing results are given below

- the most obvious is that the dams, in this area where animal husbandry is "king", serve not only to provide cultivable land but also to provide watering and pasture for animals. It has frequently occurred that the chiefs of tribes demand and obtain the construction of a dam for the sole purpose of providing a watering point for their herds.

- in addition, after a number of years of cultivation (and thus of submersion), the soils become progressively asphyxiated, which decreases yields.

- many of the dams are destroyed or severely damaged by the floods. For example, all of the dams built along the Lehbilé-Bargatanni oued in the Affolé were destroyed by the 1958 floods. Their reconstruction requires new studies, new investments and new efforts. This explains why the number of dams varies from year to year.

Two types of construction exist : the traditional dam, which consists of a simple earth dike, and the modern dam, equipped with a spillway and a drainage structure. Traditional dams have been built since the end of the 19th century. Their construction is very simple : an earthen dike is built, its height being a function of the volume of the preceeding year's flood. The earthern dike is sometimes consolidated by walls or slabs of flat stone. These dikes are easily dammaged or destroyed when floods are violent, especially as they have no spillway or drainage structure; when the farmers consider that submersion has been sufficient, they make a hole in the dike to allow evacuation of the water. This means that each year, a great deal of labor is required to repair the dike.

To remedy this serious problem, the Genie Rural has designed a modern dam composed of an earth dike, with a spillway and a drainage structure (spillway and drainage structure with cofferdams are built of cement by technicians.) Some of these modern dams, such as those at Tichilchil and Ederoum in the Tagant, have been functioning normally for years. Others have been swept away by strong floods, because the spillways were too small. (An Italian company, Il Nouvo Castoro, in charge of the study of dams for the Hodh regions, has designed new dams with a new type of spillway; based on recent hydrological work, the design of these spillways is a function of the nature of the terraine and the volume of floods.)

According to a report by the Ministry of Rural Development of November 1979[1], most traditional and modern dams are in an advanced state of decrepitude and no serious rehabilitation program has been undertaken for many years. Most structures have been destroyed or permit only the occasional cultivation of a few hectares. The dams equipped with drainage structures are all in need of major reparations, and the farmers no longer have water control. The report notes the case of the Magta-Lahjar dam, which filled three times in 1979, forcing the farmers to replant each time. This caused the surface area cultivated to be only about one third of the potential.

The Number of Agricultural Dams and Production :

According to the Third Economic and Social Development Plan[2], in 1976 there were about 180 agricultural dams built by the local populations and about 70 dams built by the State, which served for traditional irrigation over a surface area of 14 000 hectares.

According to Charles Toupet[3], there are about 50 modern dams distributed throughout the Brakna, Assaba, Hodhs, Tagant and Adrar.

(1) "Evaluation de la Situation Agro-Pastorale, Campagne 1979/80", Ministère du Développement Rural, IRM, Mission Conjointe Multi-donateurs/Gouvernement.

(2) Ministère du Plan et des Mines, IRM

(3) "La Mauritanie", PUF, 1977, p. 93

According to the Génie Rural[1], the number of traditional dams is about a thousand and the number of modern dams about two hundred, figures which are notably higher than those given by the Third Economic and Social Development Plan and by Charles Toupet.

In 1979, given the climatic conditions (which were poor for most of the country, except in the north of the country), hardly 3 000 hectares were cultivated by floodland techniques, with a yield estimated at about 400 kg/hectare.[2] As compared to the estimates of the Third Development Plan of 1976, which give the figure of 14 000 hectares, the reduction of surface areas under cultivation is 11 000 hectares (or 75%), which is considerable.

The present status of floodland cultivation does not lead to optimism for the future. Urgent measures are required to supply rural populations with the cereals they require (the populations practicing floodland cultivation to the north of the 450 mm isohyetal line are essentially Moorish and Harratin, livestock raisers

8.4 The Palm Groves

General Observations :

The term "palm grove" has been used in preference to that of "oasis", which is too restrictive in the context of Mauritania. An oasis is commonly defined as an "islet of life and cultivation in the desert, linked to the presence of water".[3] However, in Mauritania, numerous palm groves are found in Sahelian lands, to the south of the 150 mm isohyetal line and not in the Sahara desert itself. Only the palm groves of the Adrar and the extreme north of the Tagant can be qualified as "oases".

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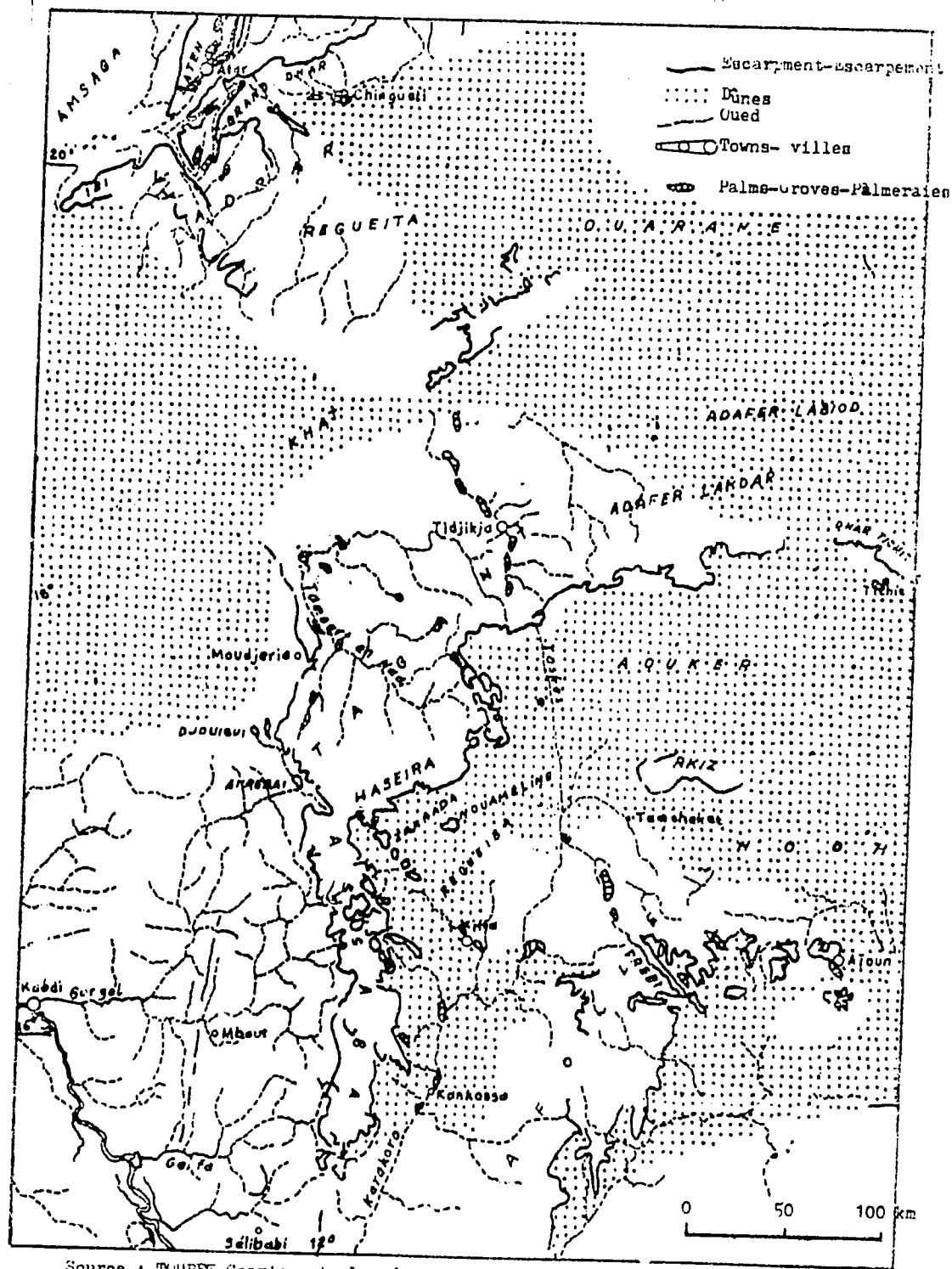
(1) Technical communication, January 31, 1980

(2) "Evaluation de la Situati n Agro-Pastorale, Campagne 1979/80" Ministère du Développement Rural, IRM, Mission Conjointe Multidonateurs/Gouvernement.

