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FOOD AND AGRICULTURE SECTOR ASSESSMENT

ANALYSIS OF CROPS, LIVESTOCK AND FORESTRY AND ENVIRONMENT

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ASSESSMENT OF CROP PRODUCTION

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This brief assessment of crop production in Mauritania is based primarily on review of the RAMS study, documents produced by USAID, the IBRD, GIRM and other sources, discussions with GIRM, donor, and project personnel and the experience of the autnor in semi-arid environments in West and East Africa. It is not a review of all crop-related studies in Mauritania; neither does it represent the integration of the full range of rural production activities called for by the RAMS Assessment Team.[1/] Syntheses of subsector studies will be presented in the integrated Food and Agriculture Sector Assessment.

The following sections discuss the importance of crop production to the Mauritanian economy; production systems; the resource base; and the constraints to, and potential for, increased production.

Importance of Crop Production

The crop subsector is reported to contribute less than two percent of the GDP, about half of that of the fisheries subsector (four percent) and much less than the livestock subsector (15 percent) (RAMS AS 4, Table II-2). Despite the likelihood that the value of crop production in Mauritania is significantly underestimated, it is clear that crop production plays a much less important role in national and household economies than in most Sahelian states.

In addition, there has been a downward trend in staple food production (four percent annually) and cereal production (five percent annually) over the 1961 to 1979 period, (RAMS, AS 4, p. 37). Over the 1970's, domestic production has been able to meet only 20 percent of national cereal consumption needs. The balance has been made up by commercial and donor imports (RAMS AS 4, p. 47).

However, there are some major doubts about the accuracy of estimates of food crop production. If current estimates are correct, the total amount of cereals available from farms and imports would indicate that much of the Mauritanian population is severely undernourished. This is not borne out by nutrition surveys (RAMS FS 1, p. 17).[2/] Production has probably been underestimated.

National census figures for 1977 place the total labor force at 451,500. About 40 percent (119,000) of the sedentary labor force of 301,000 is occupied with crop production. Fifteen percent (23,000) of the nomadic labor force also farms. A total of 31 percent of Mauritania's total labor force is involved principally in crop production. (Calculated from data in RAMS FS 2, pp. 1-9, 21-34, 78-83.)

Irrigated, dryland, and oasis agriculture account for a total cultivated surface area ranging between 110,000 and 240,000 hectares. These figures represent 0.1 to 0.2 percent of Mauritania's total land

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[1/] W. Rutherford, A. Hoben, E. Simmons, 1981, p. 39.

[2/] The USAID Health Sector Assessment Team indicates that malnutrition has been observed frequently in the 0-3 year age class of children brought to clinics surveyed.

area and 0.2 to 0.4 percent of the country's productive or non-desert land (Calculated from data presented in RAMS SS 1, p. 20; pp. 2, 4, 5; AS 4, pp. 3, 24).

Despite its critical importance to the majority of the country's population, crop production ranks only third among the four subsectors in the agricultural economy of Mauritania. However, crop contribution to GDP is substantially undervalued at official prices, crop production is probably underestimated, and the agricultural labor force is underrepresented in the census figures because of problems of definition. Yet, the relative ranking of the subsector may not change significantly if these problems are resolved because all rural sector activities have suffered from similar statistical bias in aggregate reporting. Unfortunately, as discussed under Economic Issues, location-specific data critical to an understanding of crop production processes are often no more reliable than the aggregate estimates.

Production Systems

The RAMS study divides Mauritania into eight ecological and land use zones (RAMS AS 1, p. 172-195). Five of those are agroecological zones which are used for crop and livestock production. The four zones that are important to crop production are the Senegal River Valley, the rainfed zone, the oued floodland, and the date palm zones or oases. These zones respond to a complex series of climatic, physiographic, and land use criteria. Except for the palm grove areas, their boundaries change with variation in rainfall. Consequently, there is substantial overlap among them and shifting patterns of land use.

Finally, it should be noted that livestock production takes place in all of the agroecological zones. Despite claims in the RAMS agriculture studies that, "there is insufficient or totally lacking integration of livestock and agriculture" (RAMS SS 2, p. 134), there are clear indications in RAMS production and livestock surveys of strong economic, forage, and labor links in nearly all zones. The RAMS rural income study, for example, shows that in the households sampled about 22 percent of income came from livestock activities, whereas crops contributed only five percent (RAMS AS 6, 1980). As an initial assessment of crop production systems, however, this description will omit livestock considerations. Integration of crop and livestock production will be discussed in the constraints section and in a joint team report at a later date.

The following sections give a brief capsule description of the production systems in the major crop zones.

Senegal River Valley

The Senegal River Valley contains irrigation schemes, flood recession lands (walo) and two types of rainfed fields distinguished by soil types - fonde or river levee alluvial clays, and dieri, or upland sandy to clayey sand soils. Irrigated land takes up about 4,300 hectares. The area of land under flood recession cultivation fluctuates between 3,000 and 60,000 ha and rainfed area varies from 30,000 to 40,000 ha

according to the level of flooding of the Senegal River and its tributaries and the amount and distribution of precipitation (RAMS SS 4, p. 45). Sorghum is the dominant crop of the flood recession area and is usually intercropped with cowpeas. Production is characterized by a pattern of planting which follows the seasonal descent of flood waters from their peaks (culture de décrue). Stand establishment, cultural operations, and harvest are staggered over several months. Timing of farm operations is thus only marginally under the control of farmers. To spread production risks, farmers also occupy rainfed upland sites which are used mainly for millet, sorghum, pulses and seed melons. Individual households must probably maintain fields in both walo and dieri lands if they are to meet subsistence needs from their own crop production, except in the most humid and fertile parts of the valley.

While Mauritanian development planners and donors emphasize the need rapidly to expand irrigated cereal production, only a minute proportion of the land area and the farming population is now involved. Rice is the main crop promoted by SONADER (Société Nationale pour le Developpement Rural), but farmers also grow maize, sorghum, pulses and vegetables in the irrigated perimeters. Both large perimeters (400-1,500 ha) and small perimeters (10-40 ha) have been established. The large perimeters are capital intensive and partly mechanized, while the small perimeters are divided into parcels of 0.4 to 0.5 hectares and worked by hand. With current parcel sizes and yields, no household working on the small-scale perimeters can hope to support its subsistence or cash needs solely with irrigated production.

Rainfed Zone

This zone occupies blocks of land in the southwestern portions of the country where annual rainfall averages around 600 mm and where a narrow strip of upland soils exists above the Senegal river valley. The basic crop mix is less diverse than in the valley area. Sorghum and millet are the dominant cereal crops, with millet replacing sorghum in the drier parts of the zone. Cowpeas, okra, and roselle are the other main crops.[1/] As in the valley, surface area cultivated increases or decreases with rainfall, ranging between 50,000 and 110,000 hectares (RAMS SS 2, pp.41-45).

Oued Flood Zone

North of the rainfed zone precipitation decreases to the point where dependence on rainfed cropping is no longer possible. However, local watersheds draining into seasonal streams permit the retention of run-off behind hand-constructed dikes or small dams erected with heavy machinery. Manipulation of water levels behind the structures enables recessional agriculture to be carried out, extending the zone of cultivation to about the 100 mm isohyet. Again, millet and sorghum are the

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[1/] Roselle (Hibiscus sabdariffa) is known locally as bisap. Its leaves are used as a vegetable condiment, while its fleshy flower carpels are used as condiments, tonic, and herbal medicine.

most important cereals, with intercropped pulses, vegetables and condiments being grown on small portions of the fields. About 19,000 hectares of land are cultivated annually using these water-retention techniques (RAMS SS 2, pp. 41-45).[1/]

Palm Grove or Oasis Zone

Except in the "empty quarter" desert there are locations throughout Mauritania where temperature, rainfall distribution, and reliable and shallow groundwater sources or springs combine to permit growing of date palms. Their cultivation, in turn, creates microclimates favorable for limited cereal, vegetable, and forage production. Only about 4,500 hectares of land are devoted to date cultivation but, according to a RAMS survey, over 18 percent of the Mauritanian population has an economic link with the oases (SS 4, pp. 40-41). Except for a very small group of permanent laborers, this population is present in the groves only during the harvest season.

Resource Base

Analyses of Mauritania's climate inevitably point out that rainfall is highly variable and introduces great risk to crop and livestock production systems. However, variability in rainfall is an identifying trait of arid lands. In the rainfall belt between 600 mm and 350 mm, two- to five-fold variation can be expected in rainfall. Within the 350 mm to 100 mm isohyets five to ten-fold variation is often encountered. (Cloudsley-Thompson, 1977, pp. 55-57; RAMS SS-2, p. 16). So, while drying cycles cause drought in arid and dry semi-arid environments, patterns of existence have to be adapted to large fluctuations in weather.

The implication is that land use and associated production technology must reduce exposure to climatic risk in a highly variable rainfall environment, or that ways must be found to avoid the rainfall uncertainty. River or groundwater-based irrigation systems are the two surest ways to reduce the uncertainties of rainfed agriculture. They avoid the problem of low or no rainfall almost completely, but they require enormous capital investments and operating costs. Water retention structures are less costly and reduce risks to acceptable levels in some areas. The risk may be spread by nomadism, which permits herders, if not crop farmers, to move to areas where the rainfall has been better.

Water Resources

Besides rainfall, the two major water resources for crop production are groundwater and the Senegal River. The river is at present exploited by small and large-scale perimeters drawing water from the Senegal river

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[1/] This is the highest published estimate of land area cultivated using water retention techniques. It is reported that the prefect of Maghta Lahja carried out a recent survey showing that 30,000 hectares of land were behind dams and traditional dykes in his department alone (personal communications, Richard Hough, USAID/Nouakchott, 1982). If substantiated, this indicates that existing production statistics are probably of little value for the Oued Floodland Zone.

and from seasonal streams such as the Gorgol. The role of this water resource is seen as increasing substantially over the next few decades as the Senegal River Basin (OMVS) dam construction is undertaken. Groundwater at present is used on an artisanal level by growers of dates in the oases. River and ground water for irrigation is exploited at low levels; the two systems cover about 4,000-5,000 hectares each (RAMS SS 1, SS 4).

Soil Resources

The soils along the Senegal River are alluvial deposits which rapidly intergrade with sandy and stony soils as one moves North from the river basin. General soil descriptions are available in the RAMS reports SS 1, SS 2, SS 4 and AS 1.

Labor Resources

Manpower is likely to be much greater than the census figures indicate. Whether the size of the labor force available for agriculture indicated by the 1977 census data is meaningful depends on the time allocated by individuals to crop production activities.

Employment figures are likely to be quite unreliable owing to the lack of information on the division of time by different household members among economic activities. For example, it seems that the census definitions for employment categories systematically exclude the spouses of male respondents from the labor force and economically active population.

