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Ministry of Economy and Finance

Directorate of Studies and Programming

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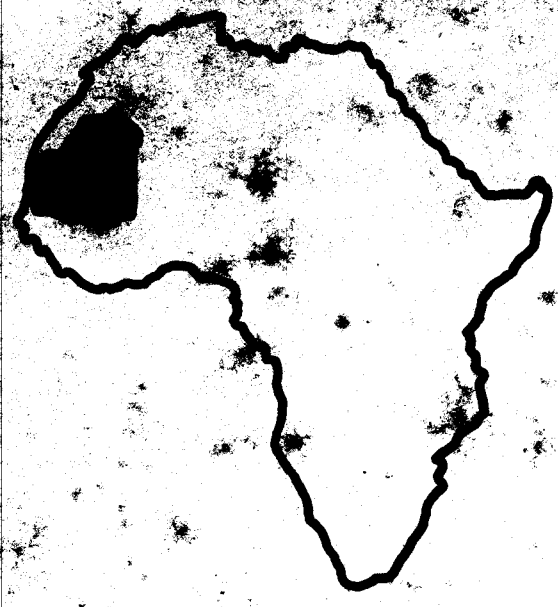
RAMS PROJECT

Rural Assessment and Manpower Surveys

Dryland Agriculture

SS 2



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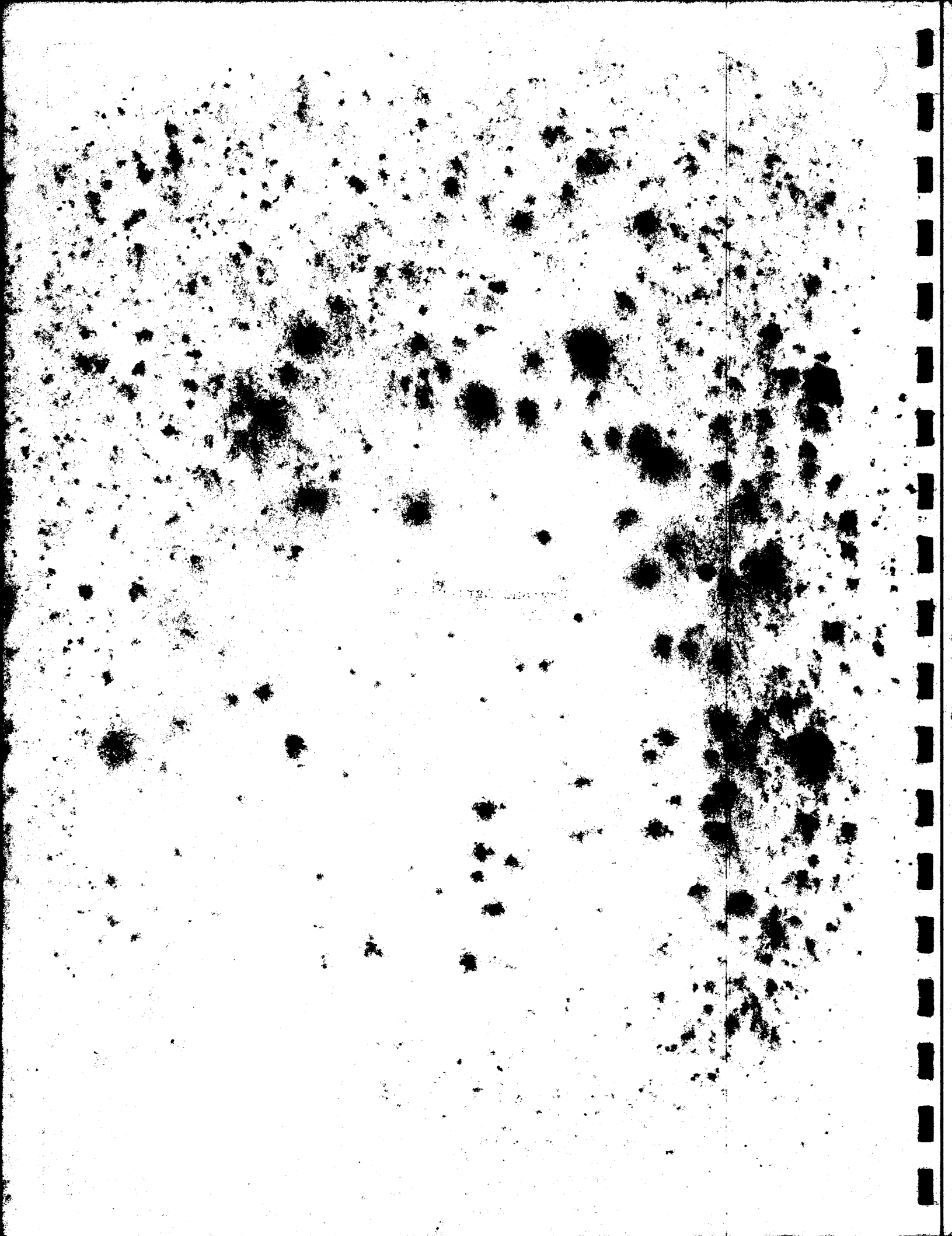

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Sub-Sector Study of Dryland Agriculture

Summary And Conclusion

1. Within the framework of the RAMS project, dryland agriculture has been made the object of a sub-sector study, in light of its importance in rural activities and its socio-economic role in Mauritania. In the past, this sub-sector has not benefited from long term development activities, but only from sporadic, short-term projects having limited effects on production.

2. Examination of the basic data showed that the production possibilities of dryland agriculture are far from being negligeable given the soil and water resources available. At present, climate factors are the main constraint to this potential and have decreased the security of this type of cultivation.

   Dryland agriculture, in all its forms, involves about 71 % of Mauritania's rural population and mobilizes more than 60.000 active inhabitants. The manpower potential in the different production zones is fairly large and should not create labor problems on a medium term basis.

   At present, dryland production is in large part destined for subsistence and traditional exchange.

3. Three major production zones can be distinguished :

   - The Senegal River Valley
   - The Southeastern rainfed zone
   - The Oued Floodland zone, including other favorable floodland areas such as Ghrairs, Tamourts and Marigots.

Agriculture in these zones is predominated by cereal cultivation, which accounts for more than 80 % of the surface area cultivated.

It is estimated that 230,500 hectares could be cultivated each year. However, the actual number of hectares cultivated varies considerably from year to year as a function of yearly and regional rainfall. Thus, it is very difficult to estimate the average surface areas cultivated.

An increase in the number of hectares cultivated may be brought about in two ways :

- Improvement of new lands :

  In the southeastern rainfed zone, which offers appreciable physical potential (however, these improvements must not be at the expense of this zone's pastoral activities).

  In the oued floodland zone, by improved water control (dam construction), which implies large investments.

- Progressive substitution of irrigated crops for traditional cultivation in the Senegal River Valley.

Three major production systems were defined, corresponding to the three major geographical production zones. These production systems have a certain number of problems in common, as well as individual difficulties. The common problems concern crop production methods and techniques. These problems are very extensive and do not allow for optimal use of the available resources. The problems particular to each production zone concern land rights, relationships to other rural activities, etc. Most of these regional problems do not constitute insurmountable constraints.

4. Production was estimated to be :

95,000 tons of cereals
19,000 tons associated crops
using the most favorable hypothesis

24,000 tons of cereals
9,500 tons associated crops
using the least favorable hypothesis.

Most of this production is destined for family subsistence. About 2/3rds of cereal production and 85 % of associated crops are consumed by the producer; these rates may be even higher in poor production years. The marketable surplus never goes beyond 1/3rd of cereal production, in the best of situations.

Traditional marketing structures are adequate for current needs, but would be insufficient in the case of sustained production increases. Thus, the production situation is fairly precarious, due to the absence of an adequate policy for pricing and market protection. An increase of cereal on the market either as illicit imports (from Mali) or through the distribution of foreign food aid seems to have a regressive effect on production.

5. In the areas of training, extension services, research and popularization, both quantitative and qualitative insufficiencies in the existing structures were noted. It should be further noted that although no recent agronomic research has been undertaken in the dryland agriculture sub-sector, there exists research results from former Mauritanian projects or from neighboring countries, which have never been applied in this sub-sector.

6. Dryland cultivation's impact on the environment is felt most acutely in the rainfed zone. Traditional production methods and the absence of fertili-

zation lead to continual clearing and cultivation of new zones, which represents a menace to the equilibrium of the environment. This trend would be further aggravated by the unstructured development of drought-animal cultivation, especially in the southeastern zone.

Thus, the dryland agricultural sub-sector seems to play an important role in maintaining the equilibrium of the rural world, given the number of persons it involves and the social character of this type of cultivation. To ignore this role would compromise the relative stability of this rural world and of its population.

Furthermore, given the slowness of hydro-agricultural improvements at the present time, dryland agriculture could contribute, on a medium term basis, to notably reduce the present cereal deficit and thus compensate to some degree for the slowness of these improvements.

In order to allow this type of agriculture to play its primary stabilizing role and eventually, a secondary compensatory role, two types of potential must be realized :

- Improvement of production techniques and means which are presently insufficient. This potential can be realized by the improvement of water control and production factors. Water control would reduce the impact of climate on production. Stabilization of production would lead to a general stabilization of the rural world.

- The second potential concerns improvement of new cultivation in the southeastern rainfed zone and possibly in the oued floodland zones. This potential could play both a stabilizing and compensatory role in production.

Realization of this potential would require :

- Large human investments in the forms of training, extension services research, and popularization, with corresponding infrastructural investments.

- Elaboration of an adequate agricultural policy for storage, marketing and price controls.

- Development of an agricultural incentive system, based on agricultural credit or through other means.

- Research to improve the existing production structures so as to optimize the effects of future development projects in this sub-sector (cooperatives, producer organizations, professional organizations, etc.).

0. Introduction

0.1. Object of this Study

The object of this study is to collect and analyze as much data as possible concerning rainfed agriculture, in order to arrive at a clear picture of the existing situation. This analysis will permit identification of existing problems and evaluation of development possibilities.

Although rainfed agriculture is of relatively lesser economic importance than livestock production, it once provided all of the cereal produced in Mauritania and continues to supply the major part. At present, its economic importance is decreasing, as a consequence of development of irrigated cultivation; however, the rate of irrigated perimeter improvement is slow. Even when irrigated cultivation reaches the projected dimensions, rainfed agriculture will not be greatly affected, as the labor it mobilizes and the land it employes will only be partially touched by irrigation.

Until now, this sector has not benefited from sustained development activities commensurate with its importance; a few local improvement attempts have been made, with limited impact on development.

Long term development activities corresponding to this sector's importance would help establish harmonious employment and land use, and thus lead to better equilibrium of regional development.

0.2. Definition of Rainfed Agriculture and its Role in the National Economy

0.2.1. Definition

As its name indicates, "rainfed agriculture" designates those agricultural ac-

tivities directly dependant on rainfall. However, it is often associated with floodland agriculture (along rivers, oueds, lowland marshes and lakes), which depends indirectly on rainfall collected as runoff water. Thus, the term "rainfed agriculture" appears insufficient to designate all these activities; we prefer the term "dryland agriculture", as opposed to irrigated agriculture. Throughout this text, the term "dryland agriculture" will be employed, and, when necessary, the type specified.

0.2.2. Role of Dryland Agriculture in the National Economy

Dryland agriculture yields mainly food crops, cereals in particular. In general, secondary crops are as ociated with these cereals, such as :

- niébé beans (vigna unquiculata)
- beref (citrullus vulgaris), cultivated for its seeds
- peanuts and "baerem", a leguminous plant akin to the peanut
- sweet potatoes and yams
- certain condiments, such as "sangoma" and "jaktenni".

On the basis of Mauritanian economic records for the period 1973-1978[1], the value at current prices of this sub-sector production represented between 37 and 63 % of all vegetable production (or an average of 52 %). However, these percentages do not take peanut production into account, as well as condiment crops, which were not evaluated.

Besides its economic importance, dryland agriculture plays a primordial role in stabilizing production systems, notably in the sylvo-pastoral zones and in the oasis zone of central Mauritania.

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1) Ministry of Economy and Finance.

0.3. Methodology

This study is comprised of two parts :

0.3.1. Examination of Existing Data

This part consists of collection and critical examination of existing data within the dryland agriculture sub-sector, to provide a basis for analysis :

(i) Collection of data from past or on-going projects and studies concerning dryland agriculture

(ii) Collection of basic data concerning the availability of human and physical resources, and on the basis of these resources, evaluation of the possiblities and limitations of dryland agriculture in Mauritania.

0.3.2. Analysis of the Current Situation

The second phase of the study consists of an analysis of the data collected and an identification of the constraints within this sub-sector, as well as its realistic possibilities. This phase is the most important, as it will serve to determine the general orientation for the sub-sector. Preparations for these analyses included several field missions ans surveys.

Homogenous sub-zones were determined on the basis of production systems (having either common or specific problems). The criteria employed were numerous and related to both the environment and its exploitation.

Thus, this study includes two orientations :

- The first examines the available data on dryland agriculture
- The second treats production problems from a tehcnico-economic point of

view, and also discusses difficulties associated with production use, training and research, popularization and the effects of production activities on the environment.

Chapter 1 : Basic Data

1.1. Physical Milieu

In this chapter the main zones where dryland agriculture is practiced are reviewed. Then a brief survey of the physical data is given, with comments on physical constraints to dryland agriculture.

1.1.1. Main Areas of Dryland Agriculture (see Figure 1) [2)]

Dryland agriculture is practiced in three agro-ecological zones :

1.1.1.1. The Senegal River Valley

This valley is flooded each year by the Senegal River (June to October). It extends 400 miles in length from Demba-Kane in the southeast to Saint-Louis in the western Delta. This valley is called the "Chemama" by the Moors. In some places, it is wider than 15 km. The river's year-long flow and alluvial deposits during the floods make this zone a high-potential agricultural milieu as compared to the surrounding Sahel.

This agricultural zone is fairly fertile. Two types of dryland cultivation are practiced :

- Floodland (or "oualo") cultivation on the floodplains, usually planted in

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2) Adapted from Chapter 9.1. of Report B_1 : Agro-Ecological Zones, by P. Hauser, RAMS.

sorghum and other crops.
- Rainfed (or "dieri") agriculture, on the valley slopes which are not flooded, usually planted in millet and often other crops.

1.1.1.2. The Southeast Rainfed Zone

This is the major rainfed agriculture zone. Crops depend directly on rainfall volume and distribution over time and space. Rainfed agriculture is practiced regularly each year south of the 450 mm isohyetal line. To the north, it can extend up to the 350 mm isohyetal line, but it is risky if rainfall is not sufficient.

Rainfed agriculture may appear in pockets to the north beyond its usual areas of extension up to the 200 mm isohyetal assuming clement rainfall (often in lowlying areas).

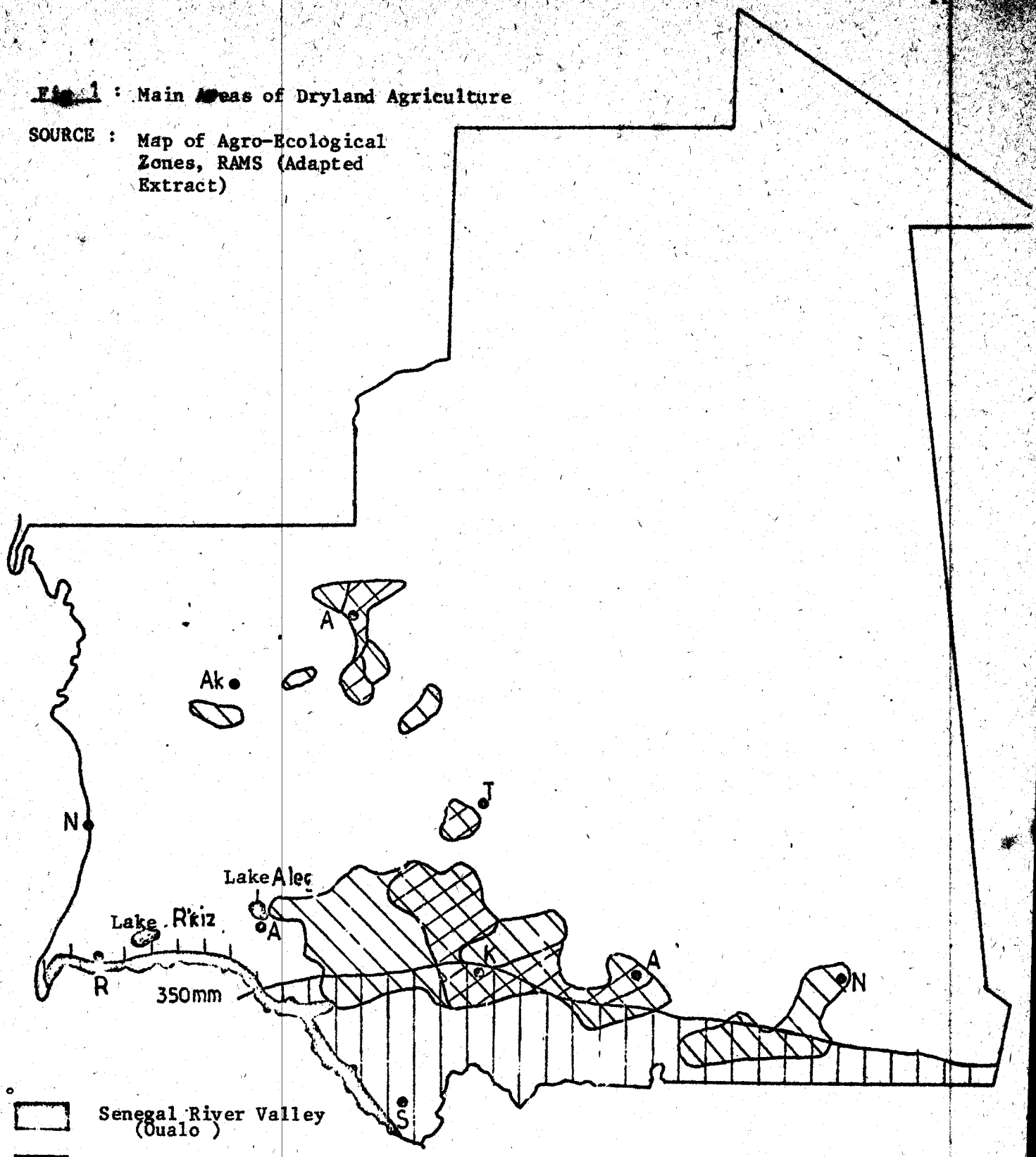
The rainfed agricultural zone is located approximately between 15° latitude N (Guidimakha) in the south and 16° latitude N (Kiffa) in the north. This is a zone of extensive agriculture (primarily millet and sorghum).

1.1.1.3. Oued Floodland Agricultural Zone

This zone is located approximately between the 350 mm isohyetal line in the south and the 100 mm isohyetal line in the north. It is concentrated mainly in the southern center of Mauritania on the piedmonts and within the sandstone high plains of the Assaba, the Tagant and the Affolé. The Aleg-Moujéria axis marks the western boundary of this zone; to the east, it extends as far as Dhar Néma, below the isolated reliefs. It is limited in the Hodhs by the Aouker sands.

Fig. 1 : Main Areas of Dryland Agriculture

SOURCE : Map of Agro-Ecological Zones, RAMS (Adapted Extract)



The concentrations of oued floodland agriculture in the Assaba, the Tagant and the Affolé are due to the topography of these high plains which collect the slightest amount of rainfall in a hydrographic network, since the sandstone rocks have a high runoff coefficient.

Floodland agriculture is localized along oueds. A small dam or dike is built across a favorable spot, in order to store water upstream. As the waters recede (often controlled), the humid banks are cultivated. This is relatively intensive cultivation, mainly of sorghum and secondary crops.

1.1.2. Climate

According to M. Leroux [3] the combined influence of the ocean trade winds, the continental trade winds, the monsoon and the distance from the ocean permit the division of Mauritania into two major climatic zones : Sahara and Sahel, both of which may be subdivided into "coastal" and "continental" sub-zones.

- The Mauritanian Sahara is divided into the northern coastal band (north of Nouakchott), characterized by constant humidity, low temperatures and low rainfall (highest rainfall in autumn). The continental Sahara is characterized by extremely dry air and very low rainfall (rendered virtually insignificant by high temperatures and the resulting evaporation). This is the most arid of Mauritania's regions.

- The Mauritanian Sahel is more or less limited in the north by the 150 mm isohyetal line and is divided into :

  - a coastal band characterized by constant humidity, cool air and summer rains
  - a continental zone, with more varied climate, characterized by a dry

3) Atlas de la République Islamique de la Mauritanie, p. 16, 1977.

winter season, high temperatures and summer rains which are heavier in the south due to the more prolonged presence of the monsoon winds.

The two main climatic factors important to this study are temperature and rainfall. Table 1 gives their characteristics for the main climatic regions.

1.1.2.1. Rainfall

The climate and geographic characterisitcs of Mauritania do not yield much rainfall. Most of the rain is carried in by the monsoons. Average annual rainfall is more than 600 mm in the extreme south (Sélibaby), rapidly decreasing towards the north. At the level of Nouakchott, Atar and north of Oualata, annual rainfall is only 100 mm; this decreases to 50 mm in the northeast and along the northern coast. Figure 2 gives the position of isohyetal lines in Mauritania, based on average rainfall from 1941 to 1970.