(3) As for example in the "Dictionnaire de la Géographie", by PierreGeorge, PUF, 1970.

Extension of Palm-Groves in Mauritania - Extension des Palmeraies en Mauritanie.



Source : TOUPET Charles, in La sédentarisation des nomades en Mauritanie Centrale et sahélienne 1977.

8.4.1 Areas of Extension of Palm Groves

The palm grove area occupies a vast triangle which includes the highlands. For this reason, it is often intermixed with the oued floodland cultivation zone.

Palm groves are found mainly in central Mauritania, in the Afrar, Tagant, Assaba and Affolé, as this is the area where the date-palm finds the ecological conditions necessary for its growth (see map of extension of palm groves in central Mauritania). The favorable climate conditions are :

- average daily temperature always higher than that required for vegetation (9°-10°C)
- average temperature during fructification higher than 28°C (length of fructification : 120 to 150 days)
- absence of rainfall during fructification period
- low hygrometry

The hydrological and edaphic conditions are also favorable

- the date-palm draws its water requirements from the shallow alluvial aquifers which characterize the multiple oued valleys which drain the highlands. It is considered that one hectare of date-palms consumes from 7000 to 8000 m3 of water per year[1], furnished by the alluvial aquifers, which is a considerable amount of water.

- the date-palm tolerates a certain amount of salinity, on the order of 10%.

Finally, on the banks of Mauritanian oueds are found the light, friable, aerated sandy and clayey-sandy soils which are required for the date-palms' extensive root system[2]

These ecological conditions explain why almost all of Mauritania's palm groves are found on the edges of oueds (Atar, Chinguetti, Tidjikja, etc.). A few plam groves are found at the foot of a spring (El-Haousseinia, in the Tagant; Toungad in the Adrar; Taghada in the Assaba), or near dams (such as the palm groves planted at the Agouenit and M'Beikat dams near Néma, in the Eastern Hodh).

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(1) C. Toupet, "La Mauritanie", PUF, 1977.

(2) P. Munier, "Le Palmier-Dattier en Mauritanie", 1955

However, these palm groves near springs or dams are exceptio
The northernmost palm grove is found at Char; it is very small and is located to the north of the Adrar Massif. The southernmost large palm grove is at Kankossa (presently, in poor condition), and was created by the IFAC.

8.4.2 Importance of Date Growing Regions

The main date-growing regions are :

- the Adrar with about 400 000 palm trees
- the Tagant with about 205 000 palm trees
- the Assaba with about 125 000 palm trees
- the Affolé with about 55 000 palm trees
- the region of Dhar Nema Oulata with about 20 000 palm trees

For a total of about 805 000 palm trees.(1)

According to the "Atlas de Mauritanie" (1977), Mauritania possesses about a million date-palms. The Adrar alone has half of the country's palm trees. Table 8-6 shows the results of the Census of Palm Trees in the Adrar covering the period 1958-59. The highlands (Adrar, Tagant, Assaba and Affolé) possess about 90% of the palm trees in Mauritania.

The palm groves are small; the largest cover only a few dozen hectares. Total surface area for the country is not more than 3 000 hectares.(2)

8.4.3 Production

Production reflects the harsh drought conditions, as can be seen by the sharp decrease in date production for the 1972-73 campaign(3)

(1) These figures are estimates from the Agriculture Service, dating from 1960.

(2) C. Toupet and J. Robert Pitte, "La Mauritanie", PUF, 1977.

(3) Third Economic and Social Development Plan, 1976-80, Ministère du Plan et des Mines, IRM.

TABLE 8-6

Census of palm giver in the aorar 1958-59 (1)

	Surface area (hectares)	Total nº palm trees	Number Young palms	Number productive palms	Percentage young palms
ATAR REGION (Oued Seguelil)	1.267	195.863	55.630	102.810	28.4
SOUTHERN REGION (Oued el Abiod Touerga)	701	169.579	58.368	96.870	34.4
EASTERN REGION (Chinguetti-Ouadane)	188	34.427	5.518	24.300	16.0
T O T A L	2.156	399.869	119.516	223.980	29.0

(1) Source : Charles Toupet. "La Sédentarisation des Nomades en Mauritanie Centrale Sahélienne". 1977

Table 3-7

Campaigns	Production (tons)
1970 - 1971	12 500
1971 - 1972	15 000
1972 - 1973	10 000
1973 - 1974	10 400
1974 - 1975	12 500

FAO sources give the following production for 1976 to 1978

Year	Production (tons)
1976	13 000
1977	14 000
1978	13 500

The generalized drought of 1972-73 severely affected the palm trees, which lacked water since the alluvial aquifers of the oueds were not replenished by the meager rainfall.

Note : The increase of production for 1977 (14 000 tons) appears curious. During this year, Mauritania experienced a generalized drought, as can be seen from the size of rainfall deficits registered by the PNUD/OMM/AGRHYMET project (MAU/77/005), especially in the date-growing regions such as the Adrar, which received only 10% of normal rainfall (only 5% at Atar). Tidjikja, in the Tagant, received only 33%.

On the other hand, rainfall in 1978 was much better and yet the FAO figure of 13 500 shows a decrease.

8.4.4 Condition of Palm Groves

The palm groves in Mauritania are from from being in satisfactory condition, for several reasons :

- the succession of dry years has diminished the level of the alluvial aquifers, and the palm trees have suffered from lack of water. Certain have dried out completely, but most are only weakened, which makes them susceptible to diseases such as Taka, and to the white caterpillar and to termites.

- sand covers represent a short term danger, which is difficult to halt. The palm grove west of Chinguetti (Adrar), for example, has been entirely covered over, only some date palm fronds (which are 10 meters high) stick out from the perpetually shifting dunes. Chinguetti has thus lost about 4000 to 5000 palm trees.[1]
  over-digging of wells in order to find deeper water as a result of the descent of alluvial aquifers and the sometimes excessive number of motor pumps in the Atar region (which possesses about 600)[2] has caused a rise of the salt water levels. Atar has lost about 25 000 palm trees since 1945. (Replenishment dams can contribute effectively to the replenishment and rise of alluvial aquifers - see Chapter on Underground Water, the example of Akjoujt.)
  The too great number of palm trees planted per hectare, up to 400 to 500 individuals, is detrimental to yields in many palm groves. A plantation should not surpass 200 plants per hectare due to the frond development of the palms, which can attain 7 meters.[3]

8.4.5 Types of Palm Groves[4]

There are two types of palm groves : the wild palm groves and the planted palm groves :

8.4.5.1 Wild Palm Groves

These are in general old palm groves, which for one reason or another have not been maintained and are in a state of abandon. No fences protect them against the ranging of camels and goats. They are only visited by the nomads at date harvest time.

In the Tagant, for example, upstream from Rachid, there are a succession of "agonizing" palm groves : two have been devastated by floods, another has only old plants, has no fences and the dead branches form an inextricable tangle. Acacias and Euphorbes are mixed with the date-palms. At Talmeurt, in the north of the Tagant,

(1) C. Lenormand, "Expose sur la Situation des Palmeraies de l'Adrar", March 1975, Ministère du Développment Rural, JRM

(2) Report of April 8, 1979, Ministère du Plan, Mission in the Adrar from March 28-31, 1979.

(3) P. Munier, "Le Palmier-Dattier en Mauritanie", 1955.