A similar problem exists with the figures on employment and underemployment. Census questionnaires are unlikely to ask for information on the basis of activity categories that permit the construction of an individual's or a household's employment profile, i.e., the allocation of time to crop production, livestock tending, trading, wage labor, domestic chores, etc. The RAMS studies of irrigated, dryland, and oasis agriculture discuss the availability and use of labor based on the production survey and the OMVS socio-economic study, but the complex seasonal and permanent migration patterns of nomadic and sedentary people make interpretations of quantitative estimates of employment, unemployment, and underemployment very problematic.

Constraints to Crop Production

There is a wide mix of constraints to increased crop production in Mauritania. Basically, crop production is constrained by the limited availability of land with sufficient rainfall to make crop production at least a feasible proposition. Questions of technology and farm prices come next (see Enger, 1981). Rank-ordering the remaining constraints becomes difficult. For some, the next constraint would be likely to be the weak public and private institutions. For others, it would be labor (although, given the diversified nature of a household's or an individual's economy, this may be closely associated with farmgate prices). Still others would see the hierarchical nature of Mauritanian society as

restricting production, and perhaps acting as a root cause of the decline of cereals production: the drought disrupted the ability of patrons and masters to support the economic and food needs of their tributaries, and legal reform enabled serfs and slaves to leave (Grayzel, personal communication, 1982).

The following discussion examines the general climatic and weather constraints and the way some of these general constraints can be analyzed in the different agro-ecological zones and production systems of the country.

Climate and Weather Constraints

There has been much debate about whether there is a trend towards a drier climate in the Sahel. As indicated by the recent World Bank report on Sub-Saharan Africa, a drying trend cannot be conclusively supported by available information (World Bank, 1981, p. 13). Preliminary analyses of rainfall data from 1941 to 1982 of the Mauritanian Agrhymet project, while also not conclusive, show cyclic wet and dry trends at most of the 22 locations studied (Ketata, Agrhymet, personal communication, 1982). The most likely interpretation of the varied periodicity and phasing of the cycles is that general climatic deterioration has not occurred.

A crucial interpretation of the Mauritanian rainfall records is that the depth and severity of the 1970's drought period is probably a result of the sharp increase of land use intensity due to the unusually high rainfall during the 1950's and most of the 60's. Rainfed cropland area probably expanded, and it is known that livestock population grew greatly during those two humid decades. The heavier the land use, the more likely it is that rainfall perturbations will disrupt dryland production. Thus, one could hypothesize that the magnitude of the drop in livestock and crop production during the subsequent drought period was due to the resource base overload of the 50's and 60's.

The lagging crop production recovery relative to the rate of livestock herd regeneration suggests that other factors besides rainfall may be involved, including such things as labor force reduction through migration, and lack of in food grain price incentives (owing to food aid programs, and subsidized consumer prices and free distributions) and more attractive returns from investment in livestock.[1/] Sorting out the weightings to attribute to the factors underlying the reported decline in per capita food production would require much better demographic, production, and marketing data than are available and more detailed analysis of the weather and hydrologic data than has taken place to date.

Special attention needs to be paid to an understanding of the role weather variation plays in production of vegetation, both cultivated and wild. In Mauritania crop and natural vegetation growth can be

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[1/] Nevertheless, one suspects that lagging crop production recovery may be as much a statistical as a real phenomenon stemming from underestimation of surface areas and yields and from poor data assembly and analysis.

stratified according to the source of water utilized: vegetation dependent on local precipitation (rainfed crops and pastures); vegetation dependent on accumulation of local rains in drainage courses and depressions (oued floodlands, bottomlands, and major seasonal streams, e.g., the Gorgol); and vegetation dependent on water transported to the area from beyond the country's watershed (walo flood recession and associated systems along the Senegal River).[1/] Each of these systems is characterized by variability, but not necessarily by the same degree and distribution of variation in space and time. Where applicable, the following sections on constraints to crop production examine the importance of weather-related variations in water supply for the different agroecological zones.

Irrigated Agriculture in the Senegal River Basin

In its study of irrigated agriculture in Mauritania the RAMS project made an inventory of the total surface area of constructed irrigation facilities and the utilization of that surface for the 1980/81 crop year. The results of the study are shown in Table 1.

Table 1. Summary of Constructed and Cultivated Surface Area Under Irrigation in Mauritania, 1980-81 Crop Year

Irrigation Sector	Facilities Constructed (Ha)	Cultivated Surface Area (Ha)	Utilization Rate (Percent)
Rosso	3,899	2,667	68
Boghé	1,590	508	32
Kaédi	1,365	900	66
Gouraye	261	237	91
Totals	7,115	4,312	61

Source: RAMS SS-1, 1981, Annex 1-4.

[1/] Modification of classification suggested by Cloudsley-Thompson, 1977, pp. 55-57.

The utilization rates shown in the table do not consider double cropping and thus underestimate the effective cultivation intensity. The Rosso sector cannot be double cropped owing to salt intrusion problems over most of its area. Cultivation intensity coefficients, including double cropping figures obtained from SONADER for the other three sectors shows only a slightly improved picture, as shown in Table 2.

Table 2. Effective Percent Utilization
1980-81 Production Campaign, Irrigated Perimeters

Irrigation Sector	Gross Utilization Rate (Percent)	Cropping Intensity Coefficient	Effective Utilization Rate (Percent)
Rosso	68	1	68
Boghé	32	1.05	34
Kaédi	66	1.25	83
Gouraye	91	1.84	167
Total	61*		67*

*Weighted.

Sources: RAMS SS 1, Annexes 1-4; Rosso, Boghé and Kaédi cultivation intensity (C.I.) from discussions with sector personnel, SONADER; Gouraye sector calculated from SONADER data cited in William Scott, 1982, "Final Evaluation of the SONADER/AFRICARE Small Irrigated Perimeter Development Project", Table 1, page 5.

Most irrigation planners in Mauritania have assumed that full utilization of constructed facilities would occur and that the coefficient of cultivation intensity would be about 1.5 at full development (i.e., half the area would be double-cropped) for a typical effective utilization of 150 percent. The weighted overall actual utilization rate of 67 percent is thus only 45 percent of the target.

There is a large discrepancy between RAMS and SONADER's estimates of constructed facilities. The former gives a total constructed surface area of 7,115 hectares for 1980/81, while SONADER lists 5,185 hectares for the same period.[1/] SONADER figures appear to exclude privately developed perimeters. Without independent verification of figures of constructed and actually farmed area, it would be unwise to assume that the low utilization figures are solely due to RAMS overestimation of facilities construction.

There seems to be a consensus among technicians working with the irrigation programs that the newer perimeters generally have greater cultivation intensities than older ones. The aggregate figures in Table 2 seem to bear this out. Rosso, with the oldest perimeters, has the lowest cropping intensity (though this is enforced by the annual salt intrusion), while the Gouraye sector, with a preponderance of new perimeters, has the highest cropping intensity. Existing information does not permit detailed analysis of this situation. Some learning has apparently taken place so that initial design and construction problems have been reduced, more reliable pumps and motors have been identified, and extension procedures have been refined. New perimeters have benefitted from the trials and errors of past irrigation efforts begun in

[1/] "Bilan de Cinq Années d'Activité de la SONADER." Tableau 1. Nouakchott, 1981.

the 1960's. Also there is probably an environmental factor influencing the relative success of new perimeters, especially in the Gouraye sector, where rainfall is significantly higher than in the other sectors, thus reducing water needs during the rainy season.

One troubling factor mentioned by many sector personnel was the inability of members of peasant groups in some older perimeters to repay their capital and production loans. A complicated set of problems is probably involved (siting, construction, land tenure, shifts in loan terms, substandard motor and pump performance, poor maintenance support, decline in soil fertility, salt buildup, etc.). Unfortunately, no assessment of the financial viability of small scale perimeters based on actual performance over time has so far been made, and there is very little information about on-farm yield trends under recommended production practices. Deterioration and increased down-time of pumps is frequently indicated as the chief culprit for the poor irrigated perimeter performance, but no specific down-time analysis has been made.

Given the lack of farm management data for a sample of perimeters stratified by age, it is difficult to explain the causes behind variations in cultivation intensity and crop performance. This problem can be exemplified by an examination of the SONADER/AFRICARE small-scale perimeter experience (Table 3).

Table 3. Evolution of Gouraye Sector Cultivation Intensity on Small Irrigated Perimeters of the SONADER/AFRICARE Project

	1978	1979	1980	1981	1982
1. Area Constructed (ha)	79.5	79.5	213	290	290
2. Area Cultivated (ha)	47.3	115.3	316	535	432*
3. Cultivation Intensity (2:1)	0.6	1.45	1.48	1.84	1.49

*Actual 1982 rainy season and projected 1982 dry season area.

Source: Cultivation intensity calculated from data given in Scott, 1982. p. 5, Table 1.

The reduction in cropping intensity was attributed to the inability of four of the nine village perimeters concerned to receive additional agricultural credit in 1982 because of prior indebtedness. This, in turn, is attributed to reduced returns due to breakdowns of the pumps which SONADER could not repair in a timely manner.[1/] Discussions with SONADER personnel indicate that this is a generalized problem in all sectors due to motor and pump inadequacies, difficulty of access during

[1/] Scott, 1982, p. 7.

the rainy season, lack of stocks of spare parts, cumbersome procurement procedures, and cash flow problems resulting from slow loan reimbursement and delayed payments for marketings. In addition, investigation by national headquarters has uncovered institution-wide budgetary constraints to effective field operations (underpaid GIRM counterpart contributions to donor-assisted projects and insufficient operating fund allocations) which systematically reduce SONADER's capacity to execute projects.[1/] Thus, institutional problems may be the cause of the micro-level phenomenon of cropping intensity reduction in 1982. However, there is probably enough diversity among individual cases to account for a wide variety of causes.

The perimeter level information gap will--it is expected--be reduced by donor-assisted OMVS programs (such as the USAID/OMVS Integrated Development and Agricultural Research Projects, and the World Bank Technical Assistance Project II). The design, operation and maintenance problems will be addressed by donor assistance to individual sector SONADER projects (Dutch assistance to Rosso, CCCE/FAC assistance to Boghé, FED aid to Kaedi), and pending IDA support for Kaedi and Gouraye. However, in 1981 SONADER plans called for an increase in irrigated area of 9,629 hectares (186%) from 1981 through 1985, or about 2,400 hectares annually.[2/]

Agreements for new donor financing will reduce new construction rates to a more realistic rate and provide for rehabilitation of some poorly designed and constructed old perimeters. But, the GIRM's recent reduction of SONADER's operating budget, according to the agency's director, and related moves to restrict growth of SONADER personnel create the risk that the construction of new facilities will spread the institution's personnel so thin that it will not have the capacity needed to make the perimeters pay their way in terms of food production and economic and financial returns. This will almost certainly become the case as the operation of large-scale perimeters start in the Boghé plain (1,000 hectares at full development) and Gorgol Noir (originally 3,600 hectares, now reduced to 2,500 hectares at full development). Even with an influx of expatriate assistance, Mauritanian staff will tend to be insufficient. This problem, along with the time lags and the low productivity that can be expected in the initial development of large scale perimeters, particularly where resettlement of farmers is required (Gorgol Noir), implies that the GIRM and donors need carefully to balance the rate of new construction with the development of the organizational, operational, and maintenance procedures required to help new and old projects produce to their designed capacity.