Rainfall is quite irregular, both over space and over time. This irregularity increases as one approaches the desert region. Table 2, which summarize the rainfall characteristics of some observation stations in southeast Mauritania, clearly illustrates this fact : the difference between maximum and minimum rainfall increases sharply as one approaches the real desert. This ratio is 2.7 at M'Bout, 5.4 at Tamchaket and attains 15 at Tichitt.

The nature of this rainfall pattern underscores that rainfall is the determining factor in the distribution and success of dryland cultivation.

Table 1 : Summary of Climate Data (monthly averages)

				J	F	M	A	M	J	J	A	S	O	N	D
Sahel Region	Coastal Zone	Saint-Louis	AT°C	21,9	21,8	21,9	21,5	22,2	25,5	26,9	27,4	28,0	27,5	25,4	22,7
			Rmm	0,8	1,4	0,0	0,2	1,3	7,2	44,2	160,9	96,7	28,5	2,4	3,3
		Rosso	AT°C			27,6	(Annual Average)								
			Rmm	0,6	1,2	0,0	0,9	1,5	8,0	43,0	135,6	81,3	31,9	1,9	4,1
	Continental Zone	Matam	AT°C	23,4	25,4	28,5	31,3	33,6	32,8	29,5	28,3	28,1	29,2	27,4	23,7
			Rmm	0,9	0,8	0,3	0,1	4,0	50,4	128,8	202,3	122,0	22,4	2,4	2,3
		Bouti-limitt	AT°C	23,0	24,8	26,8	29,2	31,7	32,1	30,3	29,8	30,3	30,3	27,8	22,4
			Rmm	0,7	1,7	0,4	0,9	4,2	5,4	44,7	70,3	544,9	14,8	2,8	3,0
		Aleg	AT°C	23,9	25,6	28,6	31,4	33,6	32,3	30,4	28,1	29,6	31,4	28,9	23,9
			Rmm	0,5	1,0	0,0	1,0	5,5	8,9	63,1	11,8	55,0	13,9	2,7	0,7
		Kiffa	AT°C	23,0	24,9	27,6	31,2	34,3	34,1	31,6	29,6	30,4	31,0	27,6	22,8
			Rmm	0,6	0,8	0,8	0,9	3,7	24,6	91,3					
		Aïoun	AT°C	23,3	23,3	28,2	31,8	34,9	33,1	31,0	28,7	30,3	31,8	28,2	22,9
			Rmm	0,3	2,0	4,0	0,2	1,0	14,8	99,0	106,5	52,4	4,5	1,5	1,6
		Néma	AT°C	24,3	27,2	29,6	33,1	35,6	34,4	31,4	29,6	30,4	32,3	29,4	24,1
			Rmm	1,1	0,3	0,2	1,7	11,2	35,5	69,0	116,7	62,3	13,7	1,0	2,3
		Séliba-by	AT°C	–	–	–	–	–	–	–	–	–	–	–	–
			Rmm	0,0	0,3	0,1	1,7	13,6	71,2	142,1	226,3	154,6	35,3	2,3	1,5
		Mouje-ria	AT°C	25,0	25,8	29,4	32,6	34,8	34,5	32,0	30,5	31,9	31,9	29,1	24,1
			Rmm	0	1,6	5,0	0,2	1,5	11,4	41,7	87,4	60,2	13,4	2,3	1,2

Source : C. Toupet

Table 1 : Cont.

Tijikja	AT°C	20,1	22,2	24,6	28,1	31,6	33,3	31,8	30,7	31,0	29,3	25,0	19,6
	Rmm	0,4	3,8	1,7	0,0	4,2	8,9	20,5	53,2	35,8	8,8	3,4	1,6
Coastal Zone — Nouakchott	AT°C	21,9	23,3	24,8	25,7	27,0	28,2	27,9	28,6	29,6	29,1	26,2	21,5
	Rmm	0,9	1,7	0,7	0,5	0,6	1,2	13,4	60,4	39,8	9,4	3,0	6,8
Coastal Zone — Nouadhibou	AT°C	19,0	19,6	20,3	20,4	21,4	22,6	22,8	23,8	25,1	24,0	21,8	19,3
	Rmm	1,9	1,3	1,7	1,1	0,2	0,8	0,3	0,6	6,9	7,1	8,0	4,4
Sahara Region — Continental Zone — Akjoujt	AT°C	22,1	22,1	26,3	28,7	32,1	34,6	33,4	32,6	33,0	31,3	27,0	21,6
	Rmm	1,1	1,9	0,9	1,2	0,6	2,6	7,8	41,0	29,5	8,0	6,8	4,7
Nemchaket (1941-60)	AT°C	-	-	-	-	-	-	-	-	-	-	-	-
	Rmm	0,3	1,4	0,7	0,7	7,3	15,8	68,6	66,9	67,6	11,4	1,5	2,7
Atar	AT°C	20,2	21,8	29,3	27,5	31,0	34,1	34,4	33,8	32,7	29,8	25,8	19,8
	Rmm	2,1	1,4	1,5	0,3	1,3	2,4	5,9	31,9	37,8	7,5	7,5	4,3
Bir-Mogrein	AT°C	19,0	20,7	23,4	25,0	27,9	30,7	33,6	33,7	31,9	28,1	24,0	18,7
	Rmm	3,3	3,5	0,8	0,3	0,1	0,7	0,3	3,9	12,4	12,9	7,7	9,9

Table 2 : Rainfall Characteristics at Observation Stations in Southeast Mauritania

Station	Number years of observations	Average annual rainfall (mm)	Maximum annual rainfall (mm)	Minimum annual rainfall (mm)	Maximum/ Minimum Ratio
Tamchaket	28 yrs.	257	513	95	5,4
Oualata	11 yrs.	107	173	69	2,5
Kiffa	42 yrs.	346	663	141	4,7
Timbedra	33 yrs.	357	520	151	3,7
Aïoun	14 yrs.	305	499	170	2,9
Néma	36 yrs.	296	506	167	3,0
M'Bout	29 yrs.	405	611	226	2,7
Sélibaby	30 yrs.	635	1.100	350	3,1
Tichitt	21 yrs.	80	167	11	15,0

Source : BURGEAP

1.1.2.2. Temperature

Temperature in Mauritania result from a combination of two main factors :

- The zenith movement of the sun, which generally determines annual temperature variations,
- Geopgraphic factors, particularly latitude and distance from the ocean, both of which increase temperatures and their variations.

Thus, the coast is permanently influenced by the maritime trade winds and has constant cool temperatures,with little variation. The annual maximum occurs in September, the minimum in December-January.

The interior of the country has much more contrasted temperatures : in the north, maximum temperatures occur in July-August; in the south, the rainy season causes increased temperatures. The maximums occur twice a year, before and after the rainy season.

Data on temperatures are summarized in Table I (monthly averages).

1.1.2.3. Ombro-thermic Diagrams (see Figure 2)

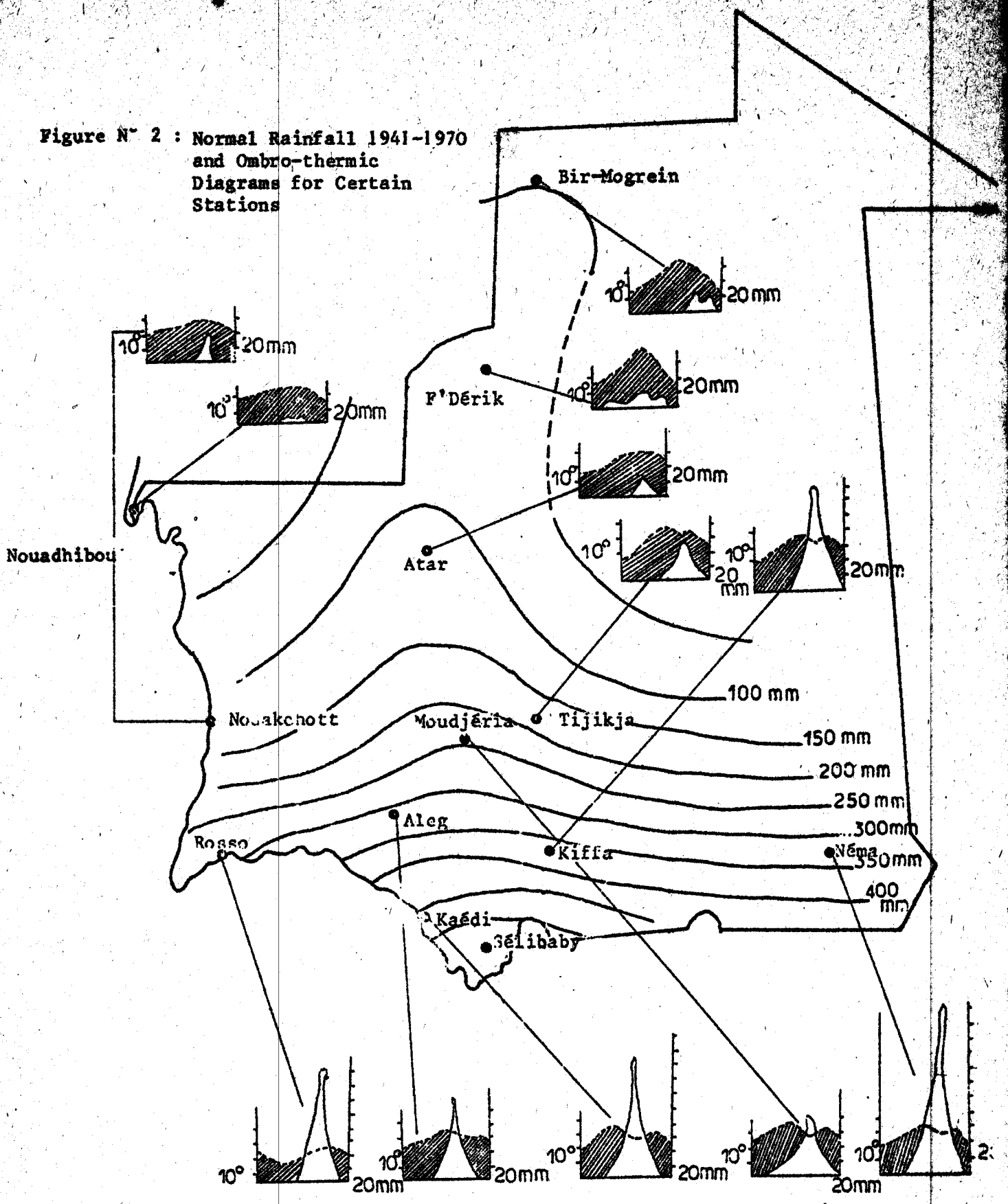
Ombro-thermic diagrams, expressing the aridity index as compared to rainfall and monthly temperatures, show that :

- There is year-long dryness in the Saharan climates and in the northern part of the Sahel climates. In these regions, P (precipitation) is always lower than 2 T (twice the average temperature).

- In the central south of the Sahel climate regions, prolonged dry periods occur during the year, but are interrupted by a humid period (P more than 2 T). This humid period occurs between July and October, and is relatively brief, according to region. It is quite brief in the north, and relatively long as one descends towards the southeast.

Dryland agriculture is conditioned by the length of the humid period, which determines the success of crops; therefore, it is only possible under the natural conditions occuring south of the 300 mm isohyetal line in Sahelian Mauritania. To the north of this line, dryland cultivation is possible only under certain ciruumstances (zones receiving not only rainfall, but also runoff or floods - whether natural or artificially produced by dams).

Figure N° 2 : Normal Rainfall 1941-1970 and Ombro-thermic Diagrams for Certain Stations



Source : P. Hauser - RAMS, 1980.
C. Toupet, 1977.

1.1.3. Soils

According to C. Barbey [5] five soil types may be distinguished in Mauritania :

- Raw mineral desert soils, classified as either complementary or ablation soils. These soils do not include vegetable matter and cover most of the country.

- Young evolving soils, classified into several types, according to climatic or non-climatic origin, and based on the nature of the rock on which they develop. These soils are found mainly north of the Western Hodh and in the Eastern Hodh.

- Isohumic soils, little evolved, fairly rich in organic matter, which are classified into three types according to clay content and the rock on which they develop. These are found in the Eastern Hodh, the Karakoro basin, in the Akchar, Azzefal and the Trarza.

- Hydromorphic soils; these are very compact and impermeable soils, developed along the Senegal River alluvia.

- Halomorphic soils; these alkaline soils are rare in Mauritania and are found mainly along the coastal region and in closed depressions. They are not arable.

The main soil types exploited in dryland agriculture are :

- Hydromorphic soils which have developped along the Senegal River Valley, as

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5) Atlas de la République Islamique de Mauritanie, p. 22, 1977.

well as along the low bassins of its major tributaries (the Gorgol, the Charfa, etc.). These soils represent a large part of the lands currently under cultivation and much of wich will be improved by irrigation.

- Brown-red sub-arid soils, developed on eolian sands. These soils represent most of the dryland cultivation in the Senegal River Valley (dieri : highlands and sandy hills) and in the southeastern peneplain (where potential is fairly high due to the good rainfall).

- Complemantary soils of sandy-clayey or clayey-sandy materials, which have developed in certain oued basins (Gorgol, Charfa, etc.). These soils represent a good part of the rainfed cultivations in the regions of central Guidimakha, Gorgol and the east of the Assaba (Barkéol).

1.1.4. Water Resources[6]

This section examines those water resources involved in dryland agriculture, specifically surface water resources (since underground water is not used for dryland agriculture).

Surface water resources are renewable. They consist of rain water which does not evaporate or infiltrate the soil. Surface runoff is used for floodland agriculture, and in the form of intermittant water courses (oueds) they replenish the aquifers.

This resource depends on both rainfall volume and on the hydrographic network which makes the water usable.

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6) Adapted from Moulaye Abdallah, May 1980.

1.1.4.1. Volume of Rainfall

The total volume of rainfall received by a given region is one of the main factors determining the quantity of runoff available.

In Mauritania, rain falls during the "rainy season" - usually from June to October. Rainfall levels vary from one zone to another and decrease from the south to the north. At Sélibaby, 650 mm/year was registered, whereas only 25 mm/year was measured at Nouadhibou.

It is very difficult to establish a general survey of rainfall cycles in Mauritania - due to the immensity of the country, the irregularity of rainfall and its spatial distribution.

In the north, 4/5ths of Mauritania have a desert climate, but in the south, the 230 mm isohyetal line (on the level of Boghé) crosses the country from west to east.

The avarage rainfall level for the country is estimated at 100 mm/year. Thus, over Mauritania's total surface area of 1,030,000 km^2, 103 billion m^3 of water falls annually, of which only 5 % (5.15 billion m^3) infiltrates and replenishes the aquifers. The rest is runoff or is lost to evaporation.

It should be noted that, in general, runoff is only possible when rainfall volume exceeds a given threshold. However, certain environmental factors may favor surface runoff for smaller precipitations. Among these factors are :

- Frequency and intensity of rainfall
- Characteristics of soil surface
- Slope
- Vegetable cover

The combination of these factors and the volume of rainfall distribution over time and temperatures will determine runoff in the hydrographic network.

1.1.4.2. Hydrographic Network

Due to the physical characteristics of Mauritania, the larger oueds flow into closed bassins, where water levels are maintained as a function of runoff and evaporation.

Only the basin downstream form the Karakoro and the western zone of the Assaba plateau have oueds which flow, at least temporarily, along their entire length before joining the Senegal River.

In its southern part, the coastal sedimentary basin is characterized by the absence of any major hydrographic network. However, in the north, a few "Khatts" manifest underground flow by lines of denser vegetation (Ataoui, Agel Khatts, etc.). In the more northern zones, (Tasiast, Inchiri, Tiris, Zemmour etc.) flows are quite localized and limited to the presense of reliefs (Akjoujt region oueds, Touerfa oued descending from the Kediat or Idjil). The northernmost regions show only rare signs of runoff along the edges of a few depressions.

The cliffs bordering the Taoudeni basin are the source of a set of oueds, the largest of which are in the Adrar : Séguilil and El Abiadh oueds, which merge in the "Ghrarah de Yaghref". In the Tagant, the Tamourt En-naaji is formed by the merger of 3 oueds draining the western part of the plateau. Towards the east, the Tijikja and Imoudran oueds flow into a Khatt depression.

To the southeast, the ancient waterway is well marked by the former tributaries of the Karakoro (Tayart, Taskass) and of the Kelembine (Maillé, Tayar, Tachoualet, El Munja, Ouassa oueds). Most of this network has been smothered

in sand or lost in marshes (the largest of which is the Mahmoude).

To the west of the Assaba, a sole network exists, with many small branches in the Aftout and the Guidimakha, which join to form several large oueds : Charfa, Niordé, Savalel and especially the Gorgol, which has a catchment basin of 11,250 km^3. All of these oueds flow into the Senegal River, draining an average of 15 billion m^3 / year. However, year-long water courses are extremely rare.

- Lake R'Kiz is at the end of the Aftout Echcherqui depression and is filled by overflow from the Senegal River valley.

- Lake Aleg is a depression filled by the rainy season flow from the Kéchi oued. Its rate of filling is quite variable: it is usually dried up by February-March.

Other smaller ponds or former marigots still communicate with the Senegal River during the flood period.

Elsewhere in the northern regions, a few small "gueltas" are perennial, as they are fed by seasonal overflows of underground spring water.

In general, we speak of surface water only when there is appreciable rain-water runoff. This runoff depends on a combination of servral factors and can only occur where there are large rocky high olanes, considerable clayey surface soils (Aftout), or where rainfall volume is high.

90 % of the total rainfall received yearly by Mauritania is evaporated or becomes runoff. This considerable potential is only partially exploited at present. More rational use of surface water is required: simple techniques near the floodland dams must be developed for soil and water conservation.

1.1.5. Possibilities and Limitations of Dryland Agriculture in Mauritania

Given the past development of dryland agriculture, it is clear that there are possibilities in this sector. While at present climatic factors hinder development by increasing the risks of dryland cultivation, this is not the major problem of this type of agriculture. In addition, climate problems vary in different dryland cultivation zones. Thus, for example, while the remedy to the problem of irregular floods in the Senegal River Valley (a problem caused by climate) is to be found in irrigated cultivation, the same does not apply to the southeastern rainfed zone of the central floodland zone.

In these latter zones, the major problem is mastery of those production factors other than climate. Dryland agriculture possibilities could be increased by the improved use of other natural resources such as soil and surface water. However, it should be noted that when planning, the surface water requirements of oasis cultivation must be taken into account, if floodland agriculture is not to interfere, especially in central Mauritania.

1.2. Human Resources

This chapter will study the human elements affecting the dryland agriculture sub-sector : population, employemnt, and the economic and social organization of dryland cultivation.

1.2.1. Total Population

The dryland agriculture sub-sector covers almost all cultivation zones of Mauritania, intermixingg more or less with other sectors such as oasis and irrigated cultivation, all of which are in turn intermixed with livestock raising in many areas.

However, the main areas of dryland agriculture is centered in three agro-ecological zones : the Senegal River Valley, the Rainfed Agricultural Zone, and the Oued Floodland Agricultural Zone. This sub-sector includes 10 regions the two Hodhs, Assaba, Gorgol, Brakna, Trarza, Adrar, Tagant, Gudimakha and Inchiri. 1,619 villages[7] of the 2,321 found in these regions are in dryland agriculture zones (or 70 %). The total rural and urban population in dryland agriculture zones is 417,963 inhabitants, representing 62.5 % of the sedentary population of these regions. As to nomadic population, if we use a constant sedentary/nomadic ratio for each region[8] this population is estimated at 118,411, or 26.7 % of the nomads in the regions concerned. Thus, the total population of the dryland agriculture zones can be evaluated (in 1977) at 536,374 inhabitants, or 48.25 % of the residents of the 10 regions, and 40 % of the population of Mauritania. In 1980, this population is on the order of 577,732 inhabitants[9] of which 468,122 are sedentary and 109,610 nomadic.

1.2.2. Population Concerned by Dryland Agriculture

Given the cereal-producing character of all types of Mauritanian cultivation, dryland agriculture should concern a large majority of the rural population. It is difficult to quantify with precision the population practicing dryland agriculture; however, an approximation was obtained from RAMS survey data.

Of a sample 251 persons interviewed, 179 (or 71.3 %) declared that they practiced at least one form of dryland agriculture. Distribution of this sample between the different zones is given in Table 3.

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7) Data from RAMS statistics unit, on the basis of BCR village survey sheet.

8) RAMS Baselin stydy : Demographic Projections

9) ibid

Table 3 : Size and Geographic Distribution of Populations Concerned By Dryland Agriculture

Major Cultivation Zones	Agro-Ecological Agricultural Zones	Number of persons interviewed (1)	Number of Persons practicing Dryland Agriculture (2)	$\frac{(1)}{(2)}$ %	% of total number of persons practicing dryland agriculture
Dryland Agriculture	I	55	47	85,5	26,25
	II	42	39	92,8	21,8
	III	39	29	74,3	16,2
Subtotal 1		136	115	84,5	64,24
Oasis	IV	41	24	58,5	13,4
Non-Agricultural Zones	V	58	39	67,2	21,7
	VI	16	1	6,25	0,5
Subtotal 2		115	64	55,6	35,76
Total		251	179	71,3	100

Source : RAMS Survey Sample

The population is concentrated in the areas defined by the first three agro-ecological zones, where typically about 64 % of the inhabitants practice dryland agriculture. Thus, those interviewed in the random sample who stated they were concerned by dryland agriculture are statistically greater than the average in these zones.