(4) C. Toupet, "La Sédentarisation des Nomades en Mauritanie Centrale Sahélienne", 1977 and "La Mauritanie", 1977

the Oulad Sidi Boubakar (Kounta) possessed 1000 productive date-palms in 1936[1]; today, due to the descent of the alluvial aquifer and the progressive salinisation of the water, the palm grove has been transformed into a park of thick, hundred-year old trees, but which are not very productive. Herds of goats graze among them and the Oulad Sidi Boubakar have created new plantations in the Oued el-Abiod, farther south.

Small spontaneous palm groves may occur in favorable sites where the nomads habitually make camp. The pits of dates eaten by the nomads which find favorable soils and a water supply may grow into small groves, which are never maintained : this is the case of the Ogeylet-en-Nemadi in the Khatt and of the Ganeb and Touf in the Baten of Tichit.

8.4.5.2 Planted Palm Groves

Most palm groves in Mauritania are maintained : impenetrable barriers are erected and maintained (either of branches of thorn bushes (Zeribas), or by walls of dry stone), coffered wells are dug, a balance beam (achilal) is used for drawing water, and the central basin (hodh) is improved to include a network of ditches (seguias) which irrigate the foot of the palm trees and plots of wheat and barley.

These palm groves are permanently supervized all year by a few families of Haratins or by nomads who have taken up palm growing. This type of palm grove is very frequent in the Adrar and the Tagant, which have long been date cultivation provinces.

The best maintained palm groves of those of the large oases : Atar and Tidjikja, which continue to grow, due to the joint advantages of their ancient date-producing tradition and their new status as regional centers, which gives them the possibility of innovating with new techniques for drawing water and irrigation : diaphragm pumps, motor pumps, tubes. This is a great advantage, as rational water use is the major problem in the improvement of palm groves.

While there are palm groves solely devoted to date-palms, other have used the shade of the palm trees for the cultivation of plots.

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(1) Cahier des Terrains de Culture, Archives du Cercle de Tidjikja, 1936

of cereals, forage and vegetables. The first, devoted only to date cultivation, are essentially rural, and are characterized by the drawing of water by hand, using a cord and the délou. The second are found in the old urban oases such as Chinguetti, Ouadane, Tichit, Tidjikja, Atar, and are equipped with wells with balance beams (achilal) or motor pumps which save labor.

The introduction of associated cultivation has not only brought a supplement to the diets of the palm grove inhabitants, but also has led to the use of intensive methods, which could be qualified as veritable gardening. The palm trees benefit from the additional watering, frequent hoeing and the use of fertilizer (animal or human). Cereals give two harvests a year : "little millet" is cultivated from July to November, and wheat and barley are grown from December to April.

Other traditional crops such as tobacco, henna, and mint are also grown. Under the influence of the French administration, citrus fruits, papayas, bananas, alfalfa and vegetables (carrots, onions, cabbage) were introduced and prosper from October to March.

However, the total surface area planted in associated crops was hardly more than 300 hectares in 1977.

8.5 Conclusions

Although the climatic situation is not favorable to the development of agriculture in Mauritania, which depends on very fragile water resources, new perspectives have been created by the construction of the Manantali Dam (Mali) and the Diama Dam (Mauritania), soon to be realized by the OMVS (Organisation de Mise en Valeur du Fleuve Sénégal), and which should permit control of the Senegal River waters and irrigation of double crops not only for all the alluvial oualo lands, but also, by sprinkling, a large surface area of the nearby diéri lands. Oualo lands for the three countries councerned are distributed as follows :

- Mauritania : 150 000 hectares
- Senegal : 250 000 hectares
- Mali : 50 000 hectares

For a total of 450 000 hectares.

With these improvements, the Senegal River valley represents considerable potential for the economies of the countries concerned. If these lands were planted in cereal, the 450 000 hectares could produce 3 million tons, or more than two times the entire annual cereal production of the three countries in 1970![1]

The Diama dam, located in Mauritania, will have many advantages : it will stop the salt water flow during the river's slack water period (sea water can penetrate up to 200 km from the mouth of the river), which will permit the availability of a permanent source of fresh water in the Delta region and irrigation of 30 000 hectares (at crest elevation of 1.50 m) and later, 60 000 hectares (at crest elevation 2.5 meters).[2] At the same time, the reservoir level will decrease the level of pumping required for the irrigated cultivations of this area.

The Diama dam will also permit filling of the Lake Rkiz depression: and the Aftout es-Sahéli depression, where large agricultural projects are planned. In Senegal, this dam will permit filling Lake Guiers

(For more information, see the Agronomic Research Unit work).

Rainfed and floodland cultivation along the oueds in the interior depend too directly on the harsh climate conditions and suffer from the quasi-permanent irregularity of rainfall. The construction of the Diama and Manatali dams can stabilize agricultural production in general, and considerably increase cereal production, in particular, of which the Sahelian populations have a vital need.

The current development of vegetable gardening in urban centers of Mauritania is useful to provide a dietary supplement. However,

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(1) "Rôle Possible de la Vallée du Sénégal dans les Economies de la Mauritanie et du Sénégal", Analyse des Projets de l'Organisation pour la Mise en Valeur de la Vallée du Fleuve Sénégal, OMVS, Ministère de la Cooperation, Etudes et documents, December 1976, N° 26.

(2) Ibid.

the production of these gardens is still fairly modest, as shown by the following figures (source : FAO, March 1978):

Vegetables and Fruits	1975	1976	1977	1978
		(tons produced)		
Potatoes	1 800	1 800	2 500	4 160
Sweet Potatoes	1 700	1 700	1 800	1 800
Water Melons	1 200	1 300	1 400	5 000
Fresh vegetables	1 700	1 700	1 800	..
Fresh Fruits	1 600	1 700	1 800	1 800

At Nouakchott, for example, the use of purified waste water permits the production of fresh vegetables on a surface area of 7.20 hectares.

A project, called the "Nouakchott Urban Perimeter Project"(1) has been studied to permit production (after improvement of 167 hectares) of from 3000 to 4000 tons of fresh vegetables in order to supply the city of Nouakchott, where the population is rapidly increasing.

At Atar, vegetable cultivation is fairly extensive under the palm groves. However, one of the obstacles to this type of cultivation is the proliferation of nematodes.

Another encouraging enterprise is the production of several tens of tons of potatoes in the town of Kiffa.

One of the objectives described in the Third Economic and Social Development Plan is to reach food self-sufficiency in Mauritania. This will only be possible if the rural sector can be rationally developed, taking into account the limits and possibilities of the Mauritanian environment.

(1) Club des Amis du Sahel, Equipe des Cultures Irriguées, Fiches de Projets d'Aménagements Hydro-Agricoles en Mauritanie (court et moyen terme).

ANNEX 8-1

In the Senegal River valley, there are two distinct cultivation zones, one of which is inundated and the other which is not (see sketch in Chapter 8) :

1. The OUALO, are the lands periodically inundated and are sub-divid as follows :

   a) the FALO : clayey-sandy banks which are more or less steep, along the minor bed of the river. In this zone are found the willow groves (Salix coluteoides), frequently employed for vegetable gardening. Also floodland cultivation of corn, niébé, pumpkins, etc.

   b) the HOLLANDE : very clayey depressions covering large surface areas, flooded each year for about two months. Area of Acacia nilotica (Gonakié) forests, many of which have been cleared to allow floodland cultivation; there are projects for the improvement of these zones as rice plots.