Two additional constraints can be added to the web of factors limiting irrigated crop production. One is the phenomenon of declining yields on older perimeters. The USAID/OMVS Integrated Development Project Paper (1982, p. 21) mentions that decline in soil fertility from

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[1/] SONADER, "Rapport Rédigé á l'Intention du Gouvernement", 1981.

[2/] SONADER. 1981, Evolution des superficies amenagées et programme d'actions projetées á court, moyen et long terme, Tableau 1.

initial levels reduces yields over time. Most of the river level soils on which small perimeters are built have moderate organic matter content of 1-2%. Virtually no nitrogen determinations have been made on perimeter soils. But phosphate levels are shown to be generally low to medium and potash levels medium to high.[1/] Current practice removes most crop trash for livestock fodder. In combination with double cropping, nutrient export and fertilization practices are likely to result in reduced organic matter, nitrogen, phosphorus, and potassium levels. While farm-yard manure could theoretically maintain organic matter and potassium levels, in practice it would require confinement rearing of livestock to be economically feasible. The high rate of manure application needed, probably in the range of 6-8 tons per hectare, implies the need for about 8-11 UBT (tropical animal units) for each hectare, or 160-220 UBT for a 20 hectare perimeter. This herd size would require substantially more vegetable biomass than the perimeter could reasonably be expected to produce. Crop rotation and soil management practices (including introduction of the water fern, azolla) to be studied in the OMVS programs would appear to have a better chance of medium-term success than the livestock integration approach.

As the preceeding sections have indicated, successful irrigation practice requires a transformation of current farming systems and, consequently, the practices of farmers. A recent study expressed the view that

> "in most of Sahelian Africa, farmers admitted to formal irrigation schemes are usually without prior experience in irrigation and the peculiar discipline it requires ... Thus, expansion of irrigation is also limited by the speed with which farmers not accustomed to irrigation can absorb new techniques and the required cultivator discipline ... Poor water management, partly due to deficiencies of the infrastructure but also to lack of expertise and management control, give rise to irregularities in water supply which increase farmers' risks and undermine their willingness to cultivate intensively. At the same time, these factors severely limit both farmers' willingness and ability to pay the water charges required for financing maintenance."[2/]

Thus a basic human constraint in terms of knowledge and skill must be addressed by field extension services. Unfortunately, while a great deal of attention has been paid to the physical problems of perimeter management it is not at all clear that extension practice is based on

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[1/] SONADER's soil laboratory LANOSOL, is not expected to acquire nitrogen analysis capability until 1983.

[2/] World Bank, 1981, Accelerated Development in Sub-Saharan Africa: An Agenda for Action. Washington, D.C. pp. 77-78.

the principle that the success or failure of a perimeter depends intrinsically on its ability to meet the risk reduction and crop production objectives of its individual members.

Senegal River Valley Floodlands

Recessional cultivation of the river valley floodlands (walo) depends upon rainfall throughout the Senegal river basin. Crop areas and yields are determined by the height, timing, and duration of the flood peaks in the main river channel and in the large seasonal tributaries (e.g. the Gorgol). The RAMS report (SS-2 pp. 37-40) shows that gross area flooded and surface area cultivated are linked and vary considerably from year to year.

In a year with high peak floods, up to 60,000 hectares of walo land may be cultivated on the Mauritanian bank. At minimum recorded peak, only 3,000 hectares may be cultivated. In an average year, walo area may reach 45,000 hectares or more.

Some measure of control of the height of the flood peak height is expected when the Diama dam near the mouth of the Senegal is completed. Additional control of timing and duration and better peak control are anticipated after the construction of the Manantali dam upstream in Mali. The dams are planned to modulate annual flooding, first reducing year-to-year variations in flooded area and then decreasing flooded area as irrigation infrastructure is developed.[1/] But there are a number of imponderables. There is no certainty with respect to the completion dates of the construction; it is not known to what degree flow management will be possible with only one upstream dam on the Senegal and one on the major tributary, the Gorgol, nor how much downstream channel infrastructure will be required to manipulate flooded area and protect irrigated perimeters. These uncertainties make it difficult to predict the overall impact on the future area under flood recessional farming. This complicates analysis of investment in control structures on discrete floodbasins (cuvettes or channels parallel to the main river channel, marigots and minor seasonal tributaries). One development to watch closely in this regard is the Foum Gleita dam on the Gorgol Noir which will affect about 7,000 hectares of walo land in the Gorgol river valley (RAMS SS-2, p. 40). Management of this hydrologic system is likely to come about much sooner than overall control of the Senegal's flood patterns.

Large annual variations will probably continue to occur for at least the next decade over most of the Senegal river valley floodlands, and these fluctuations will thus continue to be the single most important factor in walo recessional production for the foreseeable future.

The second most limiting constraint to walo production is probably loss due to insect pests and granivorous birds. As most of the walo stands are still young when the rainfed crop harvest is finished, insect

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[1/] The Diama dam is also designed as a salt water barrier.

pest populations tend to concentrate in the river valley during the early part of the dry season. As the sorghum crops mature, grain-eating birds also cause significant damage every year. Estimates of pre-harvest losses range from 10 to 50 percent (Enger, 1981; William Overholt, personal communication.). The Sahel Regional Crop Food Protection Project (RFCP) has established the Mauritanian Crop Protection Service which addresses these problems, along with plant disease (mainly head smut) control. Along with the joint FAO/USAID Integrated Pest Management Project and support slated under Title II section 206 of AID's bilateral PL 480 program, measures are being taken by the service to devise and apply effective and sustainable pest control measures.

Field operations at present are limited by an insufficient number of pest control units, long time lags between identification of pest outbreak problems and reaction (largely a function of too few control units covering too wide an area and insufficient and untimely GIRM budget allocations) and, in the case of grain-eating birds, lack of an economically efficient control method (these comments are based on discussions with regional chefs de secteur, the Director of Agriculture, and RFCP personnel). As GIRM contributions to OCLALAV's desert locust control programs have slipped, this organization no longer supplies assistance to Mauritania.

If the return figures calculated by RAMS (AS 4, SS 2, SS 4) and Enger (1981) are representative, price policy could be limiting grain production in the walo areas. It may be argued that once the floods have occurred the maximum surface area to be planted will be fixed and that the fertility of the soil will limit the yields of the planted crops to modest levels. But it is also true that farmers have a great deal of crop management flexibility after sowing: while thinning may not be practiced except to obtain plants to fill out stands, farmers can choose both when and how often to weed the planted and established crops; in a cropping system dependent on residual moisture, weeding--and its timing can play important roles in determining the yield of a given stand of sorghum. Price increases may be one way of convincing farmers to allocate more of their labor time to crop operations.

Rainfed and Dieri Cultivation

Rainfed cultivation on the dieri (sandy) and heavier intermediate soils of Mauritania is dependent on local rainfall. While year-to-year variations in total rainfall in general set the upper limits of rainfed crop production, rainfall distribution will greatly affect surface area planted and yields in any one year. Estimates of area cultivated vary from 50,000 to 110,000 hectares (RAMS SS 2, p. 45) Yield estimates for cereal crops vary from a low of 240 kg/hectare for millet (RAMS SS 2, p. 63) to a high of about 800 kg/hectare for sorghum under traditional management in the Selibaby area according to Guidimaka project personnel. In response to the variability of rainfall within seasons farmers plant various cereal cultivars with different maturities as well as intercrops with short growing seasons (cowpeas and roselle), and especially drought resistant plants (seed melons), which enable them to obtain some output during all but the driest years. The risk of yield and crop loss due to unfavorable weather variation means that intercropping aimed at optimizing production will be maintained by farmers.

Experience in the Guidimaka IRD project indicates that available rainfall is probably underutilized in many production environments under current crop management practices. In some instances, sorghum crop yields have been increased from 800 to 1,250 kg per hectare by simple water conservation measures, including early thinning and weeding and establishment of ridges perpendicular to the slope of the fields during weeding. While such practices will make best use of available soil and water resources, smaller yield response may make their use uneconomic in the drier areas of the rainfed zones (less than 450 mm), where risks are greater and returns to alternative production investments (e.g. livestock) are higher.

As the first extensive areas of crops to appear in the country, rainfed crops too, are subject to significant pest problems. In dry years, such as the 1982 growing season, estimated production losses of up to 50% have been attributed to grasshoppers. Grasshopper invasions from preferred native grass stands may may have lead to outright field loss in some locations. Stemborers and headworms contribute to crop loss in rainfed areas in most years. Bird damage, while assigned a minor role in the rainfed millet pest complex, was observed by the team to run about 5-10% on the sorghum fields on the intermediate and heavy soils in the Guidimaka region. Pest control measures are beset by the same problems as those discussed in the previous section.

Apparently because of a general belief that rainfed production is a marginal endeavor relative to irrigation and the high cost of maintaining field operations in these areas, there has been little, if any, consistent attention to the research and extension needs of these production systems. Selection of drought- and pest-tolerant cultivars has been undertaken by projects of short duration, but almost no institutional foundation has been laid to ensure continuity of these efforts. While regional programs (CILSS, ICRISAT, SAFGRAD/OAU) are beginning to have some impact on the research side, little can be expected from them in the medium run.

Oued Recession Agriculture

Oued recession agriculture is practiced in most of the agro-ecological zones of the country that support crop or livestock activity. It consists of the retention of water behind small dams or dikes placed in the oueds (seasonal streams fed by small watersheds) in areas receiving a minimum annual rainfall of 100 mm. The area cultivated each year will vary with the volume of runoff collected in the oued.

The principal constraints to development of oued recession agriculture are economic, institutional, social, and health related. As noted by Carr (1982), rates of return to investment are low for dams which are constructed according to engineering standards of donor organizations which emphasize long life and reduced maintenance needs. On the other hand, lower engineering standards affect the useful life of the structures and increase recurring maintenance costs. Génie Rural would require institutional strengthening to be able to carry out design, quality control of construction, and maintenance supervision. Next, questions have been raised, about who would benefit from dam development because

of the hierarchical nature of the social groups involved and the conflicting claims on the improved land and water resources following construction of water retention works. At the same time it is expected that significant attention and resources would have to be devoted to mitigating human parasitic disease problems (schistosomiasis,malaria, guinea worms) to avoid adverse health effects (USAID Mauritania Rural Land Reclamation Project Paper, 1981).