Even though dryland agriculture concerns populations throughout Mauritania, these populations are not involved to the same degree, due to differences in the level of production systems : in the river zone, for example, dryland agriculture (oualo and diéri) is the main activity, followed by livestock raising and fishing. In the southeastern rainfed zone, dryland agriculture is as important as livestock raising, and practically the entire population is concerned simultaneously with these two activities. In the floodland zone, given the envriornmental conditions and the relative importance of other activities (livestock, oasis, agriculture), a smaller population is concerned than in the other zones. This is illustrated by Table 4 below, which shows the importance of the main sub-sector activities.

Table 4 : Distribution of Population According to Frequency and Type of Activity

Cultivation Zones	Agro-Ecological Zone	Number of Persons Interviewed	Number of Persons Practicing Dryland Agriculture	Number of persons practicing Livestock Raising	Number of Persons practicing Oasis Agriculture
Dryland Agriculture Zone	I	55	47	18	0
	II	42	39	34	2
	III	39	29	19	5
Palm Groves	IV	41	24	20	27
Non Agriculture Zones	V	58	39	34	5
	VI	16	1	12	0
Total		251	179	137	39

1.2.3. Active Population, Employment[10)]

1.2.3.1.

In Mauritania, the active employed population equals 406,525 persons, or 30.05 % of the population of Mauritania. Distribution is as follows :

- Urban or rural sedentary - 259,166 persons or 45.3 % of the sedentary populations.
- Nomads - 147,359 persons, or 33.10 % of the nomadic populations.

This actively employed population is distributed as follows among the different economic sectors :

- Sedentary : 259,166 active employees, of which :

Agriculture	103,213	(39,9 %)	
Livestock	36,147	(14,0 %)	
Fishing	2,362	(0,9 %)	55 %
Forests	711	(0,3 %)	
Artisanal	12,161		4,7 %
Other (Industry and Services)	104,162		40,2 %

- Nomadic : 147.359 active employees, of which :

Agriculture	22,583	(15,3 %)	
Livestock	116,323	(78,9 %)	94,2 %
Artisanal	1,821	(1,2 %)	1,2 %
Other (Commerce and services)	4,632	(4,5 %)	4,5 %

10) Based on Human Resources Research Unit data.

Unemployed active populations represent 45,091 individuals, of which :

- 42,460 are sedentary males aged 12 years or over; 7,4 % of the sedentary population

- 2,631 are nomadic males 12 years or over, and female heads of households; 0,59 % of nomadic populations.

Those individuals considered to be active are :

- Sedentary males aged 12 years or more
- Nomadic males aged 12 years or more and female heads of households only.

Thus, the total inactive population is 356,121 persons, of which :

- 269,880 are sedentary individuals of both sexes, representing 47,3 % of the sedentary population
- 86,241 are male nomads: 19.37 % of the nomadic population.

1.2.3.2.

In the zones concerned by this study, these results give an active employed population in 1977 of 161,835 individuals, distributed by activtivities as shown in Table 5 below .

The unemployed active population in 1977 was 13,753 individuals, of which 13,053 were sedentary and 700 nomadic.

The inactive population, in 1977, was composed of 157,886 persons, of which 134,950 were sedentary and 22,936 nomadic. (This population is composed of males less than 12 years old, and represents a rather large potential when

Table 5 : Distribution of Active Employed by Activity in the Study Zone (1977)

Activity Sector	Sedentary	Nomadic	Total/Sector	Percent
Agriculture	48,934	6,005	54,939	33.94
Livestock	17,169	30,940	48,109	29,72
Fishing	1,116	-	1,116	0,68
Forest	355	-	355	0,21
Artisanal	5,764	483	6,247	3,86
Industry, Commerce	49,304	1,765	51,069	31,55
Total	122,642	39,193	161,835	100

combined with the active unemployed).

In summary, the employment situation in the dryland agriculture sector for 1977 was as follows :

161,835 active employed, of which 54,939 in agriculture
13, active unemployed
157,886 inactive composed essentially of males less than 12 years old.

The distribution of this population throughout the major production zones is given in Table 6.

Table 6 : 1977 Situation of Total Employment and Agricultural Employment in Different Dryland Agricultural Zones

Type / Agro-Eco.Zone	Total Active Employed	Agricultural Active	Unemployed Active	Inactive (less than 12 years)
Senegal River Zone	40,715	13,662	3,933	48,326
Rainfed Agric. Zone	76,484	27,837	6,023	70,735
Oued Flood-land Zone	44,636	14,440	3,797	38,835
Total	161,835	55,939	13,753	157,886

1.2.3.3.

In 1980, the total population of these zones is on the order of 577,732 inhabitants, or 40,7 % of the population of Mauritania. Extrapolating from employment demand trends since 1977[11] and the aging of 1977 inactive males under 12 years old, the 1980 figures would be :

173,601 active employed[12] of which 64,707 in agriculture
4,985 active unemployed since 1977.
39,466 new active unemployed[13]

11) cf. Functional Study, Employment Situation RAMS.

12) Persons having 60 years or more (past the active age) were not counted.

13) Estimate.

Using the hypothesis of proportional distribution of new employment, the 1980 situation in the study zone would be as follows (Table 7) :

Table 7 : 1980 Situation of Total Employment and Agricultural Employment in the Study Zone

Type Agro-Eco.Zone	Total Active Employed	Active Agriculture	Active Unemployed since 1977	New unemployed active (12-15 years)
Senegal River Zone	43,675	15,803	742	12,076
Rainfed Agric. Zone	82,044	32,199	630	17,680
Oued Floodland Zone	47,882	16,705	613	9,710
Total	173,601	64,707	1,985	39,466

If we suppose that the total employment structure has not changed between 1977 and 1980, then at least 34 % of the active unemployed population would be available for agricultural work (see Table 5, in Section 1.2.3.2.). Thus, in 1980, there would be :

64,700 active employed in agriculture

14,100 active unemployed (34 % of active unemployed available for agricultural work.

1.2.3.4. Agricultural Employment Trends under Present Conditions

Under the present socio-economic and political conditions, agricultural employment trends could follow two directions :

- A relative increase of agricultural employment due to the extension of cultivated surface areas in the rainfed and dam floodland zones
- A partial transfer of employment from dryland to irrigated agriculture in the Senegal River Valley.

If we consider the projects now underway (see Chapter 3.2.), we may suppose for 1985:

- A positive impact of 4,700 jobs engendered by the extension of 15,000 hectares of traditional crops, of which 10,000 will be in the southeastern rainfed zone and 5,000 in the oued floodland zone.
- A negative impact of 3,700 jobs due to the substitution of irrigated agriculture for traditional crops on about 6 000 hectares (1 200 hectares per year).

This will result in a slight increase (about 1 000 jobs in dryland agriculture) for the period 1980-1985. It should be noted that the 6 000 irrigated hectares will engender about 12,000 jobs (0,5 hectares per active person), which will be partially filled by the labor force currently practicing traditional agriculture on 6 000 hectares of oualo and 4 000 hectares of diéri.

On a long term basis, the main problem of the agricultural employment trends will be the relative aging of the active agricultural population, due to lack of renewal.

1.2.4. Forms of Economic and Social Organization

The dryland agricultural sector is characterized by extreme diversity of the cultivation zones, in both spatial and human terms.

Human diversity is reflected in the use of space by the different ethnic groups, each with unique social profiles. The Senegal River valley is dominated by the Negro-African ethnic groups, the main one being the Toucouleurs. The southeastern rainfed zone is occupied by a mixture of ethnic groups - Moors, Haratines, Sarakollés and Peulhs. The floodland zone (part of the oasis zone) is exclusively occupied by the Bidane Moors.

Thus we see differences on many levels :

- Economic behavior of the ethnic group
- Agricultural land tenure, with corresponding implications for production
- Structures for land management, which involve different forms of economic and social organization.

In the following pages, the main forms of organization encountered in the study zone are briefly described [14]

- The river valley zone, with the main ethnic group represented by the Toucouleurs
- The rainfed zone, with the Sarakollés, Peulhs, Moors
- The floodland zone, with the Moor ethnic group.

Among the Toucouleurs, agricultural exploitation appears to be highly indi-

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14) For more detailed information on social organization, the reader should see Baseline report N° 5, RAMS

vidualized. Although social organization throughout the World is almost always based on the family, among the Toucouleurs, the household (in the same sense as in Western countries) is the true economic unit. Each married man is usually the head of an agricultural unit, aided by his wife or wives, his children, as well as other close relatives. This group forms a well-defined "budgetary unit", under the responsability of the "head of household".

Among the Sarakollé, who are mainly cultivators, the socio-economic unit is the extended family or "Ka", which varies from 15 to 50 persons. This form of organization reflects the social hierarchy and the division of labor among the group members. The responsibility of each family member is a function of the amount of work to be done in the fields. Each member's capacities are used to the fullest, contributing to the group's dynamism and to the development of a sense of individual responsibility for the benefit of the whole. Each extended household, or Ka, possesses its collective field, "te Khore". The harvest is managed by the Ka chief, who stores the cereal reserves for the year, and for the entire family, in a special grain silo.

The monogamous family is the basic unit of the Moor society. This usually corresponds to the members of a family under a single tent. In spite of the family's links to the tribe or to a camp, it has autonomous control of its own possessions, the husband playing the major role. In traditional milieux, this unit of en included one or several dependants (usually slaves).

However, in spite of these ethnic differences across the different production zones, social organization is fairly similar, i.e., the economy is one of subsistence and traditional exchange. This organization seems well adapted to environmental conditions, confering possibilities for social organization and adaptation. Nevertheless, given the risks of this type of subsistence agriculture, organization rarely goes beyond the tribal or classic framework.

When planning development actions, these elements must be taken into account, especially à propos the organization of production. These problems will be solved on a long term basis by increasing the regularity and security of production.

At present, we also see a certain degradation of these forms of organization (rural exodus, abandonment of agriculture, migration), due to spatial and socio-economic changes including drought, desertification, deterioration of dams, demographic pressure, creation of new roads and the abandonment of older roads.

Chapter 2- Production Systems

2.1 Production Zones

2.1.1 Present Production Zones: Surface Areas and Geographical Distribution

As stated in the preceeding chapter, the major dryland agricultural zones are:

2.1.1.1 - The Senegal River Valley, where two types of cultivation are practiced:

a) Floodland or Oualo cultivation: practiced on the river floodplains (major and minor beds). The surface areas cultivated each year are a direct function of the river floods (see Table 8).
The fields are usually grouped together and allocated among the farmers each year according to the size of the flood. The extension also depends on the flood volume, and variations from year to year may be considerable. In order to give a general idea, Table 8 summarizes data for the entire Senegal River Valley, illustrated also by Figure 3.

Examination of this table confirms the fact that variations of surface areas cultivated are considerable from year to year. The dispersion characteristics gave the following variation coefficients :

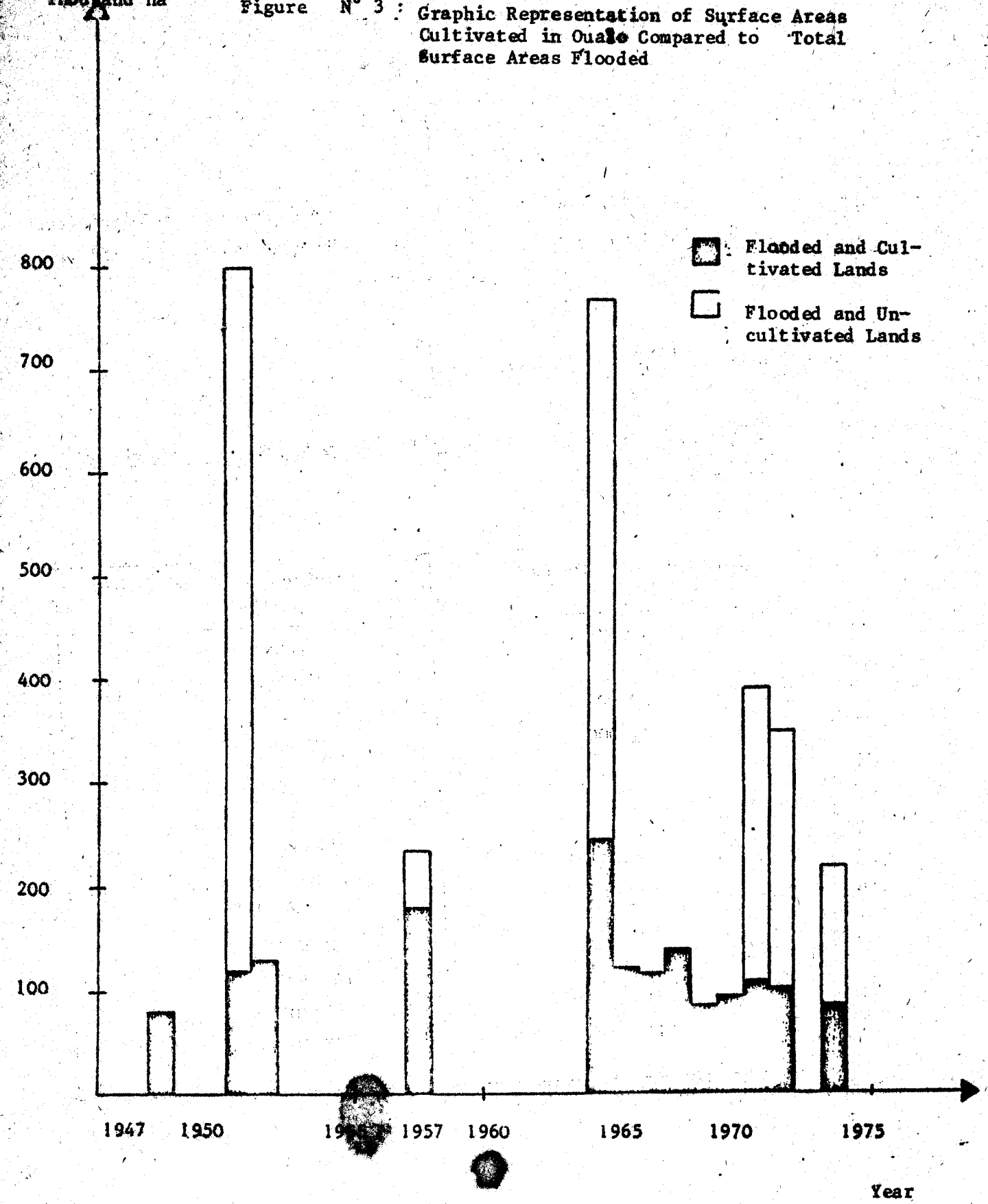
- Variation coefficient for flooded lands : 87 %
- Variation coefficient for cultivated lands : 35 %

Table 8 : Surface Area Flooded and Cultivated in Oualo in the Senegal River Valley

Year	Surface Area Flooded (ha)	Oualo surface area cultivated (ha)
1947	80.000	80.000
1950	800.000	119.000
1951	130.000	130.000
1957	230.000	180.000
1964	766.000	245.000
1965	123.000	123.000
1966	117.000	117.000
1967	140.000	140.000
1968	86.000	86.000
1969	95.000	95.000
1970	393.000	110.100
1971	350.000	101.700
1973	219.300	87.200

Source : OMVS, 1979

Figure N° 3 : Graphic Representation of Surface Areas Cultivated in Ouallo Compared to Total Surface Areas Flooded



It should be noted that while the two variables are quite dependant (r = 0,97), their dispersion coefficients are quite different. This may be explained by the fact that the surface areas cultivated depend on other factors such as the nature of the flooded soils, the length of submersion, the time of flood recession, etc.

On the Mauritanian bank, it is estimated that 60,000 hectares are cultivated in floodland (oualo) crops during a good flood and 3,000 hectares during a year of very poor flood.[15)]

During the 1970-71 agricultural campaign, the flood was considered as average to weak; JUTON [16)] established that the surface area under floodland cultivation was 48,395 hectares, of which :

- 18,645 hectares in the zone upstream, from Gouraye to Kaédi, including the Gorgol valley with 6,700 hectares
- 29,750 hectares in the downstream zone (from Kaédi to Rosso)

(b) **Rainfed or** Diéri cultivation, which is practiced on the sandy hills of the valley, in small clearings in the forest, and which are not reached by the floods.

Fields are usually individually owned and are not regularly cultivated each year. Extension is estimated at 40,000 hectares of diéri under cultivation at present. These lands are geographically distributed throughout the valley, with heavier concentrations in the middle valley downstream from Kaédi.

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15) CILSS, 1977

16) OMVS, 1978

2.1.1.2. The Southeastern Rainfed Zone

This zone extends approximately between 15° latitude North in the southernmost part (Gudimakha) to more than 16° latitude North in its northernmost part (on the level of Kiffa). It constitutes one of the major agricultural zones of the country. Extensive agriculture is practiced on those lands most favorable to crops.

In the Hodhs, the main cultivation areas are, from east to west, Bassikounou, Kossana, Amourj, Adel Bagrou, Bousteyla, Djiguenni, Gleybat and Gogui.

In the Assaba, the cultivation areas are dispersed throughout the "new world" to the southeast of Kankossa. In the Guidimakha, rainfed cultivation is distributed throughout most of the region, except in the Assaba high plains.

In the Gorgol, the main rainfed cultivation zones are found south of M'Bout and around Magama and Littamat.

The surface areas planted each year seem to depend on climate conditions. It has been estimated that rainfed surface areas cultivated can attain 111,000 hectares,[17] but data on this subject are only estimates and therefore, not very reliable. Average estimates give a surface area under rainfed cultivation of about 50,000 hectares.[18]

2.1.1.3. Oued Floodland Cultivation Zone

This zone is mainly located in the southern center of Mauritania on the piedmonts and within the sandstone high-plains of Assaba, Tagant and Affolé.

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17) CILSS, 1977.

18) BDPA, 1965, 1975.

The lands cultivated are located in dammed flood basins and are cultivated as the waters recede. In addition to this zone, are a few areas from other regions - small privileged zones which receive supplementary runoff or which have terrains particularly favorable to cultivation. Thses zones are generally found at the end of oueds, where flood waters spread (Ghraïrs), or in tamourts or basins where dam construction is often tehcnically impossible or infeasable.

It is difficult to evaluate the extension of the surface areas under oued floodland cultivation, given the doubtful reliability of existing data and the absence of a complete inventory of dams or cultivated areas. This problem is accentuated by the dispersion of cultivated zones, and lack of data on the present condition of the known dams.

The Génie Rural inventory of dams, established in 1975, lists 304 structures but furnishes practically no other information to aid evaluation. Although some of these dams were briefly described (coordinates, construction date, basin size, condition, etc.), these descriptions date from visits effected between 1955 and 1967, and are of little use today. In this inventory, only 45 dams were described in terms of their basins or by the surface areas under cultivation or potentially arable. The total arable surface areas for the dams described was on the order of 6 500 hectares. Given the lack of information, these estimates are based on data obtained in the field and on certain, fairly old, reference materials.

There are two types of dams in floodland zones :

Administrative dams (built by the Génie Rural). Of variable size, these structures are usually made of earth, and include a spillway and an evacuation outlet. Most of these dams were built during the French administration near the end of the 1940's and during the 1950's. Many have been damaged ; about 50 % were repaired around 1964.

At present, many of these dams are in poor condition or completely destroyed. Some are being considered for reconstruction; this, however, requires new studies, new credit and new goverment efforts, which explains the fact that dam inventories vary from year to year as past construction deteriorates and is sporadically replaced.

Examination of different sources lead to a total of 62 administrative dams, distributed as follows:

- Hodhs :	30 dams totalling basin areas of	2,250 ha
- Assaba :	12 dams " " "	1,650 ha
- Tagant :	10 dams " " "	2,620 ha
- Brakna-Gorgol :	8 dams " " "	2,100 ha
- Adrar :	2 dams " " "	55 ha

Traditional dams. These are simple earth dikes. This type of dam has been used by farmers for a very long time. They are of variable size, from a simple retainer dike which is rebuilt each year and having a basin less than 0.5 ha, to dams having a reservoir basis of more than 100 hectares. There are many such dikes, but only the characteristics of the larger ones are known. Synthesis of the data obtained on this subject allows an evaluation of the number of traditional dams at 2,500 localities, of which :

- 210 are medium to small dams
- more than 2 000 are dikes of very small retention capacity.

These dams are distributed as follows :

Table 9 : Geographical Distribution of Traditional Dams

Type of Structure / Regions	Traditional Dams, medium to small reservoir		Small dikes, very small retention capacity		Total (ha)
	Number	Basin surface area (ha)	Number	Basin surface area (ha)	
Hodhs	126	1 820 (26)[1]	2 000	1 500-2 000	3 320-3 820
Assaba	26	680 (17)[1]	81	n.d.	680
Tagant	34	340	n.d.	n.d.	340
Brakna-Gorgol	24	140 (5)[1]	n.d.	n.d.	140
Total	210	2 980 (48)	2 081	...	

1) The figures in parentheses indicate the number of dams for which basin surface areas are known.

As for the other floodland cultivation zones (Ghraïrs, Tamourts, etc.), it is particularly difficult to obtain a correct estimate; the literature mentions only the most well-known, which are :

- The set of Adrar Ghraïrs, which can permit, under good conditions, floodland cultivation of more than 3 000 hectares.
- Lake Gabou and the Daihera Tamourt in the Tagant, which permit floodland cultivation of more than 1 000 hectares.
- Lake Aleg in the Brakna, which permits floodland cultivation of almost 500 hectares.
- Lake R'Kiz in the Trarza, which permits floodland cultivation of more than 1 200 hectares.