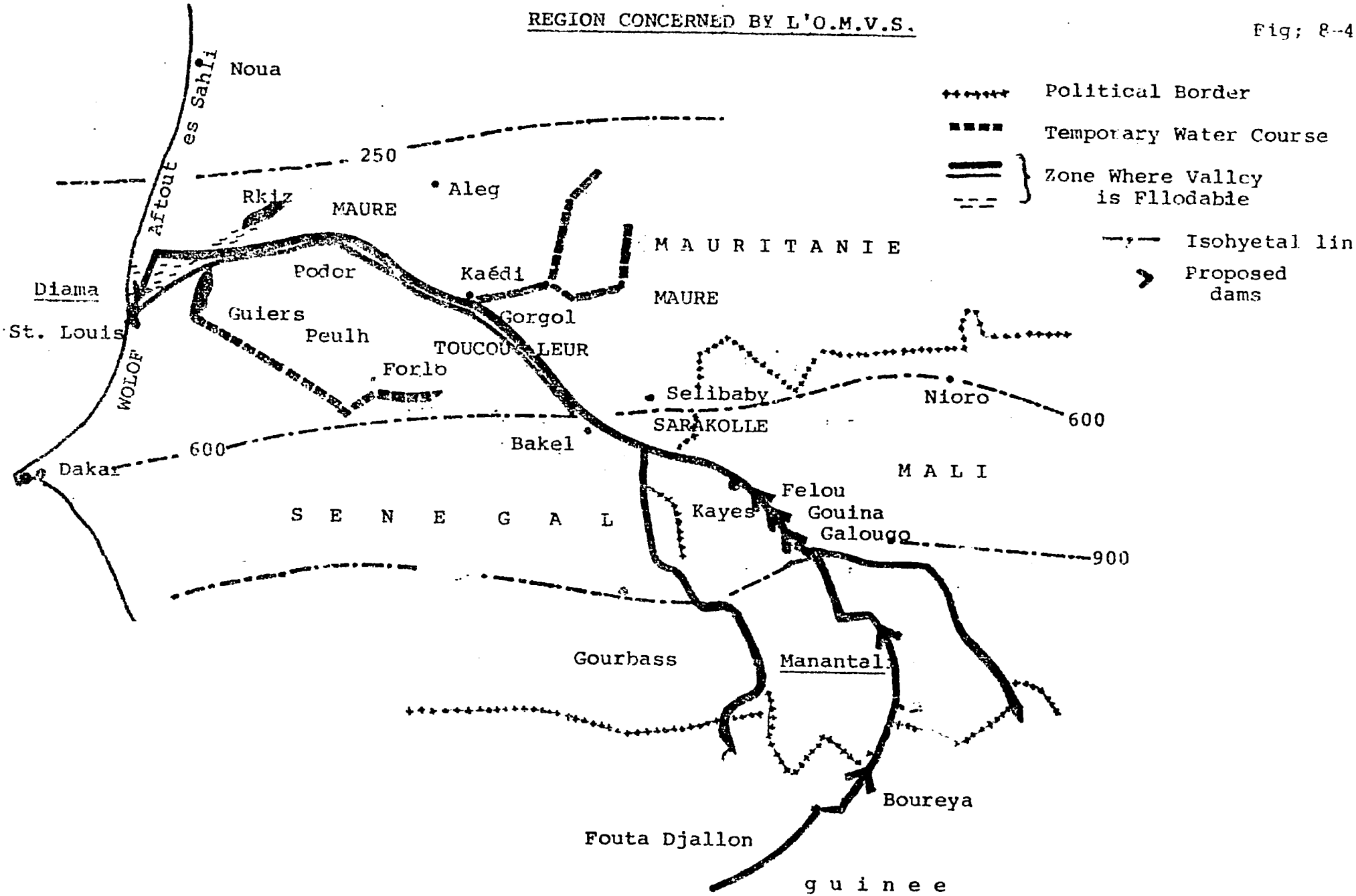
   c) the FONDE : levees along the river cutoffs, marigots and tributaries, formed by more permeable, less clayey silts. The lands are rarely flooded and the initial vegetation (Acacia nilotica, mixed with Acacia raddiana, Acacia seyal, etc.) has usually been cleared to permit rainfed cultivation or floodland cultivation according to the terraine.

2. The DIERI is composed of higher lands along the major river bed. Soils are light and sandy, of dune origin downstream from Kaédi, and more clayey upstream. These lands are never flooded, and form a transition zone between the Oualo and the Sahelian plateau lands adjacent to the valley.
   The term "diérii" is often used to designate rainfed cultivation in general, whereas originally, this term meant only the rainfed cultivation practiced along the edges of the Senegal river.

Sources : Final report of R.L. Perraudin, Forestry Expert, "Etude Hydro-Agricole du Bassin du Fleuve Sénégal", AFR/reg/ (Points II and III) - April 1972.

REGION CONCERNED BY L'O.M.V.S.

Fig; 8-4



SOURCE : O.M.V.S.

CHAPTER 9

MAJOR AGRO-ECOLOGICAL ZONES

(Description and Cartography)

9. MAJOR AGRO-ECOLOGICAL ZONES (Description and Cartography)

9.0 Introduction

The preceding chapters have demonstrated the complexity of the Mauritanian territory and permitted the identification of a certain number of major agro-ecological zones, all of which exist within an environment that can only be qualified as fragile.

The selection of these agro-ecological zones was based on the methods of exploiting the land, which in itself is determined b the constraints of the physical milieu.

Criteria for Classification of Agro-Ecological Zones :

- Cultivation practices and their areas of extension, when relatively homogeneous, served as the basis for the determination of the agro-ecological zones. As pastoral activities are omni-present in Mauritania, they could not be used as a factor in determining zones. The climate is often a limiting factor, which restricts cultivation to well-defined regions. This is the case of rainfed cultivation, which is limited in the north by the average position of the 450 mm isohyetal line (i.e., by the average volume of rainfall, which becomes increasingly irregular and insufficient to the north of the isohyetal line).

- In certain cases, in addition to climatic factors, lithological (rocks), topographical and hydrological data were considere determinant for the classification of the zone. This is the case of the palm grove zone and for the oued floodland zone.

- the different regions where only pastoral activities are regularly practiced (pastoral zones) and where cultivation is usually absent, except in exceptional years, constitute a very vast zone extending from the Senegal River valley up to the extreme north of the country, and from the Atlantic Ocean in the west to the confines of the Majabat al-Koubra desert in the east.

- in the immense desert that covers the east of the country, the Majabat al-Koubra, all human activity is excluded. This desert is an ecological zone in itself.

- Besides the major agro-ecological zones, the major recently paved road axes constitute transition zones between the different regions. The large modern cities and their immediate surroundings are also special factors which influence the environment (both physical and human) (example : rural exodus).

The five major agro-ecological zones are :

1. The Senegal River Valley Zone
2. The Rainfed Cultivation Zone
3. The Oued Floodland Cultivation Zone
4. The Palm Grove Zone (which is roughly superimposed over the preceding zone)
5. The Pastoral Zone

Important remarks :

- the large desert to the east, the Majabat al-Koubra, cannot be called an agro-ecological zone, as there are no agricultural activities; this zone is totally devoid of human activities. It will thus be classified as a special ecological zone.

the large modern cities linked to mining activities and the capital, Nouakchott, are also special zones in the Mauritanian context, linked by recently paved routes which constitute transition zones. Although they cannot be qualified as agro-ecological zones, their increasing importance in Mauritanian activities make it necessary to consider them special zones in their own right. Their relationship with the agro-ecological zones and their influence on these zones explain their cartographic representation.

Table 9-1 summarizes a certain amount of information concerning the major agro-ecological zones.
Table 9-2 shows the other (non agro-ecological) zones.
Table 9-3 concerns the agro-ecological zones and the administrative regions.
Table 9-4 concerns the other (non agro-ecological zones) and the administrative regions.
Table 9-5 shows the regions covered by the different agro-ecological zones.