However, many of these same problems have to be addressed in irrigated areas as well. Part of the problem in analyzing costs and returns from investment in recessional dam areas, relative to full control irrigation efforts in the river valley, is that fuller cost accounting (economic, environmental, and social) may have been applied to the former than to the latter.

Traditional and village dikes have been described as structures that "lack spillways, outlet works and moisture compaction, and typically over-top and wash out during the annual flash rains" (Rural Land Reclamation Project Paper, 1981, p. 25). While the implication is that maintenance costs are very high, no economic analysis of these structures appears to have been made.

Oasis Agriculture

Oasis agriculture occupies only 2-4 percent of the arable land of Mauritania, about 4,500 hectares. But the value of production from oases is extremely high, according to RAMS estimates (RAMS AS 4, p. 4), because of the high unit value of dates.

The area of oasis date production is limited by climatic factors and by the need for a reliable source of fresh water. While it has been estimated that there is a potential for the expansion of oasis culture to another 5,000 hectares, this can only occur if cheaper means of pumping water from wells are found than have been estimated by various experts (RAMS SS 4, p. 2). Moreover, land tenure problems associated with the rigid class structure of Mauritanian societies, loss of the laboring classes to the cities, and pastoral grazing competition restrict both the expansion and the intensification of date palm oases.

LIVESTOCK PRODUCTION IN MAURITANIA

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16

LIVESTOCK PRODUCTION IN MAURITANIA

This assessment of animal production is based on the findings of the RAMS project as reported in the "Livestock Subsector Study" (SS 3) and eleven other RAMS documents (see bibliography). It is tempered by research results from other sahelian countries, especially the Dutch primary production project and the ILCA[1/] pastoral program in Mali, and USAID projects in Niger and Upper Volta. Finally, the author has drawn on his own experience in Mauritania (RAMS), Niger and Upper Volta to fill certain gaps in the RAMS reports and as a basis for judging certain discrepant results and opinions which appear in them.

Importance of the Livestock Subsector

In social and economic terms, livestock production is, by far, Mauritania's most important rural sector activity. The sector yields about 22% of the gross domestic product (1979), and 80% of this (17.6% of the total) is derived from livestock production, with the remainder divided between fishing and crop production. The total value of this annual livestock production is about UM 4,548 million, or U.S. $91 million (RAMS AS 4, pp. 4-8).[2/]

Camels, cattle, sheep and goats are the major species which constitute the national herds. Calculations based on total animal numbers (RAMS SS 3) and 1979 market-level producer prices (RAMS AS 4) yield a value for the national herd of UM 47,693 million. This value is almost equally divided between camels (UM 15,141 million), sheep and goats (UM 16,581 million), and cattle (UM 15,971 million). Livestock sales provide 60% of the per capita cash income of UM 9,280 for nomads and 14% of UM 13,494 for sedentary people (RAMS AS 6, pp. 16, 27, and 52).

Animals also contribute significantly to household economies by providing food for subsistence, transportation, farm work, manure, hides, gifts and transfers. Livestock also provide flexibility in habitat utilization, economic security and investment opportunities, so that for individual stock owners and producers, animals are worth more in terms of lifestyle and survival value than market values and cash incomes would indicate. The above values of the national herds are low since they are based only on marketing.

The total labor force in Mauritania is estimated at 451,500. Seventy-eight % (117,400) of the nomadic labor force of 150,500 is occupied with animal production, and 15% (45,200) of the sedentary labor force of 301,000 is so occupied; thus, a total of 36% of the labor force is employed principally or exclusively in livestock production (RAMS FS 2, pp. 21-34).

[1/] International Livestock Centre for Africa.

[2/] 1 UM = U.S. $0.02.

Of Mauritania's total land surface of 103 million hectares, approximately 55 million (53%) is best suited in the long term for extensive livestock production (RAMS SS 3, p. 16 quoted from CILSS--Provisionary report, January, 1980). If the total surface area is reduced by 40% to account for the "empty quarter", then 89% of the productive surface area is best suited for livestock.

In conclusion, when measured in terms of gross domestic product, national wealth, income, subsistence production, occupation and land resource base, livestock production is by far Mauritania's greatest economic resource, and it exceeds the gross domestic product of the mining sector, which is in second place, by 50% (World Tables, p. 137).

The Resource Base

This section is a descriptive summary of the resource base. It has been kept brief so as not to detract from the analytical format of the assessment. More detailed information can be found in various RAMS documents and other sources which contain descriptions of the herders, the environmental resource and the animals (RAMS AS 1, AS 2, AS 3, AS 7-1, AS 7-2, AS 8-1, SS 3, SS 3a).

Livestock are kept by all ethnic groups including Moor, Fulani, Toucouleur and Soninke (RAMS SS 3, pp. 25-26). The Moor and Fulani are the principal pastoralists and own or tend a majority of the ruminant herds. They constitute most of the labor force of 162,600 which is employed principally or exclusively in livestock production.

The total livestock population is 9,416,000 (RAMS SS 3, p.12). This includes two breeds of zebu cattle (Moor and Gobra), one of goats, two of sheep (Moor black and Fulani bicolor) and perhaps two of camels (sahelian and saharan).

The RAMS documents underscored the existing confusion about the total number of cattle in Mauritania. The estimates, none of which are generated by RAMS, ranged from 1.186 million (1980) to 2 million head (1979) (RAMS SS 3, pp. 11-12; also SS 3, p. 110 and AS 1, p. 129). Also, it was unclear whether the national cattle population had been restored to its pre-drought level (of 2 million? RAMS SS 3, p. 113; of 2.5 million? RAMS AS 1, p. 128).

The geographic distribution of cattle was strongly influenced by the rainfall pattern which existed before the drought.[1/] With the drought there was a shift of cattle, sheep and goats away from the more degraded agro-pastoral areas of the southwest into the less affected southeastern rangeland (RAMS AS 1, p. 133). In 1975 the highest concentration of cattle was south of the 450 mm. isohyet in the rainfed cultivation zone (RAMS AS 1, p. 154). Fulani cattle herds occurred north to the 350 mm.

[1/] For an appreciation of the correlation between pre-drought rainfall and cattle distribution, compare maps on rainfall (AS 1, p. 26[illegible], Figure 2-2) and cattle (SS 3, p. 17).

isohyet, while Moor herds predominated in the 150 to 350 mm. rainfall zone (ibid, p. 187); however, this segregation of habitat by herder ethnicity was not verified by RAMS.

Sheep and goats together numbered about 7.5 million in 1980 (RAMS SS 3, p. 12) Only the U.N. Food and Agriculture Organization has attempted to separate the two species; in 1978 it estimated 5 million sheep and 3.2 million goats.[1/] Small stock were more evenly distributed than cattle and ranged over most of the land area of Mauritania that received more than 100 mm. of rainfall (RAMS SS 3, p. 18). Camels totaled an estimated 0.7 million head and had approximately the same range as small stock. They were concentrated in the western region and, to a lesser extent, in other areas north of the 350 mm. isohyet (RAMS SS 3, p. 19).

In terms of animal biomass calculated from the number of animals (SS 3, p. 12) and conversion factors (ibid., p. 16) cited in the "Livestock Subsector Study", there were 1.13 million UBT of sheep and goats, 0.89 million UBT of cattle, and 0.72 million UBT of camels.[2/]

Although the total potential foraging resource is about 55 million hectares, only about 39 million are in use (FAO Production Yearbook, 1979). The remainder may be underutilized owing to the lack of water for human and animal consumption. Water points consist of seasonal ponds, water courses, springs, wells and a few bore holes. The most common types are three to four wells dug in close proximity (RAMS SS 3, p. 21), and the greatest concentrations of these are in the southwest corner and just east of the Assaba escarpment (map, ibid., p. 22). No systematic survey of water points or user rights was made by RAMS.

Systems of Ruminant Production

The RAM surveys concerned cattle, sheep, goats and camels in traditional production systems. They dealt with poultry in a limited fashion, and largely ignored donkeys and horses because of their lesser importance (RAMS SS 3, p. 1).[3/] These priorities were justified and were carried over in this assessment. Poultry are dealt with briefly in a separate annex.

Mauritania's livestock herds are diversified. Most herding families own more than one species of livestock but, for management purposes, the different species may be kept in separate herds. Even in the far eastern

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[1/] Since sheep and goats have been accorded a lower priority than cattle by the GIRM, these figures may be even more uncertain than those for cattle.

[2/] Unité de bétail tropical (tropical animal unit) = 250 kg. liveweight.

[3/] Donkeys are numerous and important in Mauritania but, as providers of work, they support food production rather than contribute directly to it.

region, where the last remnants of Bedouin camel herders live (RAMS AS 8-1, p. 26), sheep and goats outnumber camels by more than 8:1 and cattle outnumber them by 2:1 (ibid., p. 32). There are more or less permanent camps of former nomads who lost most of their livestock during the drought; sheep and goats are the predominant species kept at these locations (John Grayzel, personal communication). The major exception to this mixed herd pattern may be among the Fulani of the agricultural southwest who own or tend herds in which cattle predominate (map, RAMS SS 3, p. 17).

Individual production strategies are influenced by the size, and especially the composition, of each herd. Sheep and goats require high quality forage, and sheep and cattle are principally grazers while goats and camels are browsers. (The difference between sheep and goats is recognized in RAMS SS 3, but the distinction is not made in the study because prior surveys--except the FAO survey mentioned above--combined the two species as "small ruminants".) The specific mix of animals in a herd influences the spectrum of habitats which can be exploited. Diversified herds also give herders greater economic flexibility in marketing and subsistence; for example, milk production may be extended over the year when lactation cycles of different species occur at different times (Aronson, 1982). The point of this discussion is that development activities must address all species of ruminants and numerous production strategies if the objective is to build on traditional production systems as recommended in the "Livestock Subsector Study" (RAMS SS 3, p. 8)[1/].

The majority of Mauritania's livestock is reared in extensive production systems on natural rangelands and, to a lesser extent, on fallow lands. These systems are exploitative; that is, minimal effort is made to improve the primary productivity of foraging areas beyond their natural capacity. In cropping regions, there may be supplementary feeding on a seasonal or ad hoc basis, but usually in quantities which are necessary to prevent excessive production losses during periods of stress. Some extensive production is integrated with crop production systems, especially in the southeast and southwest where cattle are allowed to forage on grain stalks after the harvest (map, ibid., p. 17). Also, economic integration with crop production is achieved when farmers purchase cattle for investment purposes and entrust them to Fulani herders (ibid., pp. 25-26). A much smaller percentage of livestock is reared in semi-intensive production systems where animals are kept on or near a farm plot and are fed a combination of natural forage and crops or crop by-products, some of which may be purchased. This applies to many sheep and goats and, to a lesser extent, to cattle (RAMS AS 7-1, pp. 31-32, 56).