2.1.1.4. Summary

The present situation of dryland agricultural zones can be presented as follows :

Senegal River Valley :	
- Oualo culitvation	3,000 to 60,000 hectares
- Diéri cultivation	30,000 to 40,000 hectares
Southeastern Rainfed Zone :	
- Rainfed cultivation	50,000 to 111,000 hectares
Oued Floodland Zone :	
- Génie Rural dams	8,680 hectares
- Known traditional dams	3,000 hectares
- Small retainer dikes	1,500 to 2,000 hectares
Natural Floodland Zones :	
(lakes, Ghraïrs, Tamourts)	
- Adrar	3,000 hectares
- Tagant	1,000 hectares
- Brakna	500 hectares
- Trarza	1,200 hectares
- Other regions	n.d.

For a total of : 230,000 hectares which could be cultivated each year.

The above figures refer to surface areas which could be cultivated, but which are not necessarily planted each year. It is particularly difficult to formulate a precise estimate of the types of exploitation, independant of the specific characteristics of each type of crop, due to rainfall variations, both from year to year and from region to region within a given year.

In natural floodland cultivation (Senegal River, lakes, Ghraïrs, etc.), the flooded surface areas may vary : twice or even four times as many hectares may be cultivated during good years as in a poor year.

In artificial floodland cultivation (dams), the same variations may occur, as there may be several floods. Floods occuring after planting of the flood basin may destroy the crops. In addition, the data given is old and has not been updated. The figures are more or less accurate, though the present state of these dams is not known.

It should be noted that 30 % of these arable surface areas behind dams are useless at present. Though these lost surface areas could be compensated for by those lands behind the traditional dams, the surface areas of which are not known.

In rainfed cultivation, the surface area planted depends on the first rains of the rainy season. While certain zones may be planted regularly each year, the crops are not always entirely harvested; often part must be abandonned due to the lack of rainfall.

In summary, the surface areas planted each year vary from approximately 90,000 hectares (least favorable climatic year) to 230.000 hectares (most favorable climatic year). During a normal year, over the period 1980-1985, the surface areas planted would be on the order of 182,000 hectares, according to Bonin.[19)]

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19) Cited by B. Machat, 1977.

2.1.2. Future Production Zones

Under present socio-economic and political conditions, the evolution of surface areas planted for dryland agriculture will not be the same for the different zones of cultivation.

For the Senegal River Valley, on a long term basis, irrigated crops will replace traditional cultivations; large improved perimeters will take over the lands formerly planted in "oualo" crops. At present, most improvement projects concern small perimeters on "fondé" lands, which are not sought-after for traditional agriculture. When the development of irrigated agriculture becomes generalized, "diéri" lands will be given over to livestock raising or abandonned.

In the Southeastern Rainfed Zone, great potential exists in the more favorable cultivation zones. These zones have been evaluated (on the basis of geographical location and climate conditions) to cover about 45,000 hectares.[20]

At present, however, the agricultural situation in this zone remains stationary, due to numerous problems and the lack of a harmonious improvement policy.

In the Oued Floodland Zone, the agricultural potential is far from being totally exploited. A great number of potential dam sites have been identified, but realization of these structures would require further studies and considerable financing. In addition, many existing dams are not optimally exploited; they also require new studies and additional funding.

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20) CILSS, 1977.

At present, there exist a few programs for reconstruction or creation of new dams, as well as a site identification program :

- The Hodhs dams project (12 dams) - currently being executed
- The Brakna and Gorgol dams project (15 dams) -execution scheduled for 1981
- The Tagant dams project (14 dams) - in the financing stage
- The Hydro-agricultural improvement of Tamourt en-Naâj project - in the financing stage.

On a medium range basis, these projects will permit floodland cultivation of more than 5 000 hectares.

In addition to these fairly advanced projects, the SONADER is currently studying an identification program for about 15 dams in the Adrar and Inchiri.

In natural floodland zones, certain areas may be effected by new hydro-agricultural improvement projects (dam construction) resulting in improved water control and the creation of new cultivation zones. Former cultivation zones may be reduced, either due to changed flood patterns or migration of the labor force towards more profitable new zones. This may be the case at Lake Gabou, for the Tamourt en-Naâj in the Tagant and Lake R'Kiz in the Trarza.

2.1.3. Production Systems

Given the multitude and specificity of types of dryland agricultural activities and their problems, in order to provide an overall and concise analysis of this subsector, a typology of production systems has been established. This typology will help identify the main problems of this subsector and determine well adapted solutions.

The global criteria employed included socio-economic and enviromental aspects. Three major production system groups were identified, spatially superimposed on the three main zones of dryland agiculture. This is quite logical and does not require extensive justification. These major groups are characterizes as follows:

2.1.3.1. The first production system group corresponds to the Senegal River Valley: (It is characterized by):

- A well deliniated area in which very ancient forms of traditional agriculture are practiced
- An economic and social organization in which the relationship between man and his land is paramount
- A very rudimentary technological "package"

In this production system group, human activity is intense; agriculture is the main economic activity, followed by animal husbandry and river fishing. With the recent introduction of irrigated cultivation, the beginnings of a radical transformation of these systems has taken place, as demonstrated by the substitution of irrigated crops for traditional crops. Given the uncertainities inherent in traditional agriculture in the river valley, such a transformation is logical and desirable: however, it is proceeding very slowly and with some difficulty.

2.1.3.2. The Southeastern Rainfed Production Group

The second group of production systems corresponds to the Southeastern Rainfed Zone. It is characterized by :

- A vast agro-sylvo-pastoral area, where dryland agriculture and animal husbandry are practiced. These two activities have begun to integrate in recent times, but conflicts persist.
- Little evolved forms of economic and social organization
- A relatively important technological package, due to transfers across the Malian border as well as former rainfed cultivation improvement projects.

At present, this system group continues without change; no notable evolution has been seen, due to the absence of measures to encourage transformation. It should be noted that this group seems capable of change and offers interesting dryland agricultural development possibilities.

2.1.3.3. The Oued Floodland Agricultural Production Group

The third group corresponds to the Oued Floodland Agricultural Zone, which is intermixed with the Oasis Agro-Ecological Zone. This production system group is characterized by :

- Dispersed production areas where dryland agriculture is one element of a rigid system based on range exploitation (livestock), surface water (dams, basins, Tamourts), and underground aquifers (palm groves).
- Forms of organization marked by the presence of only one ethnic group : the Moors.

This production system group characterizes a distinct way of life : that of the semi-nomads and transhumants often found in the central Sahel of Mauritania.

2.2. Crops

Dryland agriculture is concerned almost exclusively with cereal productich. A few secondary legumes, vegetables and condiments are also planted. A review of the different crops follows, indicating species and varieties cultivated, surface areas planted, and yields obtained for each crop.

2.2.1. Cereals

Cereals predominate in all dryland agriculture zones : the Senegal River Valley, the Southeastern Rainfed Zone and the other zones. Cereals account for more than 90 % of dryland surface areas cultivated. The main cereals are millet, sorghum, corn, wheat, barley and rainfed rice. Millet and sorghum are dominant (more than 95 % of surface areas planted), followed by corn and wheat (aoout 5 % of surface areas planted). Rainfed rice accounts for less than 1 %.

2.2.1.1. Sorghums

The sorghum botanical group is large and polymorphism is very great. In Mauritania, several varieties are cultivated, according to region :

- Sorghum Cernum, durra type - having dense spikes, also called "big millet". Planted by several local populations, it is cultivated mainly in the Senegal River Valley, but also in other regions. These varieties mature at a period when birds are less numerous, and thus are better resistant to their incursions. The growing cycle is between 100 and 130 days for the quick-growing varieties and 130 to 160 days for the slower varieties.

- Sorghum Cernum, Guineense type (Bambicum or "medimm millet) having a loose spike.
  This sorghum is cultivated in the Southeastern and other dryland regions; its productivity is less than that of the durra type, but it produces better during dry years or years of irreguler rainfall. Its growing cycle is between 100 and 110 days for quick-growing varieties and 115 to 130 days for slower varieties.

Sorghums are the major type of cereals planted in Mauritania, representing

65 % of all cereals. They are generally cultivated on natural or dammed floodlands, but are also grown in the southeastern rainfed zones.

Table 10 presents the names of some of the varieties cultivated in the different regions, according to species :

Table 10: Some Varieties of Sorghum Cultivated in Mauritania

Species / Cultivation Zone	Sorghum with dense spikes (durra type)	Sorghum with loose spikes (Guineense type)
Senegal River Valley	Séwil Féla or Fellah Sammé M'Bodéri N'Dabiri	Nioboukon Féla
Southeast	Niéniko Féla or Fellah Manganie Gadiaba Bichna Taghallit	Rheya Bichna Niéniko Féla
Floodland Zone	Taghallit Bichna	Rheya Bichna

Certain varieties, such as Bichna, Fēla and Niéniko have several ecotypes, which may have compact, semi-open or open spikes, and growing cycles varying from quick to slow (between 90 and 140 days).

Most of these varieties are well adapted to their ecological milieu, having relatively short growing cycles, a certain degree of hardiness and resistance to drought. These ecotypes originated from very heterogeneous clones, due to pluri-secular natural selection.

2.2.1.2. Millets

The millets cultivated in Mauritania are penicillar or "candle millets". There are fewer varieties than for the sorghums. The main varieties are :

- Short-spiked early varieties : The "Souna" variety is cultivated in the river valley and in the southeast; its growing cycle is 90 days. Other varieties include "Sonari" (or "Soniori" or "Moutri") and "Chounet", which are mainly cultivated in the southeast and have respective cycles of 70 and 60 days.

- Long-spiked semi-early varieties : cultivated in the south-east. Only one variety is found, the FAO variety introduced during the last decade. This variety is very productive.

In addition, in the southeast a short-spiked rustic variety of millet exists; it resists raiding by birds quite well, but its cultivation is fairly limited.

2.2.1.3. Corn

Corn is grown as a secondary crop. It is found in the Senegal River Valley on falo and fondé lands and also in the southeastern rainfed zone. This crop is fairly marginal. The surface areas cultivated in corn represent about 2 to 3 % of cereal surface areas. There are only two or three varieties cultivated; the most widely grown is known by the name of "Maka".

2.2.1.4. Wheat and Barley

Wheat and barley crops are found only in the oued floodland zones and the spread zones of the Tagant, Adrar and to the north of the Western Hodh (Tamchakett).

The varieties cultivated are not well known; they are local varieties which are well-adapted to the climate and which are sown together, giving a heterogeneous mixture. The surface areas planted in wheat and barely represent between 1.5 and 2 % of the surface areas cultivated in the above cited zones.

2.2.1.5. Rainfed Rice

Rice is only cultivated in certain flooded zones of the Guidimakha and in a few "Dhaïas" (or small depressions) in the southeast (Western Hodh). It is sown only in small surface areas and is cultivated by Soninké or Sarakollé women. The surface areas cultivated represent less than 0.5 % and cover no more than 200 hectares.

2.2.2. Legumes

The main legumes are niébé (vigna sinensis), a local bean, peanuts, and, quite secondarily, the 'Bambara pea' or voandzou (voandzeia subeerranea),

which is known to the Haratine Moors by its local name, "Barèm.".

2.2.2.1. Niébé ("Adlagane" in Moor)

The niébé is cultivated for its beans, but also for its leaves which are eaten like spinach in certain regions. More and more farmers are becoming interested in this crop, and it is the third largest crop after millet and sorghum. It is usually cultivated in association with millet and sorghum over about 10 to 20 % of the cereal surface area; it is rarely grown alone. Its relative importance in the crop system stems from its resistance to drought. The niébé is cultivated over a surface area varying from 23,000 to 45,000 hectares.

2.2.2.2. Peanuts

Peanut crops require sandy soils and high rainfall. This limits its cultivation to a few zones : it is found mainly in the wetter regions along the southeastern border, especially in the Guidimakha, and to a lesser degree, in the diéri lands along the Senegal River Valley.

There is little inforamtion about the extension of peanut crops. The surface areas planted in peanuts in the southeast represent about 2 % of the cultivated surface areas.

2.2.2.3. Voandzou (or "Barèm")

This is an annual plant, which, like the peanut, buries its yield in the soil where it develops and ripens. It is also called 'Bambara pea'. This tropical plant was probably introduced from Mali. It is cultivated on a very small scale to the south of the Hodhs, in the border zone. It is only of very limited local interest, and there is no reliable information about the surface areas cultivated.

2.2.3. Vegetable Crops

The different vegetables grown in Mauritania are quite marginal crops. The main crops are watermelon (or "beref"), gombo, sweet potatoe, yams. Data concerning these crops is practically nonexistant.

2.2.3.1. Watermelons

This is a local variety of watermelon, cultivated for its seeds which are fairly rich in fats and proteins. It is known by the name of "beref" in the river valley and "foundi" among the Moors. It is grown on diéri lands in the river valley and behind the dams in the floodland zones. It is often associated with millet and sorghum, on very small surface areas. It is usually cultivated for personal use.

The seeds are pounded and mixed with millet or sorghum flour in order to prepare gruels or cakes (Aïch). This is a strictly subsistence crop; the produce is rarely sold.

However, the surface area devoted to watermelon corps is fairly large; we estimated, on the basis of different popduction data, that this surface area is approximately 5 000 hectares.

2.2.3.2. Gombo

This is an annual plant whose fruits are eaten as vegetables. It is shrub-like and is cultivated in the river valley and in the Guidimakha. Two types are found :

- Hibiscus sabdariffa, known as "bisap". The flower or fruit is used as a vegetable or to prepare a syrup.

- Hibiscus esculentus, known as "okra", which is cultivated for its fruits in the Guidimakha region. These crops are grwon on a very small scale, usually along the edges of fields.

2.2.3.3. Sweet Potatoes (Ipomea batatas)

This annual plant ic cultivated for its roots in the falo lands (minor bed) of the Senegal river. While quite adaptable to ecological conditions, this plant's water requirements are fairly high, which limits its cultivation to the wetter regions or to irrigated lands.

The names of the different varieties are not known; they are probably introduced varieties. Sweet potatoes cultivation covers between 300 and 900 hectares.

2.2.3.4. Yams

This annual plant is cultivated for its starchy roots, and is known locally as "Ignambé". This plant has fairly strict water and soil requirements. In Mauritania, it is cultivated on a very small scale in the lower river valley, on oualo lands. As socn as the flood is stationary, it is sown at the edge of the water and is watered at the beginning. Production is usually sold in Senegal. This crop is of limited interest; yams are a tropical crop and in Mauritania they are grown outside their usual ecological milieu. The names of varieties are not known; however, they are all certainly introduced varieties. The surface areas cultivated in yams is from 40 to 80 hectares.

2.2.3.5. Other crops

Other vegetable crops grown during the rainy season, especially in the Gudimakha are : manioc, cherry tomatoes, onions, cabbage, etc. All these crops are quite marginal.

2.2.4. Condiment Crops

These condiments are usually not mentionned in studies and their botanical names are unknown. Two plants, 'Jaktenni' and 'Sangoma', are annuals which give small black seeds having prismatic forms. They are cultivated in the southeast, in the wetter zones. The seeds are used to season rice with fish and certain local pastries.

2.2.5. Yields

In general, yields vary from the same crop according to region, as each region has different soils and climate. Optimal or average growing conditions must not be considered only in terms of climate, but rather in terms of the association between the soil, the plant, and the climate.

2.2.5.1. Cereal Crops

Cereal yields are variable according to the type of cereal, and for the same cereal, according to the type of cultivation. Different studies on yields have given the following indications :

Senegal River Valley[21]

- Floodland sorghum (oualo)	430 kg/ha
- Rainfed millet and sorghum (diéri) (Middle Senegal River Valley)	240 to 460 kg/ha
- Floodland corn (falo or minor bed)	650 kg/ha

According to a CILSS study[22] millet and sorghum yields on diéri lands are

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21) OMVS - 1979.

22) CILSS - 1977.

between 0 and 300 kg/ha. Along the Senegal River Valley, yields vary from upstream to downstream - the above results concern mainly the middle river valley. For the upstream zone, the following yields were found[23]:

- Millet and sorghum	500 kg/ha
- Corn	725 kg/ha

The following yields were noted during RAMS field surveys :

- Floodland sorghum (Middle Valley)	400 to 450 kg/ha
- Diéri millet (Middle Valley)	300 to 350 kg/ha
- Early Sorghum (Guidimakha)	600 to 700 kg/ha
- Late Sorghum (Guidimakha)	900 to 1 000 kg/ha
- Corn	450 kg/ha

Southeastern Rainfed Zone[24]

- Millet and sorghum, manual cutlivation (average over 45 years)	285 to 423 kg/ha
- Millet and sorghum, ox-drawn plowing (average over 60 years)	316 to 514 kg/ha

Yields also vary according to the varieties cultivated and the nature of the terrain. The earlier varieties have the highest yields; sowing in basins gives better results than sowing on plains.

According to CILSS,[25] yields in the rainfed zone are between 100 and 300 kg/ha.

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23) USAID - 1977.

24) BDPA, 1975.

25) CILSS, 1977.

RAMS field observations and survey results indicate the following yields :

- During a poor year, 1 moud[26] of cereal seeds (millet/sorghum) gives 40 mouds at harvest.
- During a year of normal harvest, 1 moud of seed give 250 mouds at harvest.
- In a year of exceptional rainfall, 1 moud of seeds can give 500 to 600 mouds at harvest.

This corresponds to yields of :

- 100 kg/ha during a poor year
- 625 kg/ha during an average year
- 1250 kg/ha during a good year

In addition, the RAMS survey sample for the rainfed agro-ecological zone gave an average seed/harvest ratio of 205, which corresponds to a yield of 500 kg/ha for the 1978/79 campaign.

Oued Floodland Zone

Given the lack of information on this subject, only the RAMS survey sample results for the floodland agriculture zone are available. These results, for the 1978/79 campaign, were :

- Sorghum 110 kg for 1 kg of seeds
- Millet 76 kg for 1 kg of seeds

which corresponds to yields on the order of 275 kg/ha for sorghum and 152 kg/ha

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26) Local unit of measure for which the value varies from one region to another.

for sorghum and 152 kg/ha for millet.

We also indicate the following values :

- Sorghum	300 to 500 kg/ha
- Millet	150 to 300 kg/ha
- Wheat, barley	400 to 600 kg/ha

These yields were obtained for crops behind dams and represent 30 to 40 % of possible yields.[27)]

2.2.5.2. Legumes

2.2.5.2.1. Niébé

As for cereals, niébé yields are variable according to zone. Different reference sources agree on the following yields :

- Senegal River Valley	200 to 300 kg/ha
- Southeastern Rainfed Zone	300 to 400 kg/ha
- Floodland Zone	200 to 250 kg/ha

RAMS survey samples revealed an average yield for all regions of 57 kg per kg of seed, which would give about 150 kg/ha for a sowing density of 2.5 kg/ha (1958-78 campaign).

In the southeastern zone, yields between 20 and 100 kg per kg of seed were declared, which corresponds to yields of 50 to 250 kg/ha. These harvests are

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27) Agrar und Hydrotechnik, 1979.

under-estimated, however, as niébé is harvested over a period of time.

2.2.5.2.2. Peanuts

According to T. Castiaux,[28] peanut yields in the river diéri zone are on the order of 200 kg/ha (shelled nuts). In the Guudimakha region, yields are on the order of 500 kg/ha.

During RAMS fields surveys, the yields declared were about 45 kg of shelled peanuts for 1 kg of seed, which corresponds to a yield of 300 to 350 kg/ha.

2.2.5.2.3. Voandzou

Same yields as for peanuts in the southeast.

2.2.5.3. Vegetable crops

Among the different vegetable crops, we have considered only watermelons (or "beref") and sweet potatoes.

Watermelon yields are on the order of 300 kg of seeds/ha in the Senegal River Valley.[29] In the southeastern zone, yields declared are on the order of 210 kg of seeds per kg sown, or about 360 kg/ha.

No field data were available concerning sweet potato yields; they appear to range from 2 to 6 tons/ha.[30]

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28) T. Castiaux, 1971.

29) OMVS, 1979.

30) ibid.

2.2.5.4. Summary (see Table 11)

Table 11 : Summary of Yields of Main Crops

Type of Cultivation / Crop	Oualo	Diéri	Rainfed	Oued Floodland
Cereals				
- Sorghum	430	-	285 - 423	300 - 500
- Millet	-	240 - 460	285 - 423	150 - 300
- Corn	450 - 650	-	-	-
- Wheat, Barley	-	-	-	400 - 600
Legumes				
- Niébé	200 - 300	50 - 250	50 - 250	200 - 250
- Peanuts	-	200	300 - 350	-
Vegetables				
- Watermelon (Béref)	-	300	360	-
- Sweet Potato	200 - 600	-	-	-

Source : RAMS Calculations

2.3. Production Methods and Problems

In this chapter, the existing production techniques in the dryland agriculture subsector are examined. Given the predominance of cereal cultivation in the production system, this activity will be highlighted as it is of the greatest interest to farmers. Most cereal cultivation is traditional, although draught-animal agricultural techniques are also used.

2.3.1. Cereal Cultivation

The cereal campaign begins at the start of the rainy season and ends near the month of April. It begins by preparatory work on the plot to be cultivated, followed by sowing. After sowing, the farmer generally constructs protective fencing or "zéribas". This is followed by maintenance of the crops, the main operations being weeding, and possibly thinning. Later, the farmer will protect his crops against predators by guarding it. Finally, the crop is harvested, followed by transport and storage of the produce.

2.3.1.1. Soil Preparation

Soil preparation work varies according to the type of crop, but in general it is relatively simple. In the Senegal River Valley, this work is done mainly on diéri lands, which must be cleared before the rains. On oualo lands, such work is only required if the plot was not cultivated during the preceeding year, allowing shrubs to develop.