TABLE 9-1

AGRO-ECOLOGICAL ZONES

Zone N°	Name	Activity Determining Choice of Zone	Physical Limits	Other Major Activites
1	Senegal River Valley	Floodland cultivation in the Oualo, irrigation. Complementary diéri cultivation.	Senegal River alluvial valley	Livestock, fishing
2	Rainfed Cultivation	Generalized practice of rainfed cultivation, millet dominant.	450 mm isohyetal in the north, but can attain 350 mm occasionally.	Livestock (transhumance and nomadism) is the major activity.
3	Oued Floodland Cultivation	Numerous agricultural dams either traditional or modern for floodland cultivation (Sorghum dominant)	Impermeable rocky substrata : highlands and rags. Not represented on too sandy surfaces.	Livestock (transhumance and nomadism) is the main activity.
4	Palm Groves	Raising of date palms.	Average temperature higher than 28°C, presence of alluvial aquifers. Preference for highlands.	Livestock secondary. Different secondary crops : cereals, vegetables.
5	Pastoral	Raising of camels, cattle, sheep, goats.	Limited rainfall, pastures and water holes are constraints for pastoral activities.	Extensive livestock raising is the only activity. According to rainfall, small islets of occasional rainfed cultivation appear.

TABLE 9-2

OTHER ZONES
non "agro-ecological")

Zone N°	Name	Criteria for Determing Zone	Location (see map)
6	Desert (Majabat al Koubra)	Zone with no human activity. A mineral world where vegetation is rare. This extremely arid zone is a special ecological zone.	East of Mauritania
7	Modern Urban Zones	Towns linked to mining and port activities. Administrative and political capitals, with small industry. These towns have a direct and indirect impact on Mauritanian activities.	Zouérate-F'Derick (Akjoujt) Nouadhibou Nouakchott
8	Transition Zones corresponding to recently paved roads.	These road axes modify regional equilibrium by exchanges between regions and population movements, thus, their impact on the environment crossed is not negligeable.	Road axes : Nouakchott - Rosso and Nouakchott - Kiffa

TABLE 9-3

AGRO-ECOLOGICAL ZONES AND ADMINISTRATIVE REGIONS OF MAURITANIA

Zone N°	Name	Administrative Regions
1	Senegal River Valley	VI (Rosso) V (Aleg) IV (Kaédi) X (Selibabi)
2	Rainfed Cultivation - South of 450 mm isohyetal line	IV (Kaédi) X (Selibabi) III (Kiffa) II (Aioun el Atrouss) I (Néma)
	- between 350 mm and 450 isohyetal line	Regions listed above and V (Aleg)
3	Oued Floodland Cultivation (Sahelian and Saharan)	V (Aleg) IV (Kaédi) III (Kiffa) IX (Tidjikja) II (Aïoun el Atrouss) I (Néma)
4	Palm Groves (Oases)	VII (Atar) IX (Tagant) III (Kiffa) II (Aïoun el Atrouss)
5	Pastoral Zone (almost exclusively livestock)	VI (Rosso) V (Aleg) VIII (Nouadhibou) XII (Akjoujt)

TABLE 9-4

OTHER (NON-AGRO-ECOLOGICAL) ZONES AND ADMINI

ZONE N°	Name	Administrative Region
6	Desert (Majabat al Koubra)	I (Nēma) IX (Tidjikja) VII(Atar) XI (F'Derick)
7	Modern Urban Zones	District of Nouakchott Nouadhibou (Region VIII) Akjoujt (Region XII) F'Derick (Region XI) Zouérate (Region XI)
8	Transition Zone (recently paved roads)	Nouakchott- Kiffa Axis : (Regions VI, V and III) Nouakchott-Rosso Axis (Region VI)

TABLE 9-5

AGRO-ECOLOGICAL ZONES AND THE PHYSICAL REGIONS

N°	Name	Physical Regions
	Senegal River Valley	Alluvial Reiver Valley (Chemama)
	Rainfed Cultivation	Littama and Guidimaka; south of Mauritanides Arc; south of the Assaba; south of the Western and Eastern Hodhs.
	Oued Floodland Cultivation	Rags to the east of Brakna and north of Gorgol; Regions of Assaba, Tagant, Adrar, Affolé and depressions of Eastern and Western Hodhs; region of Inchiri inselbergs around Akjoujt.
	Palm Groves	Adrar, Tagant, Assaba, Affolé, a few small isolated groves around Dhars Tichit and Néma.
	Pastoral Zone	Main regions : Trarza, Brakna, Azzefal, Akchar, Amsaga, Tasiast, coastal zone of salt pastures, Aouker, north of Hodhs.

9.1 Description of Agro-Ecological Zones

(See map at end of chapter)

Zone 1 : Senegal River Valley Zone

This zone has far more potential than the other agro-ecological zones of Mauritania. The Senegal River flows through a fertile valley, annually enriched by silt deposits (floods from June through October). The valley is approximately 400 km long, extending from Dembakane in the southeast (40 km downstream from Bakel) to the western delta at Saint Louis.

The Senegal River valley is called "Chemama" in Mauritania. It can attain widths of 15 km in some areas. Its permanent flow and the silt deposits during high river floods make this a priviledged zone compared to the surrounding Sahelian regions.

a) Climate : Rainfall varies from 650 mm in the southern-most part of the zone (Guidimaka) to 300 mm in the north. Interannual rainfall variation are great.

b) Soils : These are essentially hydromorphic gleyey soils (of varied chemical richness), developed on alluvia.

c) Natural Vegetation : The dominant tree in the periodically flooded lowlands is the Acacia Nilotica. On the edges of the valley, one finds : Acacia sieberiana, Acacia seyal, Ziziphus mauritania. Grasses are represented by Vetiveria nigritana.

d) Agriculture and Population : This is a zone of intensive agriculture, due to the fertility of the soils enriched by silt deposits during annual floods. The types of agriculture practiced are : floodland cultivation (oualo), irrigated cultivation (rice) and rainfed cultivation (diéri) on the banks which are not flooded. Rainfed cultivation varies considerably from year to year as a function of rainfall.

The very compact and impermeable soils (clayey) are planted in rice and millet. The valley represents more than 80 % of the the millet production of Mauritania. There are possibilities for varia crops and interesting potential for rice cultivation (example : the irrigated rice perimeters of M'Pourié). The SONADER is studying and executing several agricultural projects in the Senegal River Valley.

TABLE 9-6
(Climatology)

ZONE n°1 : SENEGAL RIVER VALLEY

Average rainfall (mm)	Average temperatives °C	Average Humidity (%)	Evaporation Piche (mm)	Corredted Evaporation Piche (mm)(coefficient 0,6)	PET Penman
Varying from 350 mm in the north to 650 mm in the South(Guidimaka)	26 to 28°C in west 28 to more than 30°C in the interior of the country	Rosso: 6 h :65 % 12 h :34 % 18 h :34 %	Rosso : 3.221	Rosso : 1.930	Rosso : Max : 297 mm in May Min : 181 mm in Nov Mean: 223,3 mm Selibaby : Max :249 in May Min :132 mm in Dec Mean : 174,5 mm

Source : Author, RAMS, 1979

Traditional agriculture is practiced by the Wolofs in the lower valley, downstream from Rosso, by Soninkés or Sarakolés in the Guidimaka, and by Toucouleurs between Rosso and Maghama. These are all sedentary farmers.

ZONE 2 : Rainfed Cultivation

In the rainfed cultivation zone, agriculture is directly dependen on spatial distribution of rainfall, as well as rainfall volume and distribution over time.

Rainfed cultivation is usually practiced regularly each year to the south of the 450 mm isohyetal line. To the north of this isohyeta line, rainfed cultivation can extend up to the 350 mm isohyetal line, during occasional good years.

Rainfed cultivation appears in isolated plots to the north of its usual zone, when rainfall is excellent, up to the 200 mm isohyetal line.

This zone is located approximately between the 15° latitude north (for the southern part of the zone) to above the 16° latitude north (for the northern-most part, around Kiffa).

In the extreme south of the zone (Guidimaka), rainfall attains 650 mm (annual average).