Something must be said at this point about nomadism, sedentarization and transhumance as they apply to systems of production. There are many ways to define these terms and even to subdivide them (ibid., pp. 27-28, quoted from Bremard, 1977), but is is difficult to formulate a consensus definition. The RAMS "Livestock Subsector Study" ducks this issue, perhaps wisely, and only refers to mobility as an essential livestock

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[1/] Some pastoral production systems are of recent origin, and all are subject to evolution. The term "traditional" is used here to describe base line production systems; it has no historic connotations.

management tactic (RAMS SS 3, pp. 4, 24). The study "Social Change, the Future of Pastoralism" (RAMS AS 8-1) supports and extends this interpretation by separating the nomadic lifestyle from the mobility which is required for herd management, thus:

> "...nomadism is... a form of economic and social organization which always involves sedentary groups. And this form of economic and social organization sometimes remains operative even after the dynamic aspect of the nomadic lifestyle--its mobility--is, for one reason or another, blocked." (ibid., p. 25)

> "...during the remainder of the year, especially in the rainy season and at the time of the great North-South trek, they move almost every day. These movements have one sole motive: the search for pasture." (ibid., p. 28)

The Mauritanian census, out of necessity, has been more explicit about its definition of nomadism. In 1965 a nomad was any Moor not residing in an urban center; other ethnic groups were excluded by the definition. In 1977 the meaning became more restrictive and included only persons who spent more than six months each year in localities devoid of permanent physical structures (RAMS AS 3, p. 22), but, the ethnic restriction was dropped. Given the change in definition, the conclusion of the census that the nomadic population decreased from 65% of the total in 1965 to 36% in 1977 (ibid, p. 21) must be viewed with circumspection. In any case, a reduction in nomadism does not imply an equal reduction in herd mobility. It is now generally agreed that sahelian systems must remain mobile for production purposes (transhumance?) in order to cope with large and rapid changes in the vegetation which are caused by erratic seasonal rainfall. It should be clear that development efforts must deal with great herd mobility in spite of the perceived trend toward sedentarization.

Another difficulty related to mobility is how to interact with those herders who undertake seasonal migrations with their herds into Mali and Senegal (RAMS SS 3, p. 29). Many herds remain out of the country longer than they do in Mauritania, especially in years of very low rainfall. Some herds remained out of the country for the duration of the pan-sahelian drought, and part of the rapid rise in animal numbers after the drought may have merely reflected the repatriation of herders and their animals (RAMS AS 1, pp. 127-130).

Development Issues

This section is an analysis of the major problems and limitations in resources which seem to impede development in the livestock sector.[1/]

[1/] In making this analysis, due regard was given to Peter D. Little's report "The Workshop on Development and African Pastoral Livestock Production", Institute for Development Anthropology, 1982. The workshop concluded that production systems could be defined by examining eight key variables (seven in the policy and social sciences and one in the physical sciences) and that constraints could be classified as political, institutional, informational (research) or technical. Thus, constraints were defined as general impediments to development rather than as specific problems.

21

Some of these are real problems with real (and sometimes realistic) solutions, and hence may be thought of as constraints to development, while others may be more perceived--by donors of aid, by herders themselves or by government officials--than real. The analysis attempts to break away from the disaster paradigm which characterized aid programs during and after the drought, and which was the raison d'être for the Sahel Development Program. This doomsday view was commonly held by RAMS researchers, and analyses in some RAMS documents were colored by it; nevertheless, much useful information was consolidated by RAMS and can still be evaluated in a less alarmist context.

Some RAMS reports reflect a bias to radical social analysis while others are reactionary; thus, the causes of underdevelopment are seen, by some researchers, to be capitalism and colonialism and, by others, to be the ignorance and irrationality of the herders. The following analysis is made within a more pragmatic framework which includes only those sociopolitical variables which have a direct and immediate influence on economic development.

ENVIRONMENT AND HABITAT

No matter how the ecological zones of Mauritania are defined in terms of mean annual rainfall, all are sufficiently arid to require highly flexible herd management in order to cope with extraordinary resource variability over time and space (RAMS SS 3, p. 16). Spatially constrained production zones, whether ranching schemes or grazing blocks, may appear attractive in certain locations for average rainfall years, but they would arbitrarily limit management flexibility and would probably be counterproductive. The same is true for politically constrained management alternatives which would fall into the category of range management, although there may be some scope for assisting localized pastoral clans which already have firm control of a section of grazing land. However, a centrally defined land use plan would limit flexibility and would be unenforceable, and it may increase political tensions between producer groups. Recent environmental degradation in Mauritania has occurred in regional or localized areas of human settlement, or where services and infrastructural development have been introduced.[1/] The seriousness of the degradation depends on its extent, which is unknown, but according to the Dutch research team in Mali, degraded areas generally are not in imminent danger of desertification. Much of the deterioration has occurred in agricultural areas under the combined influences of herding, farming, population pressure and below average rainfall, yet the resource use patterns in agropastoral areas will be difficult to change since the human populations of these areas are stable and do not have the dynamism necessary to accomodate new modes of production.[2/]

Socioeconomic Framework

Social factors require the most demanding attention in judging what can and should be done to improve production in pastoral systems. There are two important points which must be thoroughly understood before any progress can be made:

1. Rangeland is habitat for both animals and people; therefore, any attempt to alter habitat utilization must be carried out with the cooperation of a majority of the herders.

The formation of herders' associations at sites of development activities would represent a significant step to elicit this cooperation.

2. Pastoral production systems have specific economic goals which enable herders to meet their subsistence requirements.[3/]

[1/] For a discussion of the possible environmental and production benefits derived from pastoral herding, see Aronson, 1982, pp. 9-16.

[2/] For a discussion of what subsistence means when applied to pastoral herding, see Aronson, 1982.

[3/] The problem reduces to a question of risk: if you've got it and it works, better not change; if you're trying to find it, anything's possible.

If these are understood, then the "rationality" of production from the herders' viewpoint can be accepted (Little, 1982; Aronson, 1982) and technical interventions can be introduced which assist the herders in meeting their own production goals. Unfortunately, the rationality of pastoral production may not be recognized in Mauritania, thus:

> "The introduction of a controlled grazing system should be the first priority for placing the exploitation of the Sahel pastoral resources on a more rational basis". (Resource inventory of Southwestern Mauritania, Remote Sensing Institute, South Dakota State University, preliminary copy, no pagination).

This is antithetical to the RAMS recommendation to build on traditional pastoral systems. All of this is not to say that interventions should not be environmentally sound; they should be, but socioeconomic and environmental goals must be sought together in an ecological context which includes the people, their animals and the habitat.

There are other important social factors which need to be defined on a site-specific basis in order to proceed with pastoral development. These include marketing strategy and monetization, human food procurement through production and purchase, income distribution and animal ownership. These factors are recognized in the RAMS documents but require further field research to adequately inform development efforts. Of particular importance is the degree to which Mauritania's herds are commercial (reputed to be high but, in fact, unknown); commercial, rather than subsistence, marketing is more likely to lead to large herds which are difficult to balance with forage production.

Livestock Marketing

The degree to which market structure and demand affect animal production in Mauritania is unclear. The RAMS study (SS 3, p. 50) asserts only that there are negative price incentives to the marketing of livestock within Mauritania. Small (1980, p. 45) contends that the terms of trade for herders are extremely disadvantageous vis-à-vis imported goods which cannot be supplied in adequate quantity.

The old marketing system, which had several tiers of purchasing agents who channeled animals into Senegalese and Malian markets, may have broken down. However, it seems to have been replaced by a system in which herders now trek most of their own animals into Mali or Senegal (RAMS SS 3, p. 57). There are several reasons for the shift; these include the relative purchasing power of CFA and Malian francs, the expansion of southern urban markets and a reduction of surplus grain production in southern Mauritania following sedenterization of the Haratin (ibid., p. 51; Small, 1980, p. 45). However, there is still a marketing network in Mauritania which operates more or less clandestinely because of a government decree which prohibits the export of animals for sale. It seems clear that if herding is to remain economically viable within Mauritania, an export tax cannot be levied as it would now affect the herders directly and, in any case, it would be difficult to distinguish between market and transhumant herds. A tax, if collectable, could very well result in increased settlement of Mauritanian herders in Mali or Senegal.

Water Point Distribution

Uneven and inadequate water point distribution in Mauritania may be an obstacle to complete utilization of the potential forage resource (RAMS SS 3, p. 3)[1/]. A few existing water points, such as bore holes or multiple dug wells, may have too high an output, so that inordinately large herd concentrations have become a problem. However, water development should proceed only with a knowledge of existing local herd management techniques and habitat conditions in order to ensure against negative changes in production systems. For example, wells dug in a localized browse habitat which gives easy access to ground water may lead to overforaging and destruction of the browse species with a consequent decline in the productivity of goats or camels.

In Mauritania, there is a tendency to "improve" wells by adding to them cement water troughs. But this innovation is counterproductive; settling of the earth below causes the troughs to break off and become useless appendages which limit access to the wells' edges and, perhaps worse, cement troughs cannot be adequately dried or cleaned and become foci for the dissemination of pathogens (Sollod, 1981).

Animal Nutrition

Although arid African grasslands are exceptionally high in nutritive value (PPS Project, Mali; contrary to RAMS SS 3, p. 20), the protein deficiency of the diet leads to adverse changes in the ruminal microflora, so that the "standing hay" which is eaten is inadequately digested and provides less energy to the animals than would normally be expected. There are two important consequences: first, milk production (recognized in RAMS SS 3, p. 4 as an important food product) is very low toward the end of the dry season; it may stop entirely. Second, grazing animals cannot consume enough energy to support both milk production and reproduction and, therefore, cows breed only every other year and sheep which breed twice are subject to stress-related diseases (Sollod, 1981, pp. 19-21, 28, 29). These two consequences underscore the necessity of keeping herds in which there is a mixture of animal species. Also, with limited milk production during the dry season, herders must have adequate access to grain markets in order to supplement their own diets (Loutan, 1982; Aronson, 1982; RAMS FS 1-1).

Animal Reproduction

In addition to the nutritional limitation on cattle reproduction, there are several other points which deserve attention. It has often been stated that pastoralists select their breeding stock on the basis of characteristics, such as hair color, which do not reflect production goals. However, this is unlikely to be a principal motivation and other criteria such as milk production, growth, reproduction performance and hardiness are probably more important, as they are known to be in Tuareg

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[1/] It is unclear whether undeveloped pasturage is really unused. It may be used during short periods of heavy rain in which case developed pasturage may be concomitantly reserved for late season foraging.

and Fulani systems in Niger (Sollod, A.E., Veterinary mission, July-September, 1981, USAID/Niamey; Maliki, 1981, pp. 77-78). There may be a dynamic balance between hardiness and production whereby the most productive animals, which are the most metabolically demanding, are the first to suffer in times of stress. The result may be a productivity "ceiling" which cannot be exceeded under natural rangeland conditions.