In the southeastern zone, preparatory work is the same as for diéri lands : clearing of new or fallow plots. This work is performed before the rainy season, around the month of May.

In the oued floodland zone, preparatory work concerns mainly the dams - especially those traditional dams which do not possess evacuation outlets, as well as small dikes and retainer weirs. Dams are repaired, reconstructed or maintained. This work usually takes place in June and is performed by the men, aided by their wives and children. Repair work is followed by cleaning of the basin to be cultivated, eliminating shrubs and bushes. Most of this work is performed by adult males.

In certain zones, animals are used in cultivation; in this case, preparatory work is performed at the time of sowing.

2.3.1.2. Sowing

Sowing is the first real cultivation operation. The most commonly used method is "pocket" sowing, where a simple tool is used to make a hole into which one or two seeds are dropped. These holes are made at more or less regular distances, and one or more seeds may be planted in each. The type of tool, the spacing of the holes and the number of seeds per "pocket" vary according to the type of crop and the nature of the terrain or soil.

2.3.1.2.1. Tools

For floodland cultivation (Senegal River Valley, dams) and on heavy, compact soils, a type of spike of pointed wood (or ougal) is used to make the pockets; the sown seeds are covered over by hand. For rainfed cultivation where soils are lighter, a type of spade is employed (daba, ouagil) to dig the holes and cover the seeds.

To the south of the Hodhs, a few animal drawn seeders were noted, relicts of the BMD Agricultural operation in 1966 (see Chapter 3.2.). At that time, 100 seeders were introduced, but at present most of them are not in working condition.

2.3.1.2.2. Dates of Sowing

The date for sowing is determined by the physical requirements of each crop and the type of cultivation practiced.

In floodland cultivation, the sowing date is determined by the recession of the waters. In natural floodlands and behind traditional dams without evacuation outlets, the waters recede as infiltration and evaporation occur.

Behind modern dams, the soil becomes arable as the dam is progressively emptied. This practice may also be seen at traditional dams, where an opening is made in the dike to hasten emptying of the reservoir.

Sowing is progressive as the waters recede, according to the state of the terrain; thus, floodland sowing is spread over a period of time.

In rainfed cultivation, sowing dates are determined by the size of the first rains. Generally, sowing begins after the first heavy rainfall and continues over large surface areas until the next heavy rains. This practice is used especially in the southeast in order to increase the chances of success for at least part of the crop. In addition, different types of millet and sorghum are planted, each having different growing cycles more or less resistant to drought.

In a given field, sowing is performed by several individuals : the men make the pockets and the women or children follow, sowing the seeds. In southeastern zones where animal-drawn plowing is performed at the time of sowing, the women and children follow the plow, placing and covering the seeds.

Dry sowing, in order to profit from the first rains, is also seen in rainfed zones. Although this practice is often adapted by experienced farmers, it exacerbates the problem of attacks by predators on the seeds and young shoots. This prevents homogeneous sprouting, and several resowings are often necessary.

In floodland zones where wheat and barely are grown, sowing is performed on lands that have been flooded for longer periods and are thus more humid. Wheat requires more water than millet and sorghum. Barley, which requires slightly less water than wheat, is planted a few days earlier.

2.3.1.2.3. Sowing Density

Density of sowing is varied according to the type of crop. It is difficult to determine a representative average density; however, several examples are given below :

- In the Guidimakha region,[31] sowing density varies between 8 and 33 kg/ha for sorghum, and between 10 and 33 kg/ha for corn.
- In the southeastern zone, (south of the Hodhs), density was estimated[32] at between 2 and 5 kg/ha, according to whether millet, sorghum or both were sown.
- In the floodland zone, especially in the Tagant, density is estimated at[33] 2 kg/ha for millet, 35 to 45 kg/ha for wheat.

While in general the date of floodland sowing is dictated by the recession of flood waters, whether controlled or not, this does not necessarily determine the success of the crop, which can depend on other factors (nature of terrain, length of flooding, etc.). On the other hand, in rainfed cultivation, the date of sowing plays a determining role in the success of the crop, which explains the farmers' behavior - sowing dates depend on the rainfall regime, and is, for the farmers, a veritable "game of chance."

Some research has been done in this area[34] (see Chapter 3.1.). The results are quite interesting as concern the determination of the most profitable cultivation season (dates of sowing and harvesting crops). These results were used for the development study project of Southeastern Mauritania[35] but have

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31) War on Want, 1979.

32) BDPA, 1967-1975

33) Agrar und Hydrotechnik, 1979.

34) Ministère de la coopération, République Française, RIM, 1974.

35) BDPA, 1975.

not yet been applied in the field.

2.3.1.3. Protection of Fields

Protection consists of fencing the cultivated plots in order to protect them from wandering animals. This is of capital importance for the farmers, especially in livestock raising zones. In Mauritania, there is an old saying : "If the animals do not eat some crops during the night, they will not produce the next year." Thus, the livestock raisers make no effort to control their animals in the Southeast, and it is up to the farmers to protect their fields.

In the river valley, almost all oualo fields are fenced by communal enclosures around the collective fields. Diéri fields are usually individually fenced. As soon as sowing is begun, fences are made of branches of Calotropis procera, the cutting of which is not prohibited.

In the floodland zone, the same procedure is used for the dam basins as is used in oualo lands; Calotropis is used, as well as certain thorny shrubs and brush.

In the Southeast, the fields are rarely protected, for two reasons : the first is the large size of the fields (grouped fields), for which fencing would require considerable quantities of wood or branches. The second and principal reason is the restriction imposed by the government nature protection service on cutting the existing forest. This creates permanent conflict between the farmers and livestock raisers, who are often transhumants from other regions. Mauritanian legislation has decreed that livestock raisers must supervise their herds at night and that farmers must guard their fields by day. In case of conflict, the livestock raisers may be fined by the gendarmerie (200 UM/head of cattle) and the problem is referred to the

"Kadhi"[36] where it is often neglected. One of the consequences of this permanent conflict is the migration of certain farming villages over the border to Mali, where such problems do not seem to exist.

2.3.1.4. Thinning

Thinning consists of eliminating extra plants growing from the same pocket, in order to allow a reduced number of plants to prosper. The thinned plants are usually replanted in empty pockets or between existing pockets, occasionally beside the existing field. Replanting must be performed immediately after thinning to avoid breaking the roots and to increase the survival chances of the transplants. This procedure usually concerns sorghum, millet and corn.

However, at present in Mauritania, thinning is not generalized and many farmers neglect to perform it. It is often performed too late or in an unsystematic fashion. In rainfed cultivation, the farmers usually wait for a favorable rainfall to transplant, which impedes early thinning.

2.3.1.5. Crop Maintenance

Crop maintenance is usually limited to weeding or weeding/hoeing. This operation begins generally 10 to 22 days after sowing, and continues throughout the growing cycle.

Weeding is usually performed with simple tools such as the "daba" or "ouagil." It is quite superficial, consisting of scraping the indurated soil surface. Animals do not appear to be used for hoeing. We noted one animal-drawn hoer

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36) Local judge.

imported from Senegal by a Magta-Labjar farmer, but it appears to be used only for soil preparation before sowing. In the southeastern zone, although animal-drawn field work is fairly widespread and several convertible plows exist, weeding and heoing are always performed manually .

Maintenance work is usually performed by adult males, as well as by women and children. Two weeding operations are performed, except in the southeastern rainfed zone, where the size of fields makes a second weeding difficult. In fact, it is difficult to tell the difference between the first and second weeding, as this work is carried out over a period of time, up until a certain stage of crop development, and depends on the degree of weed infestation.

Besides weeding and hoeing, other forms of maintenance, such as mineral fertilization, are nonexistant. It should be noted that millet and sorghum respord well to chemical fertilizers, when these are associated with good cultivation techniques.

2.1.3.6. Protection of Crops

Crop protection is usually limited to guarding the crop against birds and certain mammals. These predators are among the main enemies of cereal crops : the "millet eaters" (Quelea quelea) and probably other species of birds, and mammals such as monkeys, warthogs and certain rodents.

In addition, parasitic insects may cause considerable damage :

- Cecidomyies cause flower drop on millet and sorghum and thus reduce production.
- Grasshoppers ravage crops and can cause serious production losses.
- Certain species of caterpillars attack the spikes or stems and cause serious damage.

Although, they are combatted each year, these parasites continue to inflict crop damage. In spite of the existence of a permanent organization for phytosanitary protection within the Agriculture Department, most actions are circumstantial, and thus insufficient. The phytosanitary protection service was organized within the framework of two projects, for a limited period, which is nearing its end. The present structures are clearly insufficient.

Given the present state of cereal cultivation in Mauritania, as well as that of development assistance structures (extension services, popularization, agricultural services, etc.), phyto-sanitary protection of crops, as presently organized within the framework of assistance projects, cannot have lasting effects or be definitively integrated in the production process. Protection techniques must be included in a program to improve cereal productivity by attacking the overall production problems from beginning to end. If these conditions cannot be met at the present time, efforts should be oriented towards economically-adapted actions, such as agronomic research to discover and utilize those species whose genetic characteristics render them more resistant to parasites.

Guarding the crops begins when spikes begin to form and continues until harvest. Women are generally concerned, as well as children and some men; As human presence is not always sufficient to frighten predators, loud noises and scarecrows are also employed.

2.3.1.7. Harvest and Transport

Harvest, according to the crop, occur from 70 days to 5 months after sowing. Harvesting begins with early millet in the Southeastern zone and the river diéri lands, followed by other crops. Harvesting can continue until March or April in the floodland zones.

For millet, sorghum and corn, only the spikes and grains are harvested; the straw is left in the field. For wheat, barley and rainfed rice, the upper part of the plant is torn off and is threshed later. Millet and sorghum are not always immediately threshed, this depends on storage techniques as well as the size of the harvest.

In the Senegal River Valley, and the Southeastern rainfed zone, where fields are not too far from the villages, the spikes are cut and transported to the village, throughout the harvest period. Thus, transport concerns only limited quantities and is usually performed by women and children.

In the Oued Floodland Zone, where fields are generally far from villages, the produce is accumulated in sacks, and transported all at once at the end of the harvest. This transport is usually effected by animals, or in a few cases, by motorized vehicles, such as Land-Rovers.

2.3.2. Other Crops

Most other crops are associated with cereals and are given no other special care than that afforded to the cereal crops. Niébé and watermelons are sown at the same time as millet and sorghum, in the same type of "pocket", but watermelons may be sown alone, especially in rainfed zones.

2.3.3. Draught-Animal Cultivation

This section will examine the quality of animal drawn production techniques; the extension of these techniques will be examined in the next chapter.

Animal-drawn cultivation was introduced in the south of the Hodhs around the beginning of the 1960's. In following years, this introduction was sustained by a certain number of projects (see Chapter 3.1.).

Technically, animal-drawn cultivation results in a major increase in the surface areas cultivated;[37] the surface areas cultivated by a family can be increased two or three times. This increase creates a certain modification of traditional techniques, such as :

- Later sowing, as the plows cannot work efficiently until after the first rains.
- Insufficient field protection, due to their larger size.
- Insufficient weeding and hoeing, due to the lack of labor, as this operation is always performed manually.
- Increased parasite and predator damage, as protection systems have not evolved at the same time as the surface areas.
- Plowing permits better use of rainwater, which slightly increases yields.

At present, the situation has changed little since the 1960's. The introduction of the plow to the border populations continues at a very slow pace, due to the limited financial means of the farmers. Local artisans have had to adapt to the requirements of animal-drawn cultivation (maintenance and repair of plows). Thus, the effects of animal-drawn cultivation remain very limited.

This technique is only used for plowing before sowing. Plowing is superficial, due to the equipemnt used and its often precarious state of maintenance or repair. Animal-drawn cultivation yields are often fairly low, as the techniques are not fully understood, the animals are insufficiently trained and often not properly fed. The farmers do not understand the need to increase the ration for livestock during the plowing season. Untrained animals

37) BDPA, 1967.

are often used, so that plowing requires two laborers. Trained animals are often sold when a little additional income is required. The main animals used are cattle, but camels and donkeys may also be employed.

2.3.4. Summary

Production methods remain rudimentary in dryland agriculture, even in those zones where animal-drawn techniques are employed.

- Cultivation techniques, although well-adapted to physical conditions and fairly rational do not favorize optimal use of the existing resources.
- Even in zones where livestock raising is an important activity, there is no integration, even on an elementary level, of agriculture and livestock (use of manure, for example).
- The existence of the farmer/livestock-raiser conflict does nothing to hasten integration. In Mali and near the border zones in southeastern Mauritania, the farmers allow herders to rent their fields and stay there with their livestock during the dry deason. Such integration could easily be facilitated in southeastern Mauritania, where range improvement would allow use of certain grazing areas currently unexploited due to lack of water holes.

The absence of livestock-agriculture integration causes more rapid exhaustion of arable lands; farmers must allow their fields to lie fallow over long periods and cultivate other newly cleared fields, which may have a detrimental effect on the environment, on a long term basis.

Chemical protection of crops, within the framework of certain projects, will probably end when the projects are finished; these isolated actions are not integrated with other technical aspects of production and thus are not profitable.

In the future, improvement of dryland agriculture must take all the problems into account; long term programs must seek to facilitate :

- Better use of rain and flood waters
- Improvement of cultivation techniques
- Choice of better adapted varieties, in order to minimize parasite and predator damage.

Research has been conducted in Maruitania concerning these problems and the results seem promising. Among these research programs are the work of IRAT[38] in Mauritania, ICRISAT[39] and J. Castiaux[40] in Senegal.

2.4. Production Means

This chapter examines the different production factors in dryland agriculture, and the ways these factors are combined. Each factor is first examined separately, then in combinations of interest to potential development emphases.

2.4.1. Land

The first production factor, land, does not seem to present major problems in dryland agriculture. According to the type of cultivation, lands appear to be :

- Naturally grouped, due to the natural terrain, as in the oualo, the dam basins, oued spread zones and lake edges, etc.

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38) Institut de recherches agronomiques tropicales et cultures vivrières.

39) International Crops Research Institute for Semi-Arid Tropics.

40) J. Castiaux, 1970.

- Voluntarily grouped for technical or organizational reasons, such as the "adouaba" of the Haratins in the southeastern rainfed zones.
- Dispersed around villages as a function of the most favorable terrains (lowlands, basins). This is the case of the river valley diéri lands and the rainfed lands of the Guidimakha and the Assaba.

These lands usually have natural limits and their size may vary from a few to several hundred hectares.

In floodland cultivation (Senegal River valley, dams, spread zones), land is distributed to members of the collectivities or among the land owners in question. Land is attributed as a function of the surface areas flooded as well as of the labor force available to each member. The plots are usually long strips and parcelling is uncommon.

In rainfed cultivation, land is not attributed; each farmer cultivates the same areas every year, according to the means and labor he has. Cultivated plots have no particular form.

The size of cultivated plots, per production unit, is determined by phycical conditions (size of flood or rainfall, nature of terrain) and by the labor force available. The average size is about 2 to 3 hectares per production unit for the larger terrains or types of cultivation (Oualo, diéri and rainfed). For the smaller types of cultivation (Falo, fondé and oued floodland), the average size is less than 2 hectares. Table 12 below gives an idea of field distribution according to size, derived from the RAMS survey sample.

Table 12 : Distribution of Fields According to type of Crop and Field Size

Size of Plot / Type of Cultivation		Less than 2 ha	2 to 4 ha	4 ha or more
Floodland	Faŧo, Fondé	17	1	1
	Oualo	19	16	11
	Oued Floodland	10	3	3
Subtotal		46	20	15
Diéri/Rainfed		60	30	15
Total		106	50	30

The distance of fields from the village varies according to the type of cultivation. In the Senegal River Valley, for instance, villages and houses are closer fo floodland terrains than to diéri fields. In the southeastern rainfed zone, fields are usually located around villages. In the oued floodland zones, fields are generally located fairly far from the farmers' dwellings; farmers are often obliged to move to the neighborhood of the fields during the agricultural campaign. This also holds true for special cultivation zones such as "Graïrs", lake edges, etc., which are usually quite far from major villages.

The main crops are cereals, with other associated crops interspersed on part of the plot. No crop rotation is practiced; the same cereals are grown on the same fields over several years. The practice of allowing long fallow periods is frequent, especially in rainfed cultivation. When draught-animal agriculture is practiced, the use of fallow periods is frequent, due to the

more rapid exhaustion of the land. The length of fallow periods are quite variable according to the type of cultivation.

2.4.2. Labor

The second production factor, labor, is episodic. Work begins just before the rainy season in the rainfed zones and as soon as the waters begin to recede in floodland areas. After sowing, thinning, weeding and crop protection, the work is finished until harvest and transport of the produce.

While the order of work is similar for all types of cultivation, the length of these operations and their chronology differ, since the beginning of the campaign is conditionned by either the arrival of rainfall and its quantity or by the dates of floods and flood recession.

A cultivation calendar for the different types of agriculture is presented in Figure 4. Such schematic calendars are more indicative than definitive, especially for floodland cultivation (oualo and oued floodlands) in which flood and flood recession periods may be early or late in the season according to the location of the land (up or downstream) and the distribution of rainfall over time and space. However, for a given region, the cultivation calendar is more restrictive, since the labor required for most cultivation operations are not deferrable, such as :

- Sowing, which must be performed as soon as rain has fallen or flood waters recede.
- Guarding and protection of crops, which must be begun when spikes are formed and continued until harvest.

2.4.2.1. Labor Force Available

As discussed in Chapters 1.2.1. and 1.2.3, the total population of the study zone and the employment situation of this population are estimated to be (for the year 1980):

- Total population : 577,732 inhabitants, both sedentary and nomadic
- Active employed : 173,600 of which 64,700 active in agriculture
- Active unemployed since 1977 : 1,985
- New active unemployed (12 to 15 years old) : 39,466

Thus, the work force available for agriculture is represneted by :

- 62,557 agricultural actives, if the 2,150 active employed in irrigated agriculture are taken into account (0.5 hectares per active employed over 4,300 hecters)[41].
- 14,100 active unemployed (34 % of active unemployed), available for agricultural work.

Theoretically, on the basis of 250 days of work per active employed and per year, this availability represents a volume of :

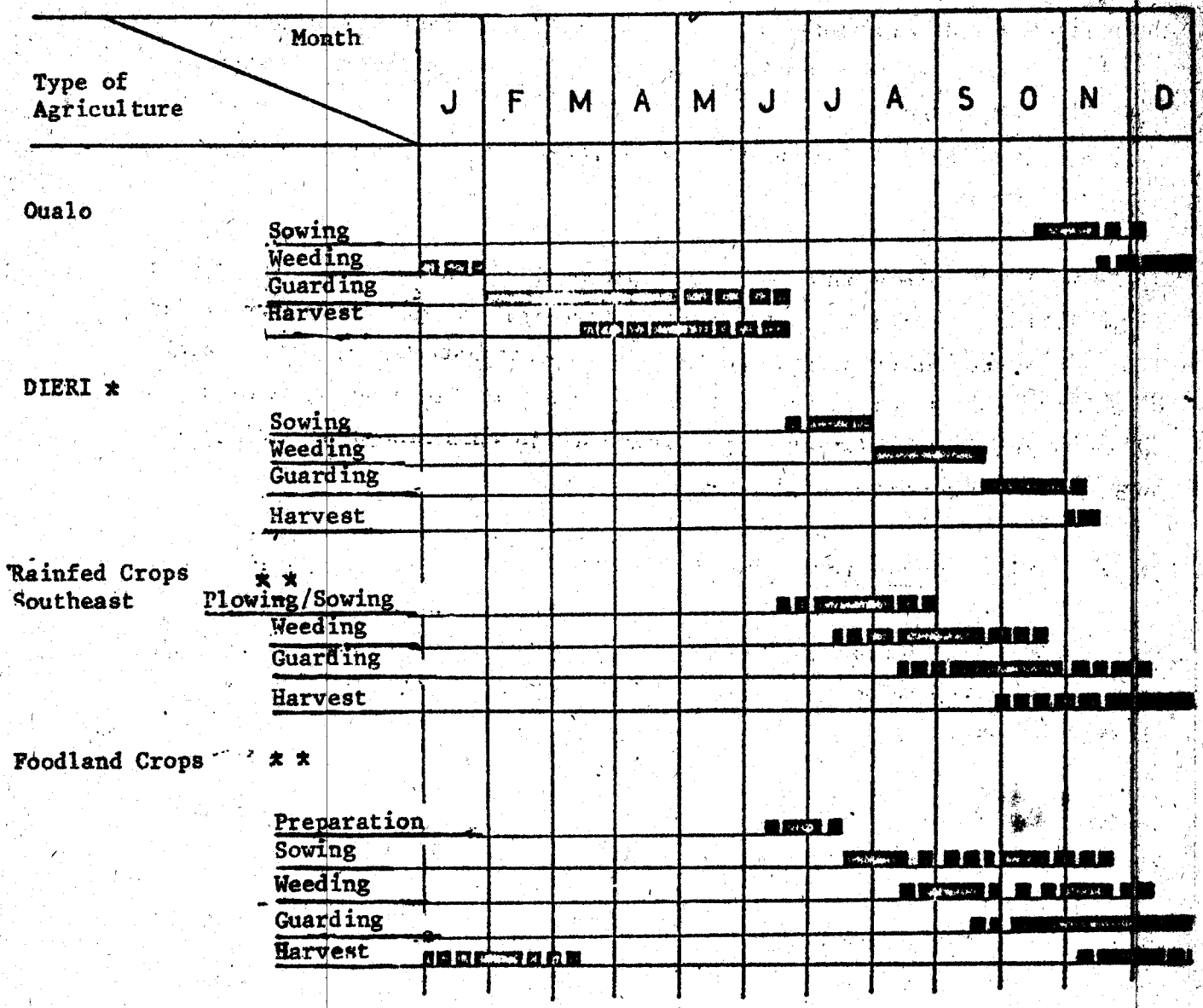
- $15,639 \cdot 10^3$ days of work in agriculture
- $3,525 \cdot 10^3$ days of potential agricultural work

However, examination of the work calendar (Figur 4) shows that :

- In the Senegal River Valley, since two types of cultivation exist which

41) See Subsector Study of Irrigated Cultivation, Y. Nasri, RAMS

Figure N° 4 : Cultivation Calendar For Main Types of Dryland Agriculture



(*) Base Source: : Boutillier 1965

(* * SOURCE : Author

are almost complementary in terms of the work calendar, an active participant can perform a maximum of work days, approximately 300 days per year.
- In the Southeastern rainfed zone, an active participant cannot perform more than 200 days of agricultural work, due to the more restrictive character of the work calendar.
- In the floodland zone, an active participant cannot perform more than 250 days of work.