Livestock raising is the dominant activity.

a) Climate : The rainy season lasts from 3 to 4 months depending on the latitude (it is shorter towards the north). The dry season lasts from 8 to 9 months according to latitude (increasing from the south to the north of the zone). Rainfall is very irregular from year to year; this has been noted especially during the drought. See Table 9-7 for the climatology of this zone.

b) Soils : This zone covers a great variety of soils. According to geomorphological criteria, they can be classified as follows :

- Hydromorphologic soils of the Gorgol Noir, Gorgol Blanc and Karakoro valleys
- little evolved complementary soils (central Guidimaka)
- subarid isohumic soils (Trarza, Southeast, Center)
- erosion and crust soils (raw mineral) - (Assaba, Affolé).

c) Natural Vegetation : the natural vegetation varies from the south to the north, but more so as a function of the major geomorphological units and soils with which they are associated. One finds :

a Combretum glutinosum group in the south (Guidimaka and along the Malian border) and grass savannas, with baobabs and palm trees in these part of the extreme south of Mauritania.

going towards the north, the landscape changes progressively from a Soudanian savanna to vegetation of the Sahelian steppe type.

from east to west, one can find groups of Acacia Sénégal (Trarza), Comiphora africana (Brakna), Ziziphus mauritiana (Aftout de M'Bout), Acacia tortilis (Assaba, Guidimaka), etc.

These vegetation groups are also found in alternating bands towards the east; the details of their distribution are quite complex.

b) Agriculture and Population .

This is a zone of extensive agriculture, devoted essentially to millet and sorghum ("little millet" in the northern-most part of the zone).

However this zone is mainly dominated by pastoral activities The Peulhs and Moors lead their herds in search of pastures (the Peulhs practice transhumance, the Moors practice nomadism). The rainfed cultivation zone is the domaine of cattle raising. Thus, it is a mixed cultivation-pastoral zone.

Herd movements are from the south to the north during the rainy season, and towards the south in the dry season. However, there are also east-west migrations according to the distribution of rainfall.

TABLE 9-7

Climatology

ZONE n°2 : RAINFALL CULTIVATION ZONE

AVERAGE RAINFALL (mm)	AVERAGE TEMPERATURES (°C)	AVERAGE HUMIDITY (%)	EVAPORATION PICHE	CORRECTED PICHE EVAPORATION (mm) (Coefficient 0,6)	PET PENMAN
450 mm : Northen limit of regulared practiced rainfed cultivations 650mm: in extreme south of Guidimaka	Kankossa Max :36,7°C Min :20,1°C	Kankossa Min : en avril à 30 % Max.août/sept à 60 %	Kankossa 3.350	Kankossa 2.010	Selibaby Max :249 mm is May Min :132 mm is Dec Mean :174,6 mm
350 mm : Northen limit of irregularly,practiced rainfed cultivation	Kiffa Max :41,4°C Min :21°C	Kiffa 6h:48,3 % 12h:27,7 % 18h:24 %	Kiffa 3.820	Kiffa 2.298	Kiffa Max :317 mm in A Min :205 mm in Sept Mean:252,6 mm in Nov

Source : Author, RAMS, 1979

Preparation of the land for cultivation is done at the end of the dry season (burning, shifting cultivation). Agriculture is manual and traditional (hoe, daba, etc.)

The population of this zone is composed of sedentary farmers and semi-sedentary nomads (in addition to some nomads who have settled definitively in the urban centers)

The sedentary cultivators are

- The Toucouleurs (distributed roughly between M'Bout and Kaédi)
- the Soninkés or Sarakolés (around Selibabi)

The livestock raisers are

- Moors (and Harratins)
- Peulhs.

These populations combine cultivation and livestock raising (mostly cattle).

It should be noted that during periods of severe drought, the nomads, both Moors and Peulhs, abandon nomadism and devote themselves on a parttime basis to agriculture.

Zone 3 : <u>Oued Floodland Cultivation (recessional agriculture)</u>

This zone is intermixed with the palm grove zone. However, the two zones will be studied separately, as they are quite different agriculturally.

Floodland cultivation is located along the oueds, and is practic after the floods. A small dam is built across a favorable spot of the oued in order to store rainwater upstream. As the water recedes (controlled by the farmers), the humid banks are cultivated. This type of agriculture depends directly on the rainfall which fills the dam reservoir, through runoff from the upstream catchment basin.

Also included in this zone are ponds in the low lands fed by the rains, which dry up progressively, allowing cultivation of the edges, and the Adrar graïrs, flow zones of the oueds (cultivation possible one year out of five).

a) Climate and Hydrology :

The floodland cultivation zone is located approximately between the 350 mm isohyetal line in the south and the 100 mm isohyetal line in the north (where floodland cultivation is very "risky"). It is essentially concentrated in the southern center of Mauritania on the piedmonts and in the heart of the sandstone massifs of the Assaba, Tagant, and Affolé ("Trab-el-Hajra" in Moorish "Land of stone"). The axis from Aleg to Moudjeria marks the western limit of the zone (sand-covered expanses to the west) Towards the east, floodland cultivation is found up to the Dhar Néma, below the isolated reliefs. It is impeded in the Hodhs by the sands of the Aoukar.

The concentration of this type of cultivation in the Assaba, Tagant, and Affolé is due to the topography of these massifs (altitude greater than 200 meters), which collects the least amounts of rainfall, due to the sandstone rocks, which have a high runoff coefficient.

Floodland cultivation is found essentially to the south of the 150 mm isohyetal line. However, it does exist in the Adrar, above the 150 mm isohyetal line (with a break between the Tagant and the Adrar, in the sandy depression (Khatt) which separates these two massifs), due to the high sandstone reliefs, which can rise to 800 m in altitude, and which have a high runoff coefficient. These sandstone massifs capture and concentrate the runoff in oueds, even though rainfall does not attain an average of 100 mm annually.

Thus the high rocky reliefs of the massif (non-porous) permit extension of floodland cultivation towards the north, above the 150 mm isohyetal line.

) Soils :

This type of cultivation is practiced on oued alluvia, which are generally sandy (with varying proportions of clay, silt and gravel). Around the ponds, one finds hydromorphic psuedo-gley soils in those areas which are submerged the longest. In the graïr, flow zones of the oueds, soils are sandy and stoney.

c) Natural Vegetation

The flora of the major oueds is not exclusive, but certain species are found in these zones where optimum ecological conditions allow them to proliferate, especially the almost permanent humidity due to shallow interflow. They cannot survive outside these depressions due to the aridity of the climate.

Species which are usually found only in the south may advance towards the north along oueds. Acacia nilotica is common along oueds, but becomes scarcer towards the north. The distribution of vegetation is complex, as a function of micro-climates and geomorphology.

d) Agriculture and Population :

Intensive cultivation is practiced along the oueds; the main crop is sorghum. However, other crops are occasionally grown : millet, corn, wheat, niébé, sweet potatoes.

Most storage dams are traditional structures (about 95%). These are composed of an earth dike, sometimes consolidated by slabs of sandstone, built across a narrow part of the oued (they are several meters high). They are not solid and very poorly maintained. They are slowly being replaced by modern dams, composed of a compacted earth dike, with a cement spillway and drainage structure.

The floodable surface area varies considerably from year to year as a function of rainfall volume, which has been mediocre in recent years.

The populations which practice this type of cultivation are essentially Moors and Harratins, in proportions varying from region to region.

Livestock raising is the dominant activity of this zone. Cattle raising can attain the 150 mm isohyetal line in the north. The Peulhs lead their herds (Zebu gobra) in search of pasture; they rarely go above the 350 mm isohyetal line, which coincides with the extreme northern limit of rainfed cultivation. The Moors and Harratins, on the other hand, practice cattle raising above the 350 mm isohyetal line (Zébu Maure).