A long-neglected issue is the time of gestation at which herders can confirm pregnancy, especially in cattle and camels. In Niger, it is known that WoDaaBe Fulani cannot confirm pregnancy in cows until 5-7 months (Maliki, 1981, p. 37). If herders or extension agents were taught to confirm pregnancy at 60 days, the new information might allow them to develop more efficient management and marketing strategies. That herders are already interested in reproductive management is shown by the Moors' practice of controlled breeding of sheep to prevent a second lamb crop during the dry season when rangeland nutrition is poor (Sollod and Vu Thi, personal observations).[1/]

Health and Disease

Animal and human health are grouped together for analysis, partly because some of the conditions which affect man also affect his animals (for example, vitamin A deficiency[2/] and brucellosis), partly because the same logistical difficulties arise in trying to address health problems among mobile herds and herders, and especially because it is recognized that the health of people and animals both contribute to the productivity of pastoral systems (Sollod, 1981; Loutan, 1982; Aronson, 1982, Chap. I[T], VII; RAMS SS 3, p. 44).

The human health study of RAMS reviews the existing literature and data from Mauritania but does not add to the limited data base, which only covers the 20-25% of the population with access to health units (RAMS FS 1-2). Epidemiological information, notably that for mobile populations, is lacking, and this limits the development of an appropriate health strategy. In any case, the health delivery system must be structured to accomodate the mobility of the people (ibid., p. 82).

The animal health situation in Mauritania is reviewed in the "Livestock Subsector Study" (RAMS SS 3, Chap. IV). Animal diseases are important constraints to production, but they are not extraordinarily

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[1/] To control breeding, the penile sheath of rams is ligated and attached with a cord to the scrotum. This causes the penis to deviate posteriorly and prevents intromission.

[2/] Vitamin A deficiency occurs seasonally in Mauritania and is manifested by night blindness in cattle, lactating women and children. Fulani suffer most as they are dependent on the seasonal supply of vitamin A in cow's milk. Moors use camel and goat's milk (and cow's milk) to supply them with vitamin A on a year-round basis; nevertheless, impoverished Moors with inadequate herds also suffer from deficiency. Fulani understand the cause of night blindness and have a word for it (Fulfulde: firango), but the syndrome has not yet entered the Hassaniya dialect of Mauritania (Sollod and Vu Thi, personal observations).

menacing in terms of mortality. More detailed work in central Niger (Sollod, 1981) has confirmed these observations. Several problems prevent improved animal health delivery in Mauritania. The first is a lack of trained personnel, both centrally and in the field. Second, there is insufficient epidemiological, etiological and economic information to develop effective animal health programs. Finally, the herders are insufficiently involved in, or cognizant of, the animal health delivery system (RAMS SS 3, pp. 4-7, 34-49, 69-72). Those problems which concern the acquisition of information (research) fall within the terms of reference of the National Center for Livestock and Veterinary Research (CNERV). This institution is gaining expertise in laboratory procedures[1/] but sorely needs assistance in developing a field capability ("shoe leather epidemiology") and expertise in animal health economics. The cost effectiveness of animal health delivery could be improved by the development of a participatory extension service (veterinary sécouriste system) in which active herders provide service for their peers in linkage with the government livestock extension service (Sandford, 1980; Sollod, 1981). Veterinary activities receive a high priority within the Livestock Service but the operating budget is low (0.5% of the national budget), as is the budget for human health services (3% of the total) (RAMS SS 3, p. 6; FS 1-2, p. 89; Dr. El Moktar, personal communication).

[1/] In microbiology, parasitology, serology, feed analysis and virology.

27

ANNEX A

Poultry Production

Poultry production in Mauritania is principally a farmyard or backyard enterprise which is undertaken on a small scale by many village and some urban dwellers. Although eggs may sometimes be eaten, most poultry rearing is geared to meat production for cash sales, gifts and occasional home consumption. The RAMS nutrition survey (FS 1-1, pp. 95-97) identified only a few households which consumed either eggs or fowl.

In 1980 there were about 3 million chickens and guinea fowl in Mauritania, and the national flock was reported to be increasing at a rate of 2 to 3% per year (RAMS SS 3, pp. 102-104). At an approximate weight of 1 kg. per bird, this was 0.44% of the total UBTs of Mauritanian livestock. Clearly, poultry was not of major importance to the national economy, although it may well make a useful contribution to some sedentary household economies.

It is questionable whether the number of poultry is increasing. Poultry require high quality feed, some of which may come from natural foraging or the feeding of farm by products, but some grain or purchased feed may be given as well. If the per capita grain production in Mauritania is declining, the only source of feed available to support a growing national flock would be internationally donated grain. Some of this grain is already being fed to ruminants, but more efficient use could be made by feeding it to poultry.

The fourth development plan (1981-1985) proposes the creation of five regional hatcheries which would produce 4 million chicks per year; it would, in effect, double the national flock overnight. It remains to be seen how these chicks be equitably distributed, or from where the feed would come.

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AS 2 Environmental Regeneration of Southern Third of Mauritania
AS 3 Demographic Projections
AS 4 Agricultural Production - Selected Aspects
AS 6 Rural Income in Mauritania
AS 7-1 Sociological Profiles--Black African Mauritania
AS 7-2 Sociological Profiles--The Moors
AS 8-1 Social Change--The Future of Pastoralism
FS 1-1 The Food and Nutritional Situation in Mauritania
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MAURITANIA AGRICULTURAL SECTOR ASSESSMENT: Natural Resources and the Environment; Assessment and a Suggested Framework for AID Cooperation

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Edited by
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30

INTRODUCTION

There are problems with the use of the terms forestry, forests and reforestation in Mauritania. With exception of natural, dense stands of Acacia nilotica (Gonakier) along the immediate vicinity of the Senegal river, these terms are unrealistic in the context of the Mauritanian environment and can thus lead to misconceptions and erroneous conclusions. "Natural vegetation" is a more appropriate term which will be used throughout this presentation.

Some tree species (notably Prospis juliflora) have been successfully introduced into the Mauritania landscape at a few, specific sites. On the whole, however, natural trees, shrubs and bushes are the major vegetation elements supplementing grasses, grasslike plants and forbs. Strengthening or establishing (and reestablishing) symbiotic relationships within the plant communities, then, becomes mainly a question of managing the existing natural vegetation resources which are either available or can be reintroduced.

II. ECOLOGICAL ZONES

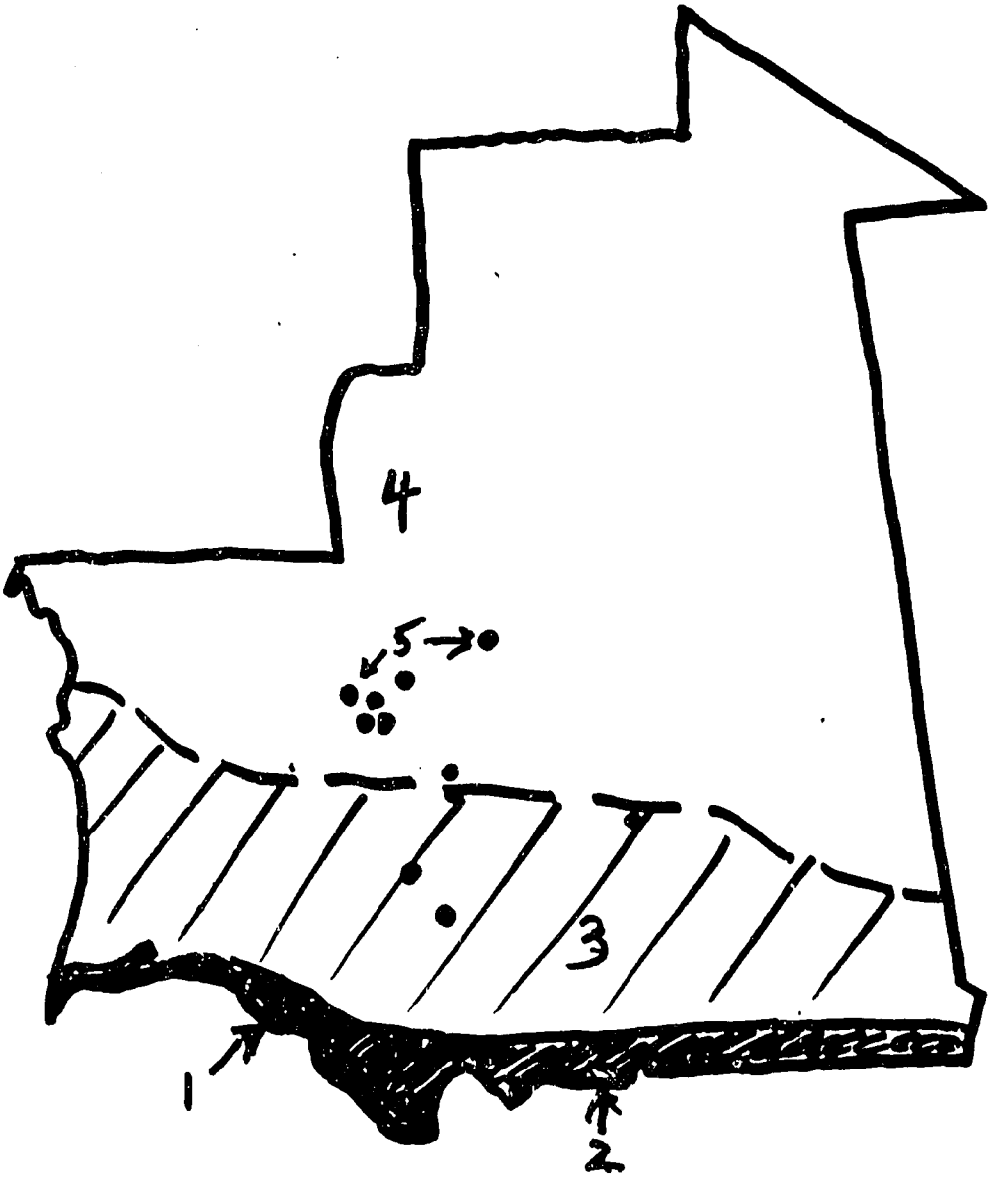
Influenced by a relatively arid climate, Mauritania's natural renewable resource base can be divided into five basic zones (see map, Figure 1):

(1) Senegal River Zone--A small, but very important strip along the Senegal River. Intensive, traditional cereal production is tied to available water, supplied by the river. In addition to irrigated agriculture this area has traditionally served as a key link in livestock management by providing pasture and water during the dry seasons. Pasture and water available here become even more important during dry years and periods of prolonged drought.