Therefore, a certain amount of under-employment of the available labor force is inevitable, especially in the southeastern rainfed zone. This results in seasonal migrations of a great number of the southeastern farmers in search of work. In the floodland zone, the intermixture of floodland agriculture and oasis cultivation (which is not discussed in this study) partially absorbe the relative under-employment.

2.4.2.2. Time Required for Agricultural Work

The time required for agricultrral work depends on the type of cultivation and whether cultivation is manual or animal-drawn. In Table 13 below, we present the time requirements for the main activities performed.

The number of days given in Table 13 are estimates, as it is difficult to evaluate the particular constraints of each type of cultivation.

On the basis of the above figures and of the cultivated surface areas estimated in this report (see Chapter 2.1.1.), it can be assumed that dryland agriculture furnishes a total employment of 16,938 x 10^3 days of work, corresponding to the maximum surface areas which can be cultivated under present conditions (and excluding the zones of Lakes Aleg and R'Kiz).

This employment corresponds to a requirement for 69,857 workers distributed as

Table 13 : Evaluation of Work Times Required for Major Types of Cultivation

(Unit = Day per hectare)

Type of Cultivation / Work	Senegal River Valley[42]		Rainfed Zone[43]		Floodland Zone[44]
	Oualo	Diéri	Manual Cultivation	Animal-drawn cultivation	Cultivation behind dams
Clearing, preparation	-	-	-	-	2
Plowing	-	-	-	3	-
Sowing	11,0	4,3	7,5	1,5	7
Fencing	-	0,5	-	-	0,5
Weeding, hoering, clearing	20,5	31,9	23	13	18
Guarding	48,0	20,2	28	28	48
Harvest and Transport of cereals	6,0	7,7	8	8	8
Harvest and transport of associated crops	-	2,4	2	2	1,5
Other	-	3,4	3,5	2,5	4
Total	85,5	70,4	72	58	89

42) Source : Boutillier et al., 1965.

43) Author.

44) Ibid.

follows :

- Senegal River Valley :26,486 employed (300 days/year)
- S.E. Rainfed Zone :37,395 employed (200 days/year)
- Oued Floodland Zone : 5,576 employed (250 days/year)

When the above figures are compared with labor availability (see Table 7), we see that :

- For the entire subsector, there is considerable under-employemnt if we take into account the total number of active inhabitants; however, there is relative over-employment if we consider only the active agricultural employed and if all the surface areas were cultivated (however, this over-employment is fictitious, as it is quite improbable that all surface areas be cultivated).

- In the Senegal River Valley, without taking into account peak work periods which exist in certain areas of the valley, full employment would exist if all the available active were employed and all the oualo and diéri lands were cultivated (which is far from being the case, given the problems inherent in traditional agriculture along the river). Thus, it appears that the equilibrium between the requirements for and availability of labor is linked to the surface area cultivated, which is in turn, influenced by several other factors.

- In the Southeastern Rainfed Zone, there is relative equilibrium between labor requirements and the active agriculturally employed. This results in corresponding under-employment for the active unemployed, during the non-active periods.

- In the Floodland Zone, although it would appear that underemployment is fairly great, in reality, it is much smaller, because :

  - The evaluations of the surface areas cultivated in this zone are incomplete

  - There is considerable intermixing in this zone between floodland and other agricultural activities (such as oasis cultivation), as well as with non-agricultural activities. These other sources of employment are difficult to evaluate and, thus, are the cause of the inflated underemployment figures.

In addition, it would seem that the productivity of [illegible] in the dryland agriculture sub-sector is among the lowest. In 1980, (relative to other sectors of the economy) employment in this subsector represented, at best, 23 % of the employment in the rural sector, yet its participation in rural production (at current prices) was on the order of 3.5 %. Table 14 illustrates five examples corresponding to the different types of dryland agriculture.

The situation may be summarized as follows :

The episodic nature of dryland agriculture, coupled with the risks inherent in this type of cultivation, creates an agricultural employment situation which is in constant fluctuation. During an average year, employ[illegible] of the available labor force is largely determined by the number of arable hectares; however, during an exceptionally good year, the labor force available for agricultural work determines the number of hectares cultivated. This is one of the major problems of dryland agriculture, a problem which could be partially alleviated by intermixing with other rural activities practiced in dryland zones, such as oasis agriculture, which is fairly developed in the floodland zone and which has begun to appear in the rainfed zone.[47]

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47) See Sub-sector report on Oasis Agriculture, by Habib Kraiem, RAMS.

Dryland agriculture results in a low level of productivity. It is affected by many risk factors : climate, parasites and predators (especially in the rainfed zone). Thus, for the same volume of work, production may differ greatly.

Table 14 : Evaluation of Productivity of A Day of Work in Different Types of Dryland Agriculture

Criteria Type of Cultivation		Surface (ha)	Employment	Production Quantity (kg)		Production Value (UM)		Total Production Value (UM)	Production Value/ Day of Work (UM)
				Sorghum/ Millet	Associated Crops	Sorghum Millet 45)	Associated Crops 46)		
Senegal River Valley	Oualo SORGHUM	1	85,5	430	45	6 235	1 350	7 585	89
	Diéri Millet	1	70,4	300	50	4 050	1 500	5 550	79
Oued Floodland Sorghum		1	89	430	60	6 235	1 800	8 035	90
S.E. Rainfed	Manaul Millet/ Sorghum	1	72	325	60	4 550	1 800	6 350	88
	Animal-drawn Millet/ Sorghum	1	58	375	60	5 250	1 800	7 050	129

45) Price to producer : Millet : 13.5 UM/kg
Sorghum : 14.5 UM/kg
Mixed : 14.0 UM/kg

46) Associated crops are expressed as niébé (beans) evaluated at 30 UM/kg, price to the producer.

2.4.3. Investment Capital

The capital for dryland agriculture is usually quite minimal, and relatively insignificant, if we discount livestock raising, which is an activity practically independant of cultivation in these zones. Means are limited to a few locally produced manual tools (ougal, hoe, daba, ouagil). Thus, the surface areas cultivated are essentially determined by the volume of the labor force.

This seems to be the major reason for the spontaneous or deliberate introduction of drought-animal techniques in the Hodhs border regions, the only area where such cultivation techniques are employed. This leads us to a discussion of animal-drawn cultivation as a capital factor in these regions.

Drought-animal cultivation in the southeastern rainfed zone is of relatively recent introduction. The populations along the Malian border were quick to appreciate the advantages of this technique for familal farming. The Haratins, a rural and servile population, saw the plow as a means to sedentarize and, above all, to provide for their cereal needs.

Animal drawn cultivation was encouraged by the government during the 1960's. When government programs terminated and means became scarce, the use of animal-drawn plows was somewhat reduced, in spite of their success.

At present, animal drawn cultivation continues in a sporadic manner, due to the modest means of the farmers and the inadaptability of this method to soil or geographic conditions in certain regions.

The plow, as an investeent capital factor, has contributed to production increases by :

- Increasing the number of surface areas cultivated. The size of family farms has been increased two or threefold for average families and even more for larger families.
- Slightly increasing yields, as plowing permits better use of rainwater. Yield increases have been limited by labor constraints; on the larger surface areas cultivated, certain manual tasks, such as weeding, cannot be well performed by the family members alone.

Thus, while animal drawn cultivation is a factor in the improvement of productivity, its present use is far from optimal, (see Chapter 2.3.3.).

The last complete survey of animal-drawn equipment was conducted in 1972[48] and listed the following :

- 2 672 plows of different types
- 116 seeders
- 1 129 animal-drawn hoes of different types
- 27 carts

Given the life span of this equipment it was estimated that only the following were in service in 1972 :

- 1 200 plows
- 450 hoes of different types
- 70 seeders

The geographical distribution of this equipment was as follows : 75 % distributed between the two Hodh Regions, the remaining 25 % in the Senegal River Valley between Rosso and Sélibaby.

At present, on the basis of data furnished by the Regional Agricultural Services, it is estimated that there are approximately 2 500 plows in service, concentrated in the southeast, especially in the Eastern Hodh. In the other regions, the equipment pool is negligible, with the exception of a few new projects currently beginning (see Chapter 3.2.).

It should be noted that in southeastern Mauritania, the above equipment is the property of a relatively small number of families. It is not unusual to encounter one family having more than two plows, and occasionally 10 or more. This phenomenon seems to have created a trend towards speculation on the prices of plows and their rental fees.

Rental fees run between 300 and 700 UM/laborer's day according to zone; rental of the plow alone costs, in the Department of Néma, 50 mouds[49] of sorghum per agricultural campaign (or 250 kg of sorghum, representing 3,625 UM at the price of 14.5 UM/Kg).

Oued Floodland Investment Costs

Oued Floodland cultivation depends on the existence of dams; these structures, especially the larger ones, represent considerable investment costs. For example, the investment costs for the Hodh and Tagant dams (12 and 14 dams respectively) were evaluated in 1979 to be between 150,000 and 170,000 per hectares of flooded (and thus, cultivated) land.[50] However, these investment costs are never imputed to the exploitations themselves and thus do not constitute a financial cost in the investment budget.

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49) At Néma, a moud corresponds to about 5 kg.

50) Agrar und Hydrotechnik, 1979.

2.4.4. Investment Budget

In this section, the different production factors and their combinations are examined for the different types of dryland agriculture. In order to permit comparison, the hectare is used as the basic unit of exploitation. Investment budgets are given for the Senegal River Valley Zone (both Oualo and diéri cultivation) and the Oued Floodland Zone (cultivation behind dams).

2.4.4.1. Senegal River Valley Zone

Oualo Foodland Crops : 1 hectare sorghum + 0.15 hectare associated crops (niébé)

i. Advances	Quantities (kg)	Unit prices (UM)	Total (UM)
Seeds			
- Sorghum	5	14,5	72,5
- Niébé	1	30,0	30,0
Fertilizer	-	-	-
Pesticides	-	-	-
Total			102,5
ii. Amortization and maintenance of equipment			
Amortization			-
Maintenance (manual tools)			100
iii. Other			
Land Rental (20 % cereal harvest)			1,250
Interest			-

iv. Labor	(A) Familial/day	(B) Hired/day	Unit price (UM)	Total (UM)
Preparation, plowing	-	-	-	-
Sowing	11	-	-	-
Weeding, hoeing	20,5	-	-	-
Guarding	48	-	-	-
Harvest + Transport	6	-	-	-
Other	-	-	-	-
Total	85,5	-	-	-

v. Gross Product	Quantity/ha (kg)	Unit Price 5(UM)	Total (UM)
Sorghum	430	14.5	6,235
Niébé	45	30	1,350
Total	-	-	7,585

vi. Gross added value : v - i = 7,482.5 UM

vii. Net added value or revenue : vi - (ii + iii) = 6,134 UM

viii. Familial Revenue : vii - iv.B. = 6,134 UM

ix. Remuneration for familial work (UM/day) = 72 UM

Dieri Crops : 1 hectare millet; 0.2 hectares associated niébé

i. Advances	Quantities (kg)	Unit Price (UM)	Total (UM)
Seeds :			
Millet	8	13.5	108
Niébé	2	30	60
Fertilizer	-	-	-
Pesticiees	-	-	-
Total	-	-	168
ii. Amortization and maintenance of Equipment			
Amortization Maintenance (manual tools)			100
iii. Other			
Land Rental (20 % cereal harvest)			405
Interest			-

iv. Labor	(A) Familial/day	(B) Hired/day	Unit Price (UM)	Total (UM)
Preparation, plowing	0.5	-	-	-
Sowing	4.3	-	-	-
Weeding, hoeing	31.9	-	-	-
Guarding	20.2	-	-	-
Harvest + Transport	10.1	-	-	-
Other	3.4	-	-	-
Total	70.4	-	-	-

v. Gross Product	Quantity/kg	Unit Price (UM)	Total (UM)
Millet	300	13.5	4,050
Niébé	50	30	1,500
Total	-	-	4,550

vi. Gross added value : v - i = 4,382 UM

vii. Net added value or revenue : vi - (ii + iii) = 3,877 UM

viii. Familial revenu (vii - iv.B.) = 3,877 UM

ix. Remuneration for familial work (UM/day) 55 UM

2.4.4.2. Southeastern Rainfed Zone

Manual Cultivation : 1 hectare sorghum/millet; 0.2 kg/niébé (associated)

i. Advances	Quantities (kg)	Unit price (UM)	Total (UM)
Seeds :			
-			
- Niébé	2	30	60
- Sorghum	8	14	112
Fertilizer	-	-	-
Pesticides	-	-	-
Total	-	-	172

ii. Amortization and maintenance of equipment (UM)

Amortization Maintenance (manual tools)	100

iii. Other (UM)

Land rental (20 % cereal harvest)	455
Interest	n.d.

iv. Labor

	(A) Familial/day	(B) Hired/day	Unit Price (UM)	Total (UM)
Preparation, plowing	-	-	-	-
Sowing	7.5	-	-	-
Weeding, hoeing	23	-	-	-
Guarding	28	-	-	-
Harvest + Transport	10	-	-	-
other	3.5	-	-	-
Total	72	-	-	-

v. Gross Product

	Quantity/ha (kg)	Unit Price (UM)	Total (UM)
Sorghum, millet	325	14	4,550
Niébé	60	30	1,800
Total			6,350

vi. Gross added value : v - i = 6,178 UM

vii. Net added value or revenue : vi - (ii + iii) = 6,623 UM

viii. Familial Revenue: vii - iv.B. = 5,623 UM

ix. Remuneration for familial work (UM/day) = 78 UM

Animal Drawn Cultivation : 1 hectare sorghum; 0.2 hectare associated niébé

i. Advances	Quantities (kg)	Unit Price (UM)	Total (UM)
Seeds			
- Sorghum	8	14	112
- Niébé	2	30	60
Fertilizer	-	-	-
Pesticides	-	-	-
Total	-	-	172

ii. Amortization and maintenance of equipment (UM)[1)]

Amortization (livestock : 2 060 UM, plow : 400 UM)	2 460
Maintenance (plow)	500

iii. Other (UM)

Land Rental (10 % cereal harvest)	525
Interest	-

iv. Labor	(A) Familial/day	(B) Hired/day	Unit Price (UM)	Total (UM)
Preparation, plowing	3	-	-	-
Sowing	11,5	-	-	-
Weeding, hoeing	10	3	165	495
Guarding	28	-	-	-
Harvest, Transport	10	-	-	-
Other	2.5	-	-	-
Total	55	3	165	495

v. Gross Product	Quantity/ha (kg)	Unit Price (UM)	Total (UM)
Sorghum, millet	375	14	5,250
Niébé	60	30	1,800
Trained oxen	0.33	7,280	2,400
Total			9,450

1) The farmer purchases 2 untrained oxen at 6 000 UM/head. He sells them 3 years later at 7 500 UM/head. His plow costs him 5 250 UM; amortization is over 15 years. The rate of depreciation of the capital employed is 10 % per year.

vi. Gross Added Value : v - i	9,278 UM
vii. Net Added Value or Revenue : vi - (ii + iii)	5,798 UM
viii. Familial Revenue : vii - iv.B	5,298 UM
ix. Remuneration for Familial Work (UM/day)	96 UM

2.3.4.3. Oued Floodland Zone

CULTIVATION BEHIND DAMS : 1 hectare sorghum; 0.2 hectare associated niébé

i. Advances	Quantities (kg)	Unit Price (UM)	Total (UM)
Seeds			
- Sorghum	5	14.5	72.5
- Niébé	2	30	60
Fertilizer	-	-	-
Pesticides	-	-	-
Total	-	-	132.5

ii. Amortization and maintenance of equipment (UM)

Amortization	-
Maintenance (manual tools)	100

iii. Other

Land rental (10 % of cereal harvest)	623.5
Interest	-

iv. Labor	(A) Familial/day	(B) Hired/day	Unit Price (UM)	Total (UM)
Preparation, plowing	2	-	-	-
Sowing	7.5	-	-	-
Weeding, hoeing	18	-	-	-
Guarding	48	-	-	-
Harvest, Transport	9.5	-	-	-
Other	4	-	-	-
Total	89	-	-	-

v. Gross Product	Quantity/ha (kg)	Unit Price (UM)	Total (UM)
Sorghum	430	14.5	6,235
Niébé	60	30	1,800
Total	-	-	8,035

vi. Gross Added Value : v - i = 7,902 UM

vii. Net Added Value or Revenue : vi - (ii + iii) = 7,179 UM

viii. Familial Revenue : vii - iv.B. = 7,179 UM

ix. Remuneration for Familial Work (UM/day) = 81 UM

Examination of these budgets confirms the modest production means of this type of agriculture and shows the very low level of remuneration for familial work. This remuneration is on the order of 55 UM/day for diéri cultivation and 96 UM/day for animal-drawn rainfed cultivation. In all cases, familial remuneration is less than that of hired agricultural help, which is on the order of 100 to 165 UM/day. Even on the basis of a minimum familial remuneration of 100 UM/day, in all cases, the exploitation benefits are negative and production costs exceed production prices. This critical situation can only be improved by increasing the yield per hectare or the price to the producer, or both.

If we hypothesize a yield per hectare of sorghum or millet allowing remunerations of 100 and 150 UM/day, on the basis of constant prices and constant yields, we obtain the following :

Table 15 : Hypothesis of Yields and Prices to The Producer for Sorghum and Millet at Remuneration Rates of 100 and 150 UM/Day of Work

Remuneration Level	100 UM/Day		150 UM/day	
Variables / Type of Cultivation	Yield at constant price (kg/ha)	Price at constant yield (UM/kg)	Yield at constant price (kg/ha)	Price at constant yield (UM/kg)
Oualo	596	20.1	890	30
Diéri	460	20.7	720	32.5
Manual Rainfed	437	18.8	694	30
Animal-drawn rainfed	389	14.53	585	21.8
Floodland behind dams	548	18.5	855	28.8

These results give us an idea of the minimum yields and prices required to attain two different levels of familial remuneration. In the first case, (100 UM/day), the yields are within the realms of possibility; however, in the second case, (150 UM/day), it would be necessary to combine increased yields with relative price increases. The efforts required, of course, differ according to the type of cultivation. For example, to attain 100 UM/day in animal-drawn rainfed cultivation, a yield increase on the order of only 3 % would be necessary, whereas to attain this same level for diéri cultivation would require an increase of 53 %.

2.4.5. Summary

At present, in the dryland agricultural sub-sector, production is determined

mainly by the combination of the availability of land and labor. Dryland agriculture is characterized by :

- Its episodic and risky nature, which is dictated by climatic conditions
- A fairly fragile equilibirum of employment and the available labor force. This equilibrium is threatened by the fact that dryland agriculture is very poorly remunerated, causing a certain portion of the labor force to abandon agriculture (especially among the young). This phenomenon partially explains the large number of active unemployed estimated in Table 7 (Chapter 1.2.3.3.), relative to the employment situation in the production zones. This situation characterizes all forms of agricultural economy which lack efficient planning, especially as concern training and human resources.[51]

In summary, we believe that an increase of investment capital in traditional agriculture, as has already been partially demonstrated by animal-drawn cultivation in the southeast, will contribute to improving the situation, provided such actions are combined with improved general planning for the use of the available resources.

2.5. Land Tenure and Its Effects on Production

Land rights in traditional agriculture are quite diversified and often complex, but in general, they do not seem to seriously effect porduction.
Two main types of tenure for cultivated land may be distinguished.

2.5.1. Rights of Usage on Communal Lands

This type of tenure concerns floodable lands of all sorts : river valley oualo lands, dam basins, tamourts, etc. These lands are generally appropriated by a collectivity, which may be a tribe or a fraction of a tribe among the Moors, a village or an extended family among the other ethnic groups.

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51) See Functional Studies by Human Resources Unit, RAMS.

The collectivity allows its members to cultivate the land; the management unit is either the household (immediate family) or the extended family.

This type of land appropriation is rarely accompanied by official sale of transfer of property and is marked by the social structures of the different ethnic groups. In general, the more fertile lands are more strictly governed.

Among the Moors, this type of appropriation is not usually accompanied by direct familial exploitation of the land; most of the farming is performed by the Haratines, who are remunerated in various ways.[52)]

Among the Negro-African ethnic groups of the Senegal River valley, in addition to direct exploitation by the land owner, several methods of land attribution are possible. Land may be rented or lent without pay for a determined period; the rental terms are defined by the land's proximity to the flood and by the flood volume. Land rental fees may be only the symbolic "Assakal" (one tenth of the harvest) or run as high as 50 % of the harvest.