Note : Since the drought which began in 1968, many Harratins have left their Moorish "protectors", who can no longer take care of them, as a great deal of their cattle resources have perished. In addition, agricultural production has decreased, as the storage dams are not filled. This has provoked the destruction of food self-sufficiency based on the cultivation of sorghum and cattle raising.

Zone 4 : The Palm Groves

The palm groves are distributed over a vast area which includes the highlands : Adrar, Tagant, Assaba, Affolé, Dhar Néma and Dhar Tichit. The larger palm groves are found in the Adrar and the Tagant.

The main resource is the cultivation of the date-palm (*Phoenix dactylifera*).

a) Climate and Hydrology :

The date palm requires an average temperature higher than 28°C and the absence of rainfall during fructification, in addition to large amounts of water (on the order of 8000 m3 per hectare), which explains its extension in the mountainous massifs, at the feet of springs, or, most frequently, on the edge of oueds.

b) Soils : These are light soils, developed on sandy alluvia.

c) Vegetation : see Agriculture

d) Agriculture and Population :

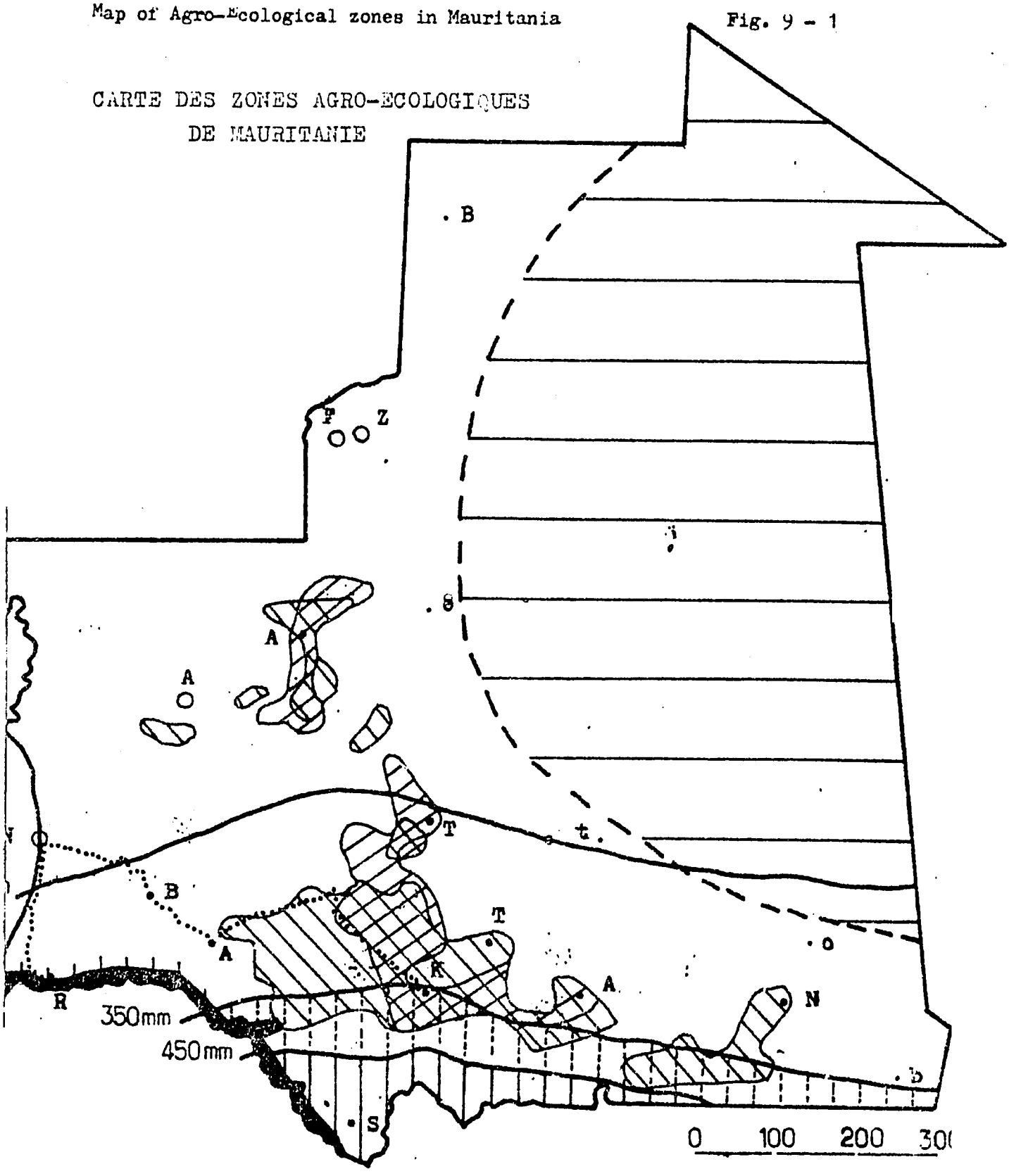
The major date-producing regions are the Adrar (which possesses about half of the date palms in Mauritania, or 400 000), the Tagant, (205 000), the Assaba (125 000), the Affolé (55 000) and the region of Nema-Oualata (20 000). The surface area covered by all these palm groves is not greater than 3 000 hectares, and the number of date palms is not greater than 1 million(1).

(1) In certain groves, a great many palms have disappeared. Thus, Atar has lost 25 000 date-palms since 1945, and Chinguetti from 4 000 to 5 000. The Mauritanian palm groves have been drying up; many of the trees are in precarious condition. Sand dunes are advancing and the weakened palms are subject to disease. Good rains in the north of the country in 1979 should help to improve the situation.

Map of Agro-Ecological zones in Mauritania

Fig. 9 - 1

CARTE DES ZONES AGRO-ECOLOGIQUES
DE MAURITANIE



E: 1/6 500 000

SOURCE : RAMS 1979.

The palm groves are small, the largest being only a few dozen hectares in size. There are two types of palm groves :

- the wild palm groves
- the farmed palm groves

The farmed palm groves are more numerous; they are surrounded by fences made of thorn branches (Zeriba) or low stone walls. The plots are small, generally a square whose side measures 30 m. Wild palm groves have been abandonned; no fencing protects them from the ranging of camels and goats and they are only visited by the nomads at date harvest time.

Some Harratins and even a few "noble" Moors (Bidan) practice permanent date cultivation in the farmed palm groves.

There are palm groves which are devoted solely to date production and others where, in the shade of the palm trees, cultivation of cereals, forage or vegetables is practiced (millet, wheat, barley, mint, alfalfa, henna, lemon trees, beans, niébé, potatoes, carrots, turnips, onions, etc.)

Many palm groves are composed of a few unenclosed palm trees besides which floodland cultivation is practiced.

Irrigation is most important. Means of drawing water vary from grove to grove ; in the "rural" palm groves, water is drawn by hand using a cord and the délou; in the old "urban" oases such as Chinguetti, Ouadane, Tichit, Tidjikja and Atar, wells are equipped with balance beams or motor pumps, and the water is received in a basin. In the Hodh, there are ditch networks which irrigate the trees and cultivations underneath.

Zone 5 : Pastoral Zone

In general, there is no cultivation in this zone; however, livestock raising is present. This zone is the domaine of the Moorish nomads. It covers a vast surface area; with the exception of the "Empty Quarter" (the Majabat al Koubra desert in the center of the country), one finds livestock everywhere in Mauritania.

a) Climate :

This zone extends to the north of the 200 mm isohyetal line; however, it can also descend to the south, (for example, in the Trarza, which has been experiencing "desertification", it reaches the Senegal River zone.)

Rainfall is quite variable from one region to another and from year to year, going from 200 mm to several millimeters.