(2) Rainfed Zone--Essentially millet land where the potential for rain supplied cereal production has been utilized traditionally for hundreds of years. Yields are mainly a function of rainfall and its adequate distribution during the growing season.

(3) Pastoral Zone--Range land. Provided rains are adequate, this area provides enough range resources to provide a subsistence base for most of the country's livestock. Grass and, to a lesser extent, browse, occur unevenly. Range conditions fluctuate and are dependent on rather erratic rainfall patterns. If rains are adequate, immense plains are covered with a dense, green grass cover for a few months. When rains fail, hardly a blade of grass can be found anywhere.

(4) Desert Zone--Natural vegetation or range can occur. However, extreme aridity limits growth to exceptional years. Moreover, most grasses are short lived so that livestock forage, even if it does occur, is limited to a few months, sometimes only weeks. Livestock exploitation of these areas is extremely difficlut and risky. It is easy to get caught without forage, except for tree and bush-browse which is in short supply to begin with.



NATURAL RESOURCE ZONES

Fig 1

(5) Oases (dots)--Oases. Favorably high groundwater levels at a few, distinct sites have led to oasis development; the main production is dates. The importance of these oases is magnified by the near-sterile surroundings and the great distances between them.

III. IMPORTANCE OF NATURAL VEGETATION TO THE ECONOMY

Natural vegetation plays a crucial role in Mauritania. Mauritania's historic, cultural, social and political structure has evolved around livestock which depend on the nation's rangelands for their existence. Despite recent trends to urbanization about 18 percent of GDP is due in some measure to exploitation of available browse and forage.

Natural vegetation also plays a role in dryland farming areas. The Sahel-wide practice of extended fallow farming relies on natural vegetation to rejuvenate and rebuild soils after they are exhausted. The combination of declines in yield, due to reduced fertility and to pests, diseases and plant parasites which further reduce the soil's productive capacity, leads to abandonment after five to fifteen years of continuous cropping. Natural vegetation is allowed to grow to reestablish a fallow cover under which the process of rejuvenation can begin. Development of the vegetation cover generally follows a natural succession:

- -- weeds, grass and cropping from intact stumps;
- -- uniform bush cover, mainly Gueria senegalensis and Combretum species; followed by,
- -- other shrubs and, occasionally trees.

After five to fifteen years of recovery the field can be cleared again and used for another cycle of dryland farming, traditionally carried out using practices which are best characterized as minimum tillage. The dynamics involved in soil recovery are based primarily on two factors:

- -- reintroduction of organic material into the soil (leaves, litter, etc.) and,
- -- soil surface temperatures reduction due to the shade produced by ground cover which, in turn, greatly stimulates biologic soil forming activities.

Although soil nutrient levels are generally low, the basic loss of soil fertility is less a matter of nutrient levels than a result of lower water retention capability of soils when the amount of organic matter is reduced through cultivation to near zero levels. This loss is particularly important in sandy soils (dieri type) in which it is primarily the organic matter that retains enough water between rains to allow the plants to grow. Thus, of all the resource deterioration problems in the dryland farming areas of the Sahel (water or wind erosion problems, disappearing vegetation, etc.) the key element is the drought-caused

loss of organic matter in traditional farm soils. This reduces productivity and fallow periods as human and livstock population pressure on fallow fields increases in agricultural areas. The lower the organic matter content, the less water is retained. Fields have to be abandoned more frequently and people are forced to open up and clear more land. Agricultural expansion accelerates in order to retain past production levels, let alone increase production. In turn, this puts more pressure on the remaining open brush type land. The high rainfall years of the 50's and 60's permitted this type of high land use intensity, which had another tragic effect. In the past people had been able to rely on natural vegetation to tide them over to sufficient rain. Provided enought surface of bush savannah and tree steppe was still available, people could survive by gathering bush foods and fruit seeds from indigenous grasses, etc. and, to some extent, even from hunting. However, as the natural bush disappeared in some areas to make room for farm fields, the fall-back reserve during drought years was no longer available.

One immediate and practical conclusion of this type of analysis is that conservation efforts (tree planting, either large scale or woodlots, controlled grazing, etc.) have only limited effect because they do not directly address the problem of the decreasing fertility of traditional farmland. Nor do other efforts, such as more efficient farming techniques, improved varieties, even fertilizers resolve the key problem: how to increase organic material in the soil so that rainwater can be retained long enough to be of use to the crops that are planted.

Wood and bush products are needed to fulfill a multitude of needs. The most obvious one is fuelwood, which provides 90% of the energy needs of rural households in the Sahel. In addition, many, to the outsider less obvious, resources come from trees and shrubs. Wood, poles, and thatch are produced for construction. Ropes are made from fibre found in indigenous plants. Wood is also used in tool making, especially handles for hoes, axes, etc. Many bush foods and fruits provide an important (and often the only) supplement to an other wise highly starchy diet. These products are items of commerce as well. Vendors sell fruit from Zizyphus, Balanites and Baobab trees in town.

Finally, natural vegetation protects the environment immediately surrounding the areas where people live. Wherever, over the years, people concentrate and begin to settle permanently, pressure on the nearby vegetation soon becomes so great that desertification takes place. In Mauritania, a comparison of recent with earlier aerial photographs (Ref. A) shows that this process begins with the areas closest to where people live and spreads outward.

The economic dynamics of pastoralist societies in the Sahel and the quantification of their "production" are most elusive subjects. One simple answer, which is quite meaningless in western terms, and yet the most realistic, is that the contribution of natural vegetation depends on last year's rainfall. Depending on the rains, people are forced (and used) to switch back and forth between survival, subsistence and a mainly localized market economy, depending on the season's and last year's rain. In good times, commodities are traded (perhaps even exported), market and cash values are established and can be measured and entered into statistics. In less favorable years, however, the available natural goods are bartered, borrowed or loaned. Little if any money is

exchanged and most of the deals are made away from market centers and the public eye. During extreme drought, the economy becomes even more basic. Survival is the foremost priority: even traditional use and access rights are voided--sometimes through mutual agreement, sometimes only after serious struggle. Under such conditions and in those areas the GDP becomes a rather abstract entity. It is, however, precisely during these moments that survival ingenuity determines who will emerge "better off" when rains again become more favorable. This leads to several important considerations.

Average rainfall, average yields and average production mean very little to the majority of the people who are out there trying to make it from one drought to the next. Even if the exact figures were available, basing judgements solely on their analysis might obscure understanding of the basic constraints and cloud the definition of what meaningful activities could be undertaken to assist in "development". Using average rainfall values from a humid time series to evaluate whether a drought is occurring is a classic example of problems with rainfall data analysis.

How does economic analysis account for such "outputs" as the meals graciously offered in hospitality and friendship in the average herder camp. They consist of little if any rice, millet, or imported or donated food. Milk, cheese and sometimes gruel made from naturally occurring grass seeds, and perhaps some meat, seem to constitute the basic "diet". None of it has been bought or is being sold. The people living in rural areas who produce and consume 90 percent or more of their production have their own sense of its worth. What basic unit price should be used in calculating GDP values for one liter of goat milk "produced" in a herder camp? Animal hides are used to fabricate camelbags. Should their value be included in the GDP and, if so, at what unit price? Or, a herder fashions a pulley from a chunk of Balanites aegyptiaca to replace an old one so he can continue to pull water from a well with his donkey. How much is this pulley worth? What is its market price? But, what if the old pulley has completely fallen apart and the nearest market is 100 km. away?[1/] Plans and projects which fail to consider local production goals and valuation systems will fail to develop practical resource management approaches.

IV. MEASURABLE OR IDENTIFIABLE PRODUCTION FROM NATURAL VEGETATION[2/]

A. Gum Arabic

At one time Mauritania was the second largest gum producer in the world. Mauritania's gum production is now at very low levels. Only about 300 tons are reported to have been exported last year, although the government currently offers 80 UM per kg at its buying stations throughout the country.

[1/] During their visit to Guidimaka, members of the team observed that an expertly fashioned wooden pulley of local manufacture on an ox-drawn well outlasted a shoddy, imported metal one by several times and cost far less.

[2/] The following quantifications have not been compared with GIRM GDP calculations.

In 1974-75 it became apparent that a mass dying of gum trees occurred throughout the traditional gum producing areas of the country (see map, RAMS AS 2 Figure 13). Local foresters and some of their expatriate colleagues feel certain that the main cause of this phenomenon has been excessive cutting to stimulate gum formation. The dying off, however is so consistent and widespread (including Mali and Niger) that other causes should not be ruled out. During a National Academy of Science sponsored trip through Mauritania several specimens were analyzed in the field by a group of international experts and no signs of disease were discovered. Local people generally believed that the tree deaths were simply a natural consequence of the drought. In fact, naturally occurring as well as planted stands of A. senegal further south (Rosso, M'Biddi, Senegal, Niamey, Niger, etc.) were not affected.

One disturbing aspect is that, so far, no natural regeneration has occurred in these Sahelian stands. However, there are reports that further south (Selibaby) recent natural reproduction has been observed in fenced areas.

A five-year FED project, presently getting underway in Mauritania's traditional production area, is expected to provide answers to some of these questions and point to some practical way of re-introducing gum arabic. Until these stands can be reestablished, gum production will continue to remain insignificant.

B. Range

A rough estimate of the importance of rangeland can be made, using the assumptions presented in the following table.

Cash Value	Available rangeland:	total 50,000,000 ha
	Carrying capacity:	1 UBT requires 30 ha
	Offtake:	10%
	Market value of 1 UBT at traditional livestock market:	5,000 UM
	Annual Cash Value:	833,000,000 UM

This calculation does not include annual value of largely home-consumed milk production.