2.5.2. Free Lands or Lands Not Subjected to Rights of Usage

This type of tenure pertains to unflooded lands which can only be used for rainfed cultivation (diéri lands). No well-determined appropriation system exists; these lands are of free access. They become the temporary or "pseudo"-property of the individuals who farm them. A field may be cultivated for a certain period, then abandonned for another, according to the availability of land.

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52) C. Toupet, 1977.

Among the some Senegal River Valley populations, land is aquired by "cutting rights", i.e., he who clears the land has the right to farm it.[53] However, managment of most of these lands remains under the authority of the head of the collectivity (in most cases, a village) to which the farmer gives one tenth of the harvest, or "Assakal."

In Moorish areas, especially in the south where the agricultural population is almost exclusively Haratine, part of the production (one tenth) may be given to the former masters, who return at the time of the harvest. This practice does not seem to be obligatory, but is rather a custom of these populations.

In summary, the land's fertility, availability and location determine the populations's attachment to rigid or relaxed land tenure regimes. While it is true that these populations' subsistence is largely based on the land, the current land tenure situation does not appear to cause serious problems in dryland agriculture. However, in the future and when development actions are undertaken, care must be taken that land does not become the object of speculation, and that rentals are not affected by improvements.

To conclude this chapter, a few special cases of appropriation of river oualo lands merit serious examination. During colonial times, local agents for the French (or "Diagraphs") were charged with collection of certain taxes, especially on inheritances. As certain inheritors were not able to pay, at times these "Diagraphs" retained a portion of the inherited land for themselves. After Independence, this situation has remained the same, and may eventually cause problems.

53) See Baseline Study N° 5 : Negro-African Mauritania, by Mona Fikry.

2.6. Relationship with Other Rural Sector Production

Dryland agriculture activities are only a part of the rural situation, and occupy a more or less important place in production systems according to the production zone.

In the Senegal River Valley Zone, dryland agriculture (traditional agriculture) is the major agricultural activity. Between the two types of dryland cultivation, oualo and dieri, the populations of the valley are occupied during the entire year.

Several other activities may be intermixed, however, such as livestock raising or river fishing. The importance of the secondary activities varies according to the proximity of the cultivated lands to the river; most of the fishermen are found among the people having land near the river (falo, fondé, oualo); the livestock raisers are found among the populations having the least floodable lands (mainly diéri farmers).

In addition, in recent years, irrigated agriculture has developped. On a medium term basis, irrigated cultivation is supposed to replace traditional cultivation. At present, given the small size of irrigated plots (0.1 to 0.5 hectares), this activity is only intermixed with traditional agriculture, wihtout causing notable perturbation of the locally available labor force.

In the southeastern rainfed zone, dryland agriculture is fairly important, along with livestock raising. According to the RAMS survey sample, 80 % of the farmers in this region also practice livestock raising. Livestock provides a complementary activity to rainfed agriculture, which is episodic.

During the off-season, in order to procure supplementary revenu, some of the less well-off of these farmers may migrate to the river region or to Mali

in search of work. The more well-to-do farmers may create palm groves in favorable zones.

In addition, given the sylvo-pastoral character of this zone, some of the Haratine farmers supplement their income by exploiting wood for the manufacture of charcoal to be sold in urban centers.

This zone is visited by the transhumant livestock raisers from more northern zones, during the dry season and even during the rainy season. This results in three phenomena :

- To a certain degree, during the dry season, there is mutual benefit for livestock raisers and farmers alike. The livestock feed on the residues of cultivation; their manure contributes slightly to fertilization of the land. This occurs only in the dry season, after harvests, and in zones where pastoral water holes are available. This spontaneous phenomenon is to be encouraged.

- Conflicts between livestock raisers and farmers, during the agricultural campaign, due to the damage livestock may cause to crops. This problem occurs frequently and should be examined with a view to solving these conflicts.

- On a long term basis, competition may arise between livestock raising and agriculture for the use of space. Since there is no control of agricultural extension, certain zones have been cleared at the expense of the better ranges.

In the Oued Floodland Zone, which is intermixed with the oasis cultivation zone, dryland agriculture is part of a group of activities, which are of equal interest to the populations concerned and important for the equilibrium

of exploitation of the milieu. Oasis agriculture employs the alluvial aquifers, whereas dryland agriculture uses surface water.

On an overall basis, dryland agriculture in this zone contributes to the maintenance of a certain equilibrium of employment and exploitation of the land. This equilibrium must be taken into consideration when planning improvements, if betterment of one activity is not to interfere with the other.

2.7. General Summary

This study has discussed the traditional and fairly precarious nature of dryland agriculture. Dryland crops are in most part grown for subsistance and are dominated by cereals. Cereal cultivation in dryland agriculture is characterized by :

- Very different cultivation zones, a function of the physical milieu and human factors. The distinct types of cultivation are generally representative of the major ethnic group of a given cultivation zone.

- The use of cereal varieties which are more or less well adapted to the environment.

- Fairly rudimentary production methods and techniques. Manual work plays the main role. While these techniques are rational, they are very extensive and do not permit optimal use of the resources available. Attempts at improving these techniques have been made, but the results were limited due to the lack of integration of these attempts and their conjunctural, rahter than structural, nature.

- Variable climate conditions, which cause dryland agriculture to be episodic and fairly risky. This results in a rather fragile equilibirum between

the employemnt of the available work force and productivity (which is often very low). Most of the farmers' means are quite limited.

All the above elements render dryland agriculture a fairly precarious activity; this seems to be the cause of the abandonment of agricultrual work by young workers.

However, land tenure rights do not appear to be a constraint in dryland agriculture.

As a rural production activity, dryland agriculture plays an important role in stabilizing the population and determining its use of space. This role may be weakened or reinforced by different factors in each of the cultivation zones.

Chapter 3 : Past and Current Improvement Projects

As has already been mentioned, the dryland agricultural sub-sector has benefited only from isolated or limited improvement actions, most of which were not followed-up. This chapter gives a fairly brief summary of both the past and the current improvement actions in dryland agriculture.

3.1. Past Projects

3.1.1. Credit Operations for Draught-Animal Cultivation

These operations took place between 1965 and 1972 in the Hodhs region located in the southeast of Mauritania, where the farmers had already begun to purchase plows from Mali (see Chapters 2.3. and 2.4.). Before 1965, about a thousand animal-drawn plows existed in this region; the credit operations were instituted to enlarge this spontaneous diffusion of animal-drawn cultivation.

The first project in 1965 was initiated by the rural communes, using their own budgets. 600 plows were distributed on credit. In 1966, the second project, financed by the Mauritanian Development Bank, involved the distribution on credit of 670 plows and 800 draught oxen.

These two operations were assisted by the agricultural services, responsible for credit operations as well as for extension services and popularization.

Results : These operations were not successful. While there was a notable increase of the surface areas planted, and thus, of production, the agricultural agents did not have the time to very successfully popularize the new cultivation methods (the creation of cooperative groups did not facilitate their task). The economic results were a collapse of cereal prices, due to the increased production and a lack of complementary actions to facilitate marketing or to protect the market.

In 1972, an operation to revive draught-animal cultivation was initiated by the agricultural services in the Guidimakha region; however, this operation was limited to the distribution of 31 multicultivators and 45 hoes.

3.1.2. Study of Cereal Crop Development Possibilities in the Rainfed Zone of Southeastern Mauritania

This study was performed in 1967 by BDPA experts in order to establish a development program for crops in the rainfed zone, so as to increase cereal production and disseminate new methods among the local farmers. This fairly general study assessed the existing situation, focusing on animal-drawn cultivation. There was no follow-up.

3.1.3. Southeastern Mauritania Development Project

This study to prepare a five year program for the development and improvement of agriculture in the southeastern zone of Mauritania was performed in preparation for a financing request to the World Bank. The study was to define the methods and organisation required to improve production systems and increase the farmers' revenues.

Ths study defined several geographic zones in which different actions could be undertaken; the whole of these actions constituting the project. The project size was limited so that the benefits would justify the investments proposed.

This study appears fairly concrete and complete. However, due to lack of financing, there was no follow-up.

3.1.4. Study of Dams in the Hodhs Region

This study was financed by the FED and concerned the technical study of the construction of a certain number of new floodland dams in the Hodhs region, as well as the repair or reconstruction of existing dams. The project concerned about 50 structures (14 existing and 38 new); these dams were to permit new floodland cultivation on about 3 600 hectares. Only 18 dams were finally selected, of which 12 are currently the object of a SONADER project.

3.1.5. Eastern Mauritania Dams Project

This project took place in the 1960's following a hydro-agricultural study mission. Thirteen dam sites were identified in the Gorgol, Guidimakha, Assaba and the two Hodh regions. The project was begun under Génie Rural supervision; however, only 6 dams were finished near the end of the 1960's.

The remaining dams are the object of a request for financing to the United Nations Equipment Fund.

3.2. Current Projects

At present, there are a fair number of projects which directly or indirectly concern dryland agriculture. These projects are either in the study stage or are being executed. The most important of these projects are described below :

3.2.1. Rural Development of the Tagant Region

This project studies the actual situation in the Tagant Region and concerns all aspects of the rural world. It proposes actions in the following areas :

- Agriculture and Environment (popularization, research, water conservation, improvement of palm groves, agricultural services, etc.).
- Social infrastructures
- Physical infrastructures
- Hydraulic infrastructures (the project proposes the reconstruction and creation of a certain number of floodland dams. A project of 14 priority dams has been selected).

This project is in the preparation phase for execution under the management and organization of the SONADER.

3.2.2. Project for the Reconstruction and Creation of 15 Dams in the Brakna-Gorgol Region

This project, financed by USAID, is being carried out by the SONADER. It concerns floodland dams and is in its last phase.

3.2.3. Project to Promote Dryland Agriculture

This project concerns the development of cereal production in the Assaba and the Guidimakha regions by the promotion of animal-drawn cultivation and improvement of cultivation techniques. The financing of 15,000 000 UM is provided by the FAC; the project will last two years and is being carried out within the framework of exceptional aid to Sahelian countries.

This project will concern 1,200 families : 500 in the Assaba region and 700 in the Guidimakha region. It is managed in Nouakchott by expatriate personnel in conjunction with the Goverment agricultural sectors.

This projcet was to start during the 1980 rainy season. It does not include a training program, but is associated with a training project of the International Labor Bureau.

3.2.4. Project for Protection of Cereal Crops in the Sahel

This project will train 40 Mauritanian managers in phytosanitary crop protection. It provides scholarships, seminaries and training jobs, as well as training assistance through reinforcement of the ENFVA in Kaédi. It will also provide means and assistance in the field.

Financed by the USAID for four years, with a budget of 250,000 US-Dollars, this project is nearing its end. It would appear that it will be followed by a realization stage.

3.2.5. Rural Development Project in the Guidimakha Region (War on Want)

This project concerns the improvement and mastery of existing production systems in order to satisfy the food requirements of the region's farmers (in 10

villages along the river).

Financed by a non-governmental British organization, 'War on Want', the project budget is 12,635,900 UM; the project began in July 1976 and will last five years. For each village, the project is concerned with the development of cereal and vegetable crops as well as the introduction of animal-drawn cultivation.

3.2.6. Integrated Rural Development of the Guidimakha Region

This is a research and popularization project to improve agricultural and sylvo-pastoral production and to permit the Guidimakha region to become self-sufficient in cereal production, while preserving the environment.

The project is financed ty the USAID; the budget is 3,346,000 US-Dollars scheduled over a five year period. The project began in April 1978.

3.2.7. Integrated Rural Development of Barkeol Region

This project concerns improvement of cereal production by rational use of local resources. The project will study cereal crops (production and protection), vegetable crops, forage crops and reforestation.

Financed by the World Lutheran Federation, this projcet has a budget determined each year as a function of the operations to be performed. It began in June 1979 and will last 4 years.

3.2.8. Reinforcement of Phytosanitary Protection of Crops

As its name indicates, this project will reinforce crop protection by furnishing treatment products. This project is on a national level and is financed by the

FAC, with a budget of 11,000,000 UM. It is limited to furnishing the treatment products.

Table 16 summarizes these different projects.

3.3. Comments

There are three types of improvement projects :

- Rural development projects
- Hydro-agricultural projects (dam construction)
- Specific actions (phytosanitary actions, credit, etc.)

3.3.1. Rural Development Projects

This category appears to be the most interesting as it has an overall approach and concerns all aspects of the rural world. It is important that these studies be followed by execution and an evaluation of results.

3.3.2. Hydro-agricultural Projects

Most of these projects are concerned with repair or construction of dams, in order to increase the surface areas under floodland cultivation.

Two remarks are in order concerning this category of projects :

- It is important that the data used in technical feasibility studies be reliable (dimensions of structures, choice of dam sites, etc.). A poorly designed or located dam will soon be destroyed (especially as these dams are usually earth structures). Dam location may also create conflicts of interest among several groups along a oued.

Table 16 : Summary of Current Projects

Project Name	Financed by	Project Cost	Type of Action	Population Concerned	Project Zone	Beginning Date	Project Length
Rural [redacted] of the [redacted]	n.d.	?	Integrated Rural Development	4368 families (35000 inhabitants)	Tagant Assaba Brakna	n.d.	n.d.
Brakna-Gorgol Dam Project	U.S.A.I.D.	n.d.	Construction and Reconstruction of Dams	750 families 1)	Brakna Gorgol	n.d.	n.d.
Promotion of Dry-land Agriculture	F.A.C.	15.000.000 UM	Promotion of Animal-drawn Cultivation	1200 families (7200 inhabitants)	Assaba Guidimakha		2 years
Protection of Grain Crops	U.S.A.I.D.	250.000 US-Dollars	Training of 40 managers, furnishing of equipment	n.d.	All Regions	1977	4 years
Rural Development of Gudimakha Region	War on Want	12,636,000 UM	Popularization	10 Guidimakha villages	South of Guidimakha	1976	5 years
Integrated Rural Development of the Guidimakha	U.S.A.I.D.	3,346,000 US-Dollars	Research and Popularization	Villages within 20 km around Selibaby	Department of Selibaby	1978	5 years
Integrated Rural Development of Barkeol Region	World Lutheran Federation	Cost Fixed each Year According to Program actions	Development of Production Systems	n.d.	Department of Barkeol	1979	4 years
[redacted]yto-Sanitary Crop-Protection	F.A.C.	11,000,000 UM	Furnishing Treatment Products	n.d.	All Regions	1980	n.d.

1) Estimates

- The second remark concerns the absence of actions accompaning these projects to provide popularization and extension services. At present, impact on production can only be measured in terms of an increase of the surface areas cultivated.

3.3.3. Specific Actions

The crop protection and credit for draught-animal cultivation programs are generally limited to distribution or sale of products and agricultural equipment.

The absence of actions accompanying these projects to permanently anchor their impact on production is further noted. It is easy to fear that this category of project (on the basis of past experience), may develop a certain paternalism towards the farmers, which would have damaging effects.

In addition, once the budget of these projects is exhausted, the farmers find themselves in their original situation unless additional funds are advanced.

In general, there has been a lack of coordination and consultation between past and current projects. This is due to the absence of a governmental agricultural policy and the insufficient personnel and material means allocated to this sector.

Chapter 4 : Production and Destination of Products

This chapter will examine the main production of the sub-sector. The products and their byproducts are presented; overall production is evaluated and transport as well as problems of storage and marketing are discussed.

4.1. Production

4.1.1. Products and Byproducts

The products of dryland agriculture are almost exclusively food grains, given the subsistence character of this type of agriculture. These cereals are the basis of the rural population's diet in Mauritania. The major cereals are millet and sorghum; they are followed by corn, wheat and barley; rice is the smallest production. All these cereals can be consumed in the form of "couscous", the most common meal in Mauritania, or in other forms.

The other products grown in dryland agriculture are :

- Food legumes, such as niébé, peanuts and voandzou. Niébé is cultivated for its beans which can be eaten fresh after cooking, or dried and mixed with vegetables in certain dishes. Some Mauritanian farmers consider niébé beans to be a substitute for meat. Peanuts are also cultivated for the nuts, used as a vegetable in certain dishes or to make a kind of "couscous", especially among the Negro-African populations of the upper Seeegal River Valley. Voandzou, while not very well known, is appreciated by the farmers who eat its beans as a vegetable, along with meat.

- Vegetables : The main vegetables cultivated are sweet potatoes and watermelons (beref). The roots of the sweet potato are eaten as a vegetable with rice, but may also substitute for cereals. Watermelon seeds, given their richness in fats and proteins, are always mixed with cereals for special preparations.

Byproducts. The byproducts of dryland agriculture are of limited interest. Straw from millet and sorghum is usually left in the field. Given its coarseness and its condition after harvest, it is not greatly sought-after by live-

stock. However, wheat and barley straw is generally stored and given to livestock. Other byproducts are the green leaves of the niébé, peanut and sweet potato, eaten like spinach by certain river populations. Niébé stalks are fed to livestock by some farmers.

4.1.2. Production

It is difficult to evaluate the production of this subsector due to the insufficiency and unreliability of data concerning the surface areas cultivated and the yields obtained. The difficulty of such an evaluation is increased by the changing rainfall from year to year, which determines, either directly or indirectly, the production level.

Thus, one is obliged to use estimations based on the available data, for both high and low production levels.

4.1.2.1. Cereal Production

On the basis of the data given in this report (see Chapter 2.2.) concerning the surface areas planted and the yields obtained, the production levels are given in Table 17.

These calculations, while quite approximative and based on hypothetical situations (due to the lack of precise data) give a general idea of production variations.

Thus, production is within the margins of 24,000 to 95,000 tons. It should be noted that our H 1 hypothesis is very pessimistic, as generalized poor climatic years are not very probable. Thus, the lowest production level will always be higher than the estimates given in Table 15. On the other hand, H 2

Table 17 : Evaluation of Cereal Production

(Millet, sorghum, wheat, barley)

Cultivation Zone	Surface Areas Planted (ha)	Yields[54] kg/ha	Production[55]			
			H 1 Low (tons)	H 2 High (tons)	H 1 Low (%)	H 2 High (%)
Senegal River Valley	3,000 - 60,000 (oualo)	430	12,901	25,800		
	30,000 - 40,000 (diéri)	240 - 460	7,200	13,800	35,5	41,7
Southeastern Rainfed Zone	50,000 - 111,000	285 -423	14,250	46,953	59,7	49,5
Oued Floodland Zone	3,350 - 13,430	250 - 430	837	5,775	3,5	6
Other Zones	1,140 - 5,700	250 - 430	285	2,451	1.2	2.6
Total	87,500 - 230,130		23,362	94,779	100	100

54) Yields or yield margins which appear the most probable

55) H 1 : Unfavorable hypothesis : generalized poor climate during year
H 2 : Favorable hypothesis : generalized good climate during year

is quite optimistic, since the effects of the recent drought on the Mauritanian population (rural exodus, migration, etc.) mean that all the available surface areas cannot be cultivated. Thus the highest level of production will not reach the levels given in Table 15. However, Mauritanian statistics from before the drought period indicate that such high production levels were attained and even surpassed.

It can be seen that production is not the same in the different cultivation zones. In the Senegal River Valley, as well as in the Oued Floodland Zone, production varies more greatly than in the Rainfed Zone, especially if diéri cultivation is not taken into account. Thus, the risky nature of production seems more accentuated in the valley and in the oued floodland zones than elsewhere.

This observation justifies the increasing interest in irrigated cultivation in the river zone as a replacement for traditional agriculture. However, interest should also be directed to the rainfed zone (and, in fact, the slowness with which the hydro-agricultural improvements are proceeding in the irrigated sector has increased this interest.)

4.1.2.2. Associated Crops

Although these crops are associated with cereal cultivation, their production does not appear to vary as greatly as that of the cereals. This is due mainly to the fact that surface areas planted in associated crops do not necessarily follow the rythm of surface areas planted in cereals. We have estimated that production of associated crops equals a volume of 10 to 20 % of cereal production at its highest level (9,500 to 19,000 tons). This production is dominated by niébé, which accounts for about 60 %; the rest is distributed among the other associated crops.

4.2. Destination of Production

4.2.1. Subsistence

Dryland agriculture is mainly a subsistence agriculture; most production serves to feed the producers themselves as well as their dependents. Production is stored after harvest and daily food is taken as needed.

According to the literature on this subject, this subsistence accounts for 2/3rds of cereal production. However, this ratio is not fixed and varies from one harvest to another. When production is low, this rate can attain 80 % or more; when production is abundant, the rate is stabilized at around 66 %.

The RAMS production survey showed, for the 1978-79 campaign, a subsistence rate of about 85 % for all cereals in the country. This rate varies according to production zone and the type of cereals. For instance, in the rainfed zone and (all cereals considered together) the subsistence rate was 97 %; it was only 30 % in the oued floodland zone. Considering the different cereals, we find that millet and sorghum are consumed on a subsistence basis at the rate of 85 and 87 %, but corn and wheat are 67 % and barley 57 %. This may be explained by the different quantity of production in each zone, by the economic behavior of the farmers and by the populations' tastes.

The rate of subsistence consumption for associated crops varies according to the product. The RAMS survey sample revealed the following rates for the entire country :

- Niébé 87 %
- Sweet Potato 12 %
- Peanuts 22 %

For other products, such as beref, voandzou, etc., the majority is generally consumed by the producer. The reminder is not sold, but bartered or exchanged for other products. Thus, most associated crops seemed to be subsistence crops, with the exception of peanuts and sweet potatoes, which may be sold (however, the importance of these two products is quite limited).