The climate is basically arid, with high temperatures in the summer (16 to 49°C), and cool temperatures in the winter (0 to 33°)

b) Soils : Desert and steppe soils dominate.

c) Vegetation :

Vegetation is of the steppe type, becoming more sparse towards the north. The main vegetation groups are :

Acacia tortilis ss. raddiana which extends over the Regueibat Dorsal and the Atlantic Sahara, to the north of the Akchar and Azeffal dunes. Grasses are represented mainly by Panicum turgidum ("Markba").

in the Trarza, the Hodh and the east, Stipagrostis pungens ("Sbatt") dominates, characterized by large tufts scattered throughout the landscape.

d) Population and Livestock :

Pastoral migrations are linked to distribution of rainfall. The Moorish nomads move from one well to another, in search of pasture for their animals. The "Acheb", or "spantaneous pasture", appears after the first rains of the rainy season, and is especially sought after. The Moors follow the movement of the rains. In the dry season they move their camps towards the south, returning north during the rainy season.

The livestock raisers on the edge of the Sahelo-Sahara and the Sahara stay farther north in the dry season, to benefit from the winter rains, and move southwards towards the Sahel during the summer rains.

In the Saharan zone, dromedaries are the main resource. In the Sahelian zone, most livestock consists of cattle.

The Moorish nomad communities live in camps (tents) and follow the herds in their migrations. The extent of migrations has decreased due to the current drought conditions.

TABLE 9-8
Climatology

ZONE n°3 : Oued Floodland cultivation and
ZONE n°4 : Palm groves

AVERAGE RAINFAIL (mm)	AVERAGE TEMPERATURES (°C)	AVERAGE HUMIDITY (%)	EVAPORATION PICHE (mm)	CORRECTED PICHE EVAPORATION (mm) (coefficient 0.6)	PET PENMAN (mm)
About 350 mm in south to 100 mm in north (Adrar) (Dams: most are distributed south of 150 mm isoheyetal line)	Moudjeria Max :36.6°C Min :23.4°C Aioun el Atrouss Max 35.9°C Min. 22.5°C Atar Max. 35.8°C Min 20.6°C	Moudjeria 6h :68 % 12h :39 % 18h :50 % Aïoun el Atrouss 6h 41 % 12h 26 % 18h 24 % Atar 6h 24 % 12h 28 % 18h 24 %	Tidjikja 4.345 Aïoun el atrouss 4.920 Atar 4.371	Tidjikja 2.610 el atrouss: 2.892 Atar 2.670	Tidjikja Max :251 in June Min :138 in Dec Mean:194.5 mm Moudjeria Max :268 in June Min :207 in Dec Mean :254,4 mm Aïoun en atrouss Max :323 in June Min :207 in Dec Mean :254,4 mm Atar Max :308 in June Min :160 in Dec Mean :231,3 mm

Source : Author, RAMS,1979

TABLE 9-9

Climatology

ZONE n°5 : PASTORAL

AVERAGE RAINFALL (mm)	AVERAGE TEMPERATURES (°C)	AVERAGE HUMIDITY (%)	EVAPORATION PICHE (mm)	CORRECTED PICHE EVAPORATION (mm) (coefficient 0,6)	/PET PENMAN (mm)
About 300-350 mm in south to 50mm in north(Bir Moghrein) and less (Nouadhibou:36.3 mm).	Boutilimit Max :34,4 Min :20,6 Nouakchott Max :32,7 Min :19 Akjoujt Max :35,9 Min :21,4 Bir-Moghrein Max :31,3 Min :16,3	Boutilimit 6h :53 % 12h :30 % 18h :24 % Nouakchott 6h :68 % 12h :39 % 18h :60 % Akjoujt 6h :56 % 12h :33 % 18h :28 % Bir-Moghrein 6h :63 % 12h :34 % 18h :27 %	Boutilimit 4.460 Nouakchott 2.351 Akjoujt 4.230 Bir-Moghrein 3.840	Boutilimit 2.680 NOuakchott 1.290 Akjoujt 2.538 Bir-Moghrein 2.304	Boutilimit Max :321 in May Min :218 in Dec Mean:261 mm Nouakchott Max :234 in May Min :133 in Dec Mean:181 mm Néma Max :305 in mar Min :231 in nov Mean:257,1 mm Tamchakett Max :287 inJune Min :188 in Nov Mean:221,2 mm

Source : Author, RAMS,1979

Note : Since the beginning of the 20th century, nomads have tended to buy or plant palm groves and to have millet and sorghum fields cultivated by their former slaves. Therefore, they now stay a longer time in the oases during the periods of date harvest ("getna") in July, or near their fields during harvests (zones 2 and 3). Thus, they have become semi-nomads.

It should also be noted that since the drought began in 1968, many nomads have been forced to sedentarize, as certain wells have dried up and sanded-over, and many pastures did not regenerate or have become very degraded.

9.2 The Ecological Zone of East Mauritania

Zone 6 : The Desert

This zone is empty of all human activity. It is located in the eastern center of Mauritania. Locally, it is known as the "Majabat al-Koubra" ("land of the great crossing"), or as the "west Saharan Empty Quarter" (Theodore Monod).

This desert covers about a third of the country's surface area Most of the countryside is covered by an erg which is difficult to cross due to the extreme rarity of water holes.

a) Climate : There are no climate observation stations in this desert. However, it is known that rainfall is extremely weak and temperatures are very high.

b) Soils : Desert soils, and complementary desert soils on eolian sand.

c) Vegetation : Vegetation is extremely sparse. The areal richness rate is 4, one of the lowest in the world. *Stipagrostis pungens* (a grass) is the dominant vegetation group; it is very sparse and found only in favored areas.

9.3 Other Zones (Non-agro-ecological)

Zone 7 : Modern Sector

This classification includes :

- new towns linked to mining : Nouadhibou, Zouérate, F'Derick, Akjoujt.
- towns with political and administrative functions : Nouakchott, the capital of Mauritania

Since the drought began in 1968, sedentarization of the nomads has greatly increased the population of these towns.

Nouakchott has been the most marked by this phenomenon. It had 104 000 inhabitants in 1975, and now has 150 000 inhabitants.

Such great population concentrations have a decided effect on the environment :

- degradation of the surrounding milieu, which increases the avance of shifting dunes (desertification)
  the demand for water becomes enormous, with possible depletion of aquifers in the future

Zone 8 : Transition Zones
(recently paved roads,

These are the Nouakchott-Rosso and Nouakchott-Kiffa roads. They are transitional sectors, where populations have located along these new routes. This has tended to increase deterioration of the environment due to the increased population of sedentary peoples.

9-4 Conclusions :

These major agro-ecological zones are representative of the production conditions in rural Mauritania.

They do not have "fixed" borders, with the exception of the Senegal River Valley and the palm groves, which are in relatively stable zones.

Rainfed cultivation fluctuates, especially in the north, beyond the 450 mm isohyetal line.

Dams are destroyed each year along the oueds; sometimes they are rebuilt on the same site, sometimes at other sites.

The limits of the pastoral zone depend on the spatial variations of the other zones.

There are complex zones which result from the inter-mixing of the rainfed, floodland and palm grove zones (see map of agro-ecological zones and legend).

The complexity of the situation in the field cannot be explained on the basis of these classifications alone, and it goes without saying that the agro-ecological zones have no connection with the various administrative borders(which makes it all that more difficult to estimate production of these zones).

Legend of the map of mauritanian agro-ecological zones

1. Agro-ecological Zones

1. Senegal River Valley

2. Rain-fed cultivation
   - 250mm to 450mm
   - 450mm +0 650mm

3. Oued floodland cultivation

4. Palm - groves (oasis)

5. Pastoral zone

Overlapping zone

1. Oued floodland cultivation and Palm Groves

2. Oued floodland cultivation and rainfed cultivation (between 350mm +0 450MM)

3. Intermixing of 3 zones - Palm groves
   - Oued floodland cultivation
   - Rainfed cultivation (between 350mm +0 450mm)

2. Special ecological zone

Majabat Al Koubra

3. Autres non-ecological zones

Modern urban zones

Transitional zones: recently paved roads.