C. Fuelwood

Even in remote herder camps, charcoal is the main fuel used. An average consumption need of 2 kg/day/person is a reasonable assumption. Natural vegetation at present provides these supplies for approximately 80% of Mauritania's population. Most of it comes either from the "bush" or from along the Senegal River, but it is not known how much comes from which source. Assuming a fifty-fifty split and half of the river region's portion coming from the Mauritanian side, 75% of Mauritania's fuelwood

would come from natural vegetation inside the country. Only a wild guess can be made about the "stumpage" value of this wood since by far the major portion of the retail price goes into retailing, transport "fees" along the road, production (in the case of charcoal), local haul and cutting. Even at a basic standing volume price of only 20 UM/per ton, the value of production nevertheless amounts to about 16.5 million UM per year.[1/]

The cost of energy for cooking fuel is an important economic issue in Mauritania. A recent CILSS report ("Bilan/Programme" for Mauritania of the CLUB/CILSS, in preparation) summarizes the latest consumption and production figures. In addition, projections are made for the next twenty years indicating that, if existing natural vegetation can be managed more "rationally", most of Mauritania's rural energy supplies can continue to be supplied by the country's own resources. However, by the year 2000 all fuel energy needs for the urban centers will have to be covered by imports, either in the usual form of charcoal (from Senegal) or by expanded use of bottle gas or other imported products.[2/]

D. Other Products

If it is difficult to quantify the output and value of the most common and important natural products such as gum, grass and browse and fuelwood, it becomes impossible to do so for the plethora of survival and subsistence products (some of which are occasionally traded) that make it possible for people to live in the sylvo-pastoral areas. These include primary, secondary and tertiary products, in accordance with the conventional sahelian classification, such as wood for construction, tools and furniture; fruit, berries, leaves, roots, sprouts, etc. for human consumption; pods and bark for tanning; kapok, leaves and branches for thatch and mats, and twigs, bark and roots that are made into rope and cord. Natural vegetation also contributes most of the traditional medicines, poisons, dyes, detergents and salts. To this should be added the non-edible and non-marketed products of livestock which are given much added value by home processing, such as wool and hides. (A complete list of such products can be found in three articles in the IUFRO Newsletter No. 6).

V. PRODUCTION SYSTEMS

The following describes briefly the production systems, how they work and their present user status.

[1/] 1.5 million people x 2 kg x 365 days x 20 UM per ton x 0.75 (assumed proportion produced in country from natural vegetation).

[2/] Any practical (and reasonably cheap) application of solar technology--for Mauritania at least--still seems to be years away. Major problems are: high initial costs of equipment, lower output of photovoltaic cells above 70 degree F, dust accumulating on collectors, diffusion of sunlight due to dust, immobility of equipment, etc.

37

A. Wood

Senegal River area. Wood cutters and charcoal makers practice traditional and systematic exploitation of trees and forests which still exist along the river. Althought they operate mostly in clear violation of existing laws which prohibit the cutting of protected tree species, important quantities of charcoal are being produced and shipped daily. Some of the cutting is done "legally" with permits, but the great majority is going on extra-legally and without much interference by government agencies (primary responsibility lies with the Nature Protection Service), which are understaffed, ill equipped and have only a minimal operating budget.

This is not the whole problem, however. If, by some magic, clandestine cutting and charcoal making could be stopped tomorrow, charcoal and wood prices in all of Mauritania would immediately skyrocket. Moreover there would be increasing pressure on the Senegal side of the river where extra-legal exploitation would instantly double. If that, too, could be controlled, there would be an immediate fuel shortage in Mauritania as well as in the northern sections of Senegal. At the same time, a valuable resource is disappearing at a rate at which little will be left in another 20 or 30 years. This is unfortunate for two reasons. First, since wood grows on wood, overcutting will deplete the resource base. It would be only better to cut what grows each year so as to leave a base-capital of trees and forests to produce more wood each year. Once the naturally occurring trees are gone, it will be a very costly, difficult and lengthy process to reestablish the necessary reserves.

Second, these trees still play a most important protection and conservation role. Their disappearance will cause soil and crop losses which will be felt in terms of further declines in farm yields.

Remainder of the country. Natural vegetation provides a considerable amount of fuelwood in the areas away from the river. Production rates are higher in the south and drop to near zero in the northern half of the country.

Mauritanian foresters are aware that, even where firewood is still freely available, people prefer to use charcoal (tea cannot be brewed on a wood fire in the customarily graceful and clean manner). Therefore, a certain amount of charcoal seems to be produced up-country, even though it is less appreciated than the dense, "good" charcoal from the river. Also, the extensive dieback of gum trees has shifted more charcoal production to the interior.

B. Food/forage

Mass population movements induced by the recent drought seem to have disrupted a traditional use-right pattern to such an extent that in most areas food and forage are now harvested on a common good basis. Ownership of individual trees or pastures, which are part of the natural vegetation, is not recognized, and there are few remaining systems that limit harvest and use to any particular individual or group.

The major tree species are protected by law. Their cutting or even pruning is forbidden. Due to the size of the areas involved, however, enforcement of such laws is virtually impossible. Herders set fire to grassland in order to stimulate a certain amount of regrowth which results from burning dry stems. When the grass pasture is lacking, animals browse heavily on trees and shrubs to the extent that little foliage is left within their reach. (Even in the forest reserves along the river, there is virtually no green matter visible below the browse reach). To provide additional forage, herders revert to the age-old technique of cutting live branches from trees and bushes above this height. Although trees and shrubs can stand a certain amount of trimming without being unduly hurt (though they will be stunted), too much damage will kill the tree. If lopping is practiced over large areas, trees and shrubs will soon disappear. The results are obvious: more desertification.[1/]

Gathering of food products, of special significance during dry seasons and drought years, is less destructive and more widespread than is often assumed. Pastoralists throughout the Sahel gather and eat kram-kram seeds (Cenchrus bifloris), fonio and other natural pasture grasses, especially in periods of food shortage.

Although wood from many tree species is used in the manufacturing of utensils, there are no reports of specific species having disappeared or come under stress because of excessive gathering activities. It is, however, possible that Doum and Run palm (Hyphaene and Borassus) in some places are under so much pressure that natural regeneration is seriously impaired.

VI. STATUS OF RENEWABLE RESOURCES

Climatic irregularities and human pressure have taken an obvious toll of Mauritania's natural renewable resources, as documented in numerous analyses since 1976. For a recent analysis, see Ref. A. Only a summary update is presented here in the form of map overlays which synthesizes the available information.

These maps show the different deterioration elements, the most important of which are:

-- Sand invasion (Figure 3)

-- Deterioration of natural vegetation. Its adverse consequences are described above (Figure 4). It represents the next immediate problem area according to the reported results of a 1980 UNSO seminar on desertification (Ref. 4).

[1/] Excessive trimming of shade trees was observed even in front of GIRM ministry buildings in November, 1982.

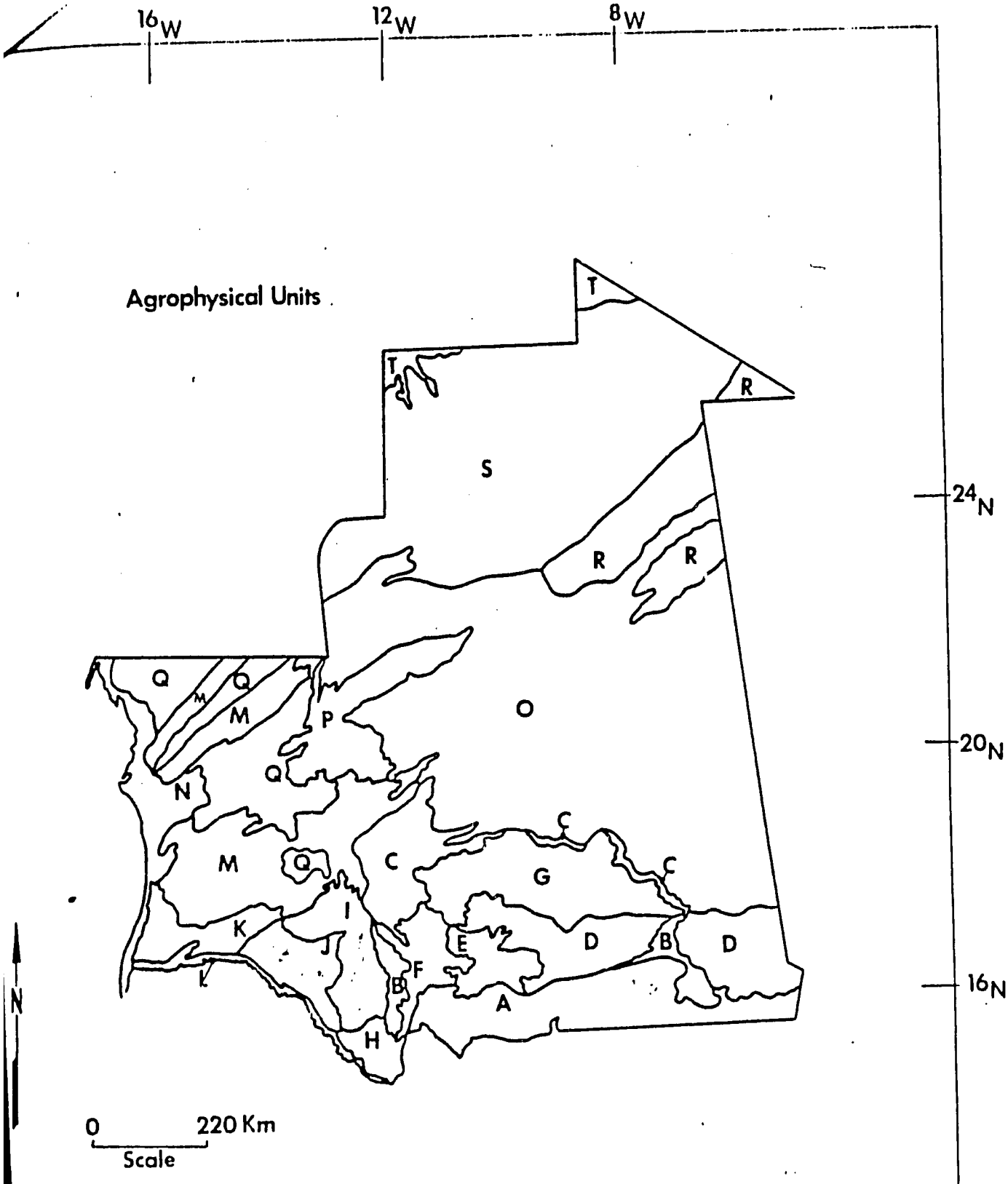


Figure IV-1. —*Agrophysical unit delineations*[x)] *of Mauritania (see legend in Table IV-1 - original map was at a scale of 1:1,000,000).*

—Base map for overlays used in this write-up.

x) based on satellite imagery

Figure 2

Fig 3

SAND INVASION

ALL TRAFFIC CORRIDORS ARE HIGH HAZARD AREAS, REGARDLESS WHERE LOCATED. →

HIGH HAZARD
MEDIUM HAZARD
LOW HAZARD

NOTE: "HAZARD" IS A COMBINATION OF OCCURRENCE AND PEOPLE OR INSTALLATIONS EXPOSED.

SAND MOVEMENTS IN MANY AREAS OTHER THAN THOSE SHOWN ARE SEVERE, BUT RELATIVELY FEW PEOPLE ARE THREATENED.

NATURAL VEGETATION DETERIORATIO

HIGH → PLUS ALL TRAFFIC CORRIDORS AND POPULA CENTERS

MEDIUM

LOW