4.2.2. Storage

4.2.2.1. Storage Techniques

As dryland agriculture in Mauritania is basically a subsistence agriculture, storage is of capital importance, especially given the risky nature of production. In order to assure food resources for the year and possibly provide for security in poor years, the farmer must store and save for later use the crops he has harvested. After the last drought period, the government was concerned with providing to the different production zones the new storage methods needed to constitute security stocks or stocks to regulate the market. Storage operations suppose a certain level of production.

At present, farmers employ traditional storage methods for their cereal production. The most common traditional system is the grain silo made with local materials.

In the Senegal River Valley, the silo is generally a square, more or less elevated platform, with walls. It is usually made of wood and clay; the roof is of thatch. In certain villages, the silo is built against a wall of the house.

In the southeast and to the north of the Hodhs, the grain silos are cylindrical and have walls of fine clay mixed with straw. The conical roof is made of thatch from the "Krou krou", a pastoral grass. These silos are usually elevated on blocks of stone or laterite. Their interior is often divided into

four or five cells to contain different grains. Ths storage caaacity of these silos is fairly limited; their diameters rarely attain two meters, their heights 0.75 meters, and about 20 to 25 % of their useful space is occupied by the walls.

In the Boumdeid Department (Assaba Region), it is customary to store part of the cereal harvest in non-hermetic underground chambers. A hole is dug to provide access to an underground room, the size of which depends on the harvest. The walls of this room are covered with a cob made of clay and straw mixed with water. The cereals are left on the spike and piled up to the height of the vertical hole: then, a layer of straw is laid down and the hole is filled.[56)]

In addition to these systems, and especially in the floodland zone, produce is often placed in sacks which are stored in a corner of the dwelling or in a special storage area (Makhzen). This storage method is also practiced by urban grain merchants.

The government agency concerned with grain storage, the Mauritanian Cereal Office (OMC), considers storage from a socio-economic point of view. The OMC's purpose is to build and manage two types of cereal stocks :

- Stocks for the stabilization of market prices
- Stocks for security against natural disasters.

At present, this service maintains a storage capacity of 12,500 tons, of which 10,000 consist of concrete silos and 1,500 of storage hangars. The OMC is currently constructing five hangars of 500 tons capacity each, in five dif-

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56) B. Machat, 1977.

ferent regions. In addition, there is a project to create new warehouses in Nouakchott, Nouadhibou and Rosso, for a total capacity of 52,000 tons.

A certain number of other storage facilities are at the disposal of the OMC, but are not currently in use. These are metal or concrete silos located in the south and southeast of the country; they were built in the 1960's and have a total capacity of 2,800 tons.

4.2.2.2. Storage Possibilities and Limitations

Storage by the producers themselves is a very ancient practice linked to agricultural sedentarization and benefiting from centuries of experience. The construction techniques (materials, forms, dimensions and locations) show a capacity to adapt local resources and an architectural mastery which is both efficient and esthetic.[57] However, the main drawback of this storage method[58] is the impossibility of inexpensive parasite prevention. It is difficult to know the extent of parasite damage to stored grains, due to the small quantities stored by the individual producers. However, the risk is always great. Simple and inexpensive storage and prevention improvement methods should be sought and spread throughout the country.

The OMC storage facilities do not have sufficient capacity to meet current needs.[59] This is the main limitation on its role as a storage agency. A CILSS study on storage in the Sahel[60] evaluated the total storage capacity require-

57) CILSS, 1978.
58) B. Machat, 1977.
59) Ibid.
60) CILSS, 1978.

ments in 975 to be about 124,000 tons (or, 10,000 tons less than existing capacity). This situation is aggravated by the insufficiency of storehouses and warehouses, due to the absence of adequate maintenance.

4.2.3. Marketing

Marketing is quite irregular in dryland agriculture, due to its subsistence character and the variations of production. Only a limited portion of production is marketed (mainly millet and sorghum). According to the literature on this subject, 2/3rds of cereal production may be marketed. This rate must be considered a ceiling which is only attained when production is quite abundant. In cases of weak production, this rate can be 20 % or less. The RAMS production survey indicated for the 1978/79 campaign, a marketing rate on the order of 15 % for all cereals. This rate varied according to production zones and the type of cereal considered. For example, marketing of production was 3 % in the rainfed zone, 17 % in the Senegal River Valley and 30 % for the Floodland Zone. For the different cereals, the rate was 13 to 15 % for millet and sorghum, 33 % for corn and wheat, and 43 % for barley. These variations can be explained by the volume of production in each zone and the economic behavior and traditions of farmes.

There exist no well-defined marketing structures or circuits for cereals. However, two types of marketing can be distinguished :

- Traditional marketing : This is a local traffic in cereals by merchants who collect the stocks of grain for speculation purposes. Speculation occurs on two levels :

  - the merchants may extend consumer credit to the farmers in the form of certain goods such as tea, sugar, tobacco, cloth. These goods are given at inflated prices; for example, during the 1979/80 campaign, the following

prices were noted :

tea	: 700 UM/kg,	instead of 480 UM
sugar	: 110 UM/kg,	instead of 94 UM
tobacco	: 350 UM/kg,	instead of 250 UM

- in order to reimburse debts after the harvest, the farmer must sell a part of his produce to these merchants. Since the merchants have little competition, they profit additionally by offering low prices for the grain.

This type of marketing is also employed by some merchants whose activities go beyond the local framework. Some merchants transport and store the cereals, buying at the production site and selling in the urban centers. This activity is always speculative; these merchants run caravans which go as far as Mali to import cereals.

- Marketing by the Mauritanian Cereal Office

The OMC has organized and continues to organize collection campaigns for cereals in the major production zones. However, at present, its actions are conjunctural, rather than structural, and remain limited. Collection is usually done by producers hired by the OMC, who are paid in proportion to the quantity collected.

Two collection campaigns bave been organized to date. The 1976/77 campaign collected 1 '500 tons; the 1978/79 campaign collected 1 800 tons.

Whatever the production level, the quantities collected by the OMC do not represent more than a small portion of the marketable production. This can be explained by the dispersal of production zones over a large area combined with the insufficient roads, and the isolation of certain zones. All these factors prevent the OMC from evacuating cereals from all production zones.

Production prices vary considerably, according to the RAMS survey. This

is shown in Table 18 below :

Table 18 : Production Prices of Cereals in Different Regions 1978/79 Campaign

Cereal-Production Region	Millet	Sorghum	Corn
AEZ I, Regions 4,5,6	16,6	15,4	14,8
AEZ II	n.d.[1]	10	n.d.
AEZ III, Regions 4,5,9	12,7	14,3	n.d.
AEZ IV Regions 7,9	n.d.	24,3	25
AEZ V Regions 5,6	n.d.	8,8	n.d.
All Regions	13,5	14,3	15,6

1) n.d. : not determined

Unit : UM/KG

We feel that these variations do not always reflect the market realities, but rather particular situations. For example, the lowest prices may result from :

- Large localized supply, as is often the case in some production zones
- Situations where the farmer has no other possibility but to sell to the local merchants
- Situations where supplementary supplies are available, at relatively lower prices, as for example, the cereals distributed and sold within the frame-

work of foreign aid[61] or the cereals imported illicitly from Mali by merchant caravans, especially in the southeast of Mauritaina.[62]

Thus, it appears that the cereal market is fairly precarious and that the OMC's role as a regulator is non-existant.

The OMC prices are established each year by its administrative council and the State, and take into consideration :

- The rate of traditional cereals marketed
- The customs and traditions of the producers
- The foreseeable costs and sale prices, etc.

These prices are between 7 and 12 UM/kg; the average price was :

7.84 UM/kg in 1976/77
8.2 UM/kg in 1978/79

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61) It should be noted that food aid was formerly managed by the Emergency Plan, which was limited. The prices established were :

- 2 UM/kg in 1974
- 3 UM/kg in 1975
- 4 UM/kg in 1976
- 6 UM/kg in 1977
- 8.2 UM/kg in 1978

62) During a three day visit in May 1980, to the region between Bousteila and Néma in the southeast, we observed two caravans coming from Mali, carrying 2,500 kg of cereal each. According to these merchants, the purchase price of sorghum at this time (the "hungry period") was 12 UM/kg. These same cereals were sold in the southeast, especially at Aïoun, at 22.25 UM/kg; thus, the purchase price of Malian cereals at the end of the agricultural campaign was markedly less than 12 UM/kg.

These prices do not appear to incite producers, especially when large quantities of cereals at lower prices are introduced on the market.[63] In other words, this situation is discouraging to the farmers and encourages the domination of the market by the entrepreneurs and established merchants. However, there are a number of objective constraints which prevent the OMC from fulfilling its role :

- The limited volume of marketable production (as there is no sense in inciting the farmers to sell more at the expense of their annual subsistence requirements).
- The dispersal of production, the marketed quantity of which does not justify the development of structures for collection.
- The insufficient road infrastructure, which increases the cost of both collection and distribution

In addition, there are a certain number of less objective constraints to OMC actions, such as :

- Duality of structures for cereal distribution and marketing (Mauritanian Cereal Office, ex-Emergency Plan and Commissariat For Food Aid), which, instead of increasing complementarity and efficiency, aggravates the situation.
- The absence of cereal market regulation and controls, in order to stem the main cereal traffic trends, etc.

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63) According to OMC, between November 1977 and July 1979, 84,000 tons of cereal were distributed.

The above problems merit very serious attention.

In summary, given the character of the dryland agricultural production, the existing marketing structures are more or less well adapted to the situation, in spite of the problems which result. The quantities of cereals marketed are not sufficient to warrant major intervention in marketing systems. However, total neglect of marketing problems will only serve to aggravate the situation. Actions to improve dryland cereal marketing must be combined with improvements of the production systems themselves if problems are to be solved. Such an undertaking can only be realized within the framework of a well-defined governmental policy - integrating problems of production, storage and marketing.

Chapter 5 : Training and Research

This chapter reviews the different organizations and structures concerned with agronomic training and research, after which it examines the applications of these institutions to dryland agriculture : technicians and agents trained, research programs applied, and human resources employed; emphasis is on qualitative aspects.

5.1. Current Situation of Training and Research

There are three institutions in Mauritania for agronomic training and research :

- L'Ecole Nationale de Formation et de Vulgarisation Agricoles de Kaédi (ENFVA)

This public institution is aided by a FAC/PNUD project. This school provides two types of training :

- Training of rural economic [redacted]rs
- Training of rural economic works supervisors

The training provided by this school involves agricultural production, agricultural protection, tree cultivation, popularization and rural economy.

- Le Centre Nationale de la Recherche Agronomique et du Développement Rural (CNRADR) at Kaédi

THis public institution is fianancially autonomous. It is concerned with organization, execution and dissemination of all reaearch work related to agriculture and the promotion of agricultural production. Its activities range from research to training, from economic studies to popularization projects. However, given the small number of national researchers, this center has not been able to completely fulfill its mandate. In theory, three research and application stations were to be part of this institution 's work :

- A palm-growing station at Kankossa
- An entomology station at Nouakchott
- A fruit-growing station at Rindio (Senegal River Valley)

At present, however, the CNRADR program includes only two ot these projects :

- The date palm-growing project (Oasis agriculture), with emphasis mainly on crop protection
- The irrigated fruit-tree project in the southern zone of the Senegal River Valley

- Le Centre National de l'Elevage et de la Recherche Vétérinaire (CNERV)

This center serves essentially the same function as the CNRADR, in the areas of livestock health, protection of forage crops and sheep raising.

5.2. Integration of Training and Research in Dryland Agriculture

Integration of training and research was examined on several levels :

- At the producer level
- At the level of agronomic research
- At the level of extension services and popularization, which are the main purposes of training and research

5.2.1. Producer Level

The problem of training dryland farmers is not as acute as with other activities such as irrigated cultivation. In traditional dryland agriculture, the technological "package" acquired by the farmers is the result of centuries of experience and does not lack rationality.

However, at present, this "package" is not adapted to the needs of further development and must be reinforced. Adequate extension services and material assistance must be provided to adapt production methods to new needs and realities.

In addition, there exists another important problem - the training of rural young people in agriculture. The development of agricultural production will in large part depend on these young people; they represent the potential labor force to :

- Carry on present agricultural [illegible] by replacing older farmers
- Increase the availability of labor

Examining the ages of the rural active at the present time, we see that, according to the RAMS survey sample, almost all of the active are more than 25 years old. Ths distribution by age group of the population interviewed (farmers, livestock raisers or both) is as follows for the main dry-land agricultural zones.

Table 19 : Distribution By Age Groups of the Rural Active Interviewed

Age Group / Zone	Less than 25 years		25 - 40 yrs		41 - 60 yrs		More than 60 years		Total active
	Sample	%	Sample	%	Sample	%	Sample	%	
Senegal River V.	0	0	10	18	34	62	11	20	55
Southeastern Rain-fed Zone	1	2.3	15	35.7	13	31	13	31	42
Oued Floodland Zone	1	2.5	17	43.6	19	48.7	2	5.1	39
Sub-Total	2	1.4	42	30.9	66	48.5	26	19	136
Other Zones	2	1.7	31	27	63	54.8	19	16.5	115
Total Mauritania	4	1.5	73	29	129	51.4	45	18	251

This table shows that the proportion of active young people (less than 25 years) represents only 1.5 % of the total, whereas the sample nearing retirement age is on the order of 18 %. These figures concern all rural active populations about 71 % of which are concerned with dryland agriculture (see Table 5).

On the basis of this date, it must be feared that in the future a notable decrease in the active rural population will occur., causing a reduction in existing production.

Efforts must be planned to train the farmers, especially the young. In addition, this training must be accompanied by measures to motivate the younger farmers and to create more favorable production conditions.

5.2.2. Agronomic research

Agronomic research constitutes one of the important links in the production process. Agronomic research must study the milieu, analyze production systems and use its results to propose technically and economically feasible improvements.

At present, in Mauritania, there exist research projects for livestock, irrigated cultivation and oasis agriculture; however, none of the programs are concerned with traditional agriculture. Dryland research was scheduled in the past, but terminated around 1972.

Given the economic importance of livestock and the more intensive character of irrigated cultivation, it is understandable that these two activities benefit from a major part of resources allocated to research. However, traditional agriculture must not be ignored, especially in the agro-pastoral areas (rainfed and floodland zones), lest it be condemned to stagnation, which would accelerate destabilization of the populations in these zones.

Although present research means in Mauritania are insufficient to permit dryland research programs, the results of former projects and of work outside Mauritania should be studied for possible application to Mauritanian dryland cultivation.

5.2.3. Extension Services and Popularization

At the production level, extension services are provided at the level of agricultural sectors and subsectors. The sub-sectors are run by middle-level managers, most of whom have been trained at ENFVA. The sector chief is usually a rural economy work supervisor, assisted by rural economy monitors and specialized workers, who are mostly former farmers.

In principle, the main tasks of these agents are to provide extension services and foster popularization of new techniques. In reality, this is not possible, for a number of reasons discussed below :

- Quantity of agents : The number of agents is quite insufficient; thus, they are usually limited to administrative tasks, such as seed distribution, insecticide distribution, sale of equipment, etc. For all of Mauritania, there are only 116 agents, whereas the agricultural population (sedentary and nomadic) is about 92,500.[64] This gives a ratio of about one agent per 800 farmers. If we consider that these agents concern themselves only with dryland agriculture, the ratio would be one agent per 2 000 hectares, which is quite large, especially if we take into account the dispersal of cultivation areas and the limited means available to these agents.

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64) See Functional Study, Manpower Skills, Volume III, RAMS.

- Quality of agents : Although in theory the training received by the agents in dryland agriculture is fairly extensive, it was noted that there are no qualified technicians to aid the agents in their work or to assist in technical matters and popularization methods.

- Insufficient means and logistics prevent these agents from covering all the areas under their jurisdiction.

- Popularization : Despite the good will of the agents, popularization efforts are not effective. There is no advance preparation of dissemination techniques. Even if advance preparation existed, the agents would still lack the necessary means and work tools to reach the farmers and carry out the mandate.

A major part of the popularization actions should be handled by high-level specialists working on a regional, or if necessary, national scale. On the basis of agronomic research, these specialists could program simple popularization themes and propose the methods and logistics required for their dissemination. The themes proposed should concern the farmers' basic problems.

- Credibility : At present, the extension service and popularization agents do not enjoy a favorable reception by the farmers. This "credibility" problem may be caused by :

  - The fact that certain agents are perceived to be of low social status or limited financial means
  - The independant spirit of many farmers towards government structures in general.

- Another important problem is the financial motivation of the agents themselves. If the agents are not motivated in some humanitarian way, why should they wish to conduct field trips instead of remaining in the shade of their offices for the same salary?

In summary, the above problem must be considered as a whole and solved by an integrated approach to all aspects of production. It is not sufficient to adapt training and research methods to dryland agriculture specifically; improvement will result only if programs attack the problems at the level of entire production systems.

Chapter 6 : Dryland Agriculture and The Environment

In this chapter, the main factors causing environmental degradation in the dryland agriculture zones and the methods to prevent or halt this degradation are discussed.

6.1. Degradation Factors

As discussed in preceeding chapters, dryland agriculture plays an important role in maintaining the equilibrium of human exploitation of the rural environment.

In spite of unfavorable soil and climate conditions, dryland agriculture occupies a considerable place in the overall agricultural production of Mauritania. It is often practiced on soils of low agronomic value and within the context of Sahelian climates (characterized by a summer rainy season and a dry period during the rest of the year), where rainfall is irregular over both space and time during a given season.

These elements render the dryland agricultural environment extremely fragile. Soils and vegetation exist in a very delicate state of equilibirum.[65]

In the absence of any form of exploitation, this equilibirum is already subjected to the instability of the climate (prolonged drought, for instance), but on a long term basis, these effects are corrected naturally. Adverse climatic effects are usually manifested by generalized degradation resulting in a decrease or destruction of the biological potential of arable lands.

However, this equilibrium becomes even more fragile in the presence of exploitation: the effects of adverse climate are less liable to be naturally corrected, given exploitation of the milieu.

To aggravate the eco-climatic conditions which continually expose this environment to the possibility of degradation, dryland agricultural techniques increase the vulnerability of the milieu to the effects of climate. These techniques take into consideration neither restoration nor conservation of soil fertility and do not return to the soil elements depleted by crops. Soils are rapidly exhausted; farmers leave their fields in fallow or permanently abandon them and move to virgin or more favorable terrains, especially during poor years. This phenomenon of land abandonment, characteristic of rainfed agriculture, exposes the soil to damaging climate effects (wind and water erosion, drought, etc) in regions where the envriornment is already quite vulnerable to such degradation. Large surface areas may become "desertified" due to such agricultural exploitation.

In order to illustrate the extent of this degradation phenomenon, increased by the effects of drought, it is only necessary to cite the fact that the

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65) B.K. Worcester, K.J. Dalsted, D.G. Moore, 1978.

surface areas cultivated in 1969/71, 272,000 hectares, decreased to 187,000 hectares in 1972/74; during these same periods, cereal production decreased from 93,000 tons to 41,000 tons.[66] The degraded lands are often exploited by farmers and livestock raisers in turn, which increases the risk of desertification. While over-grazing (resulting from more livestock than the range can support) is often localized, it must be stressed that in the rain-fed zone 27.1 % of the land is devoted to cultivation and 66.6 % to exploitation by livestock raisers.[67]

Another factor which leeds to envriornmental degradation is the insufficient or totally lacking integration of livestock and agriculture. When limited integration exists, it reduces livestock pressure on the range and limits over-grazing during the "hungry period".

In dammed floodland zones, different phenomena may reduce the number of hectares cultivated or decrease the fertility :

- Destruction of dams, due to very heavy floods; this is often caused by poor structural supports of the dams. Incidents of this problem are numerous.
- Soil evolution. In 1958, F. Dubain compared two dams and showed that an increase in the number of years of cultivation (and thus, of submersion) caused progressive asphixia of the soil[68] decreasing its agronomic value.

Soil evolution seemed to be more marked in the lowest basin zones where pseudo-clay hydromorphic soils are formed; these soils are characterized by a high content of absorbent clay. The succession of flooding and drying

66) UNSO, IRM, 1978.
67) Ibid.
68) C. Toupet, 1977.

creates fairly marked slickenslides. These characteristics confer poor physical properties on the soil, especially with current cultivation techniques. At present this phenomenon appears only in limited areas, but on a long term basis, it could affect larger surface areas.

This type of degradation is fairly slow. It concerns most of the flood-land cultivation zones, but the extent of damage depends on the length of submersion and the alternation of floods and drying.

In summary, it appears that existing cultivation methods in dryland agriculture do not encourage envriornmental conservation and may actually contribute to degradation caused by the Sahelian climate.

6.2. Envriornmental :Conservation

Environmental degradation causes a more of less reversible deterioration of arable land, which is the basis of all agricultural production systems. Production may be reduced or completely stopped, causing serious economic and social consequences. Agricultural exploitation must be organized in such a manner as to contribute to conservation of the milieu, if production is to be improved.

Adaptation of dryland agriculture methods and means to permit increased environmental conservation would require :

- Increased knowledge of the milieu and climate variations in order to limit dryland agriculture to the more favorable zones and thus preserve the marginal zones.
- Improved techniques and production methods : better use of water, improvement of physio-chemical properties of soils, conservation of soil fertility.
- Education of the dryland populations as to the seriousness of the degradation phenomena.

- Elaboration of systems to encourage the practice of more profitable agriculture
- Research concerning ways to integrate the different activities of the rural world.

It is evident that such measures will give satisfactory results only if they are part of a structured and well-defined policy, which includes training, research, popularization and encouragement of production.

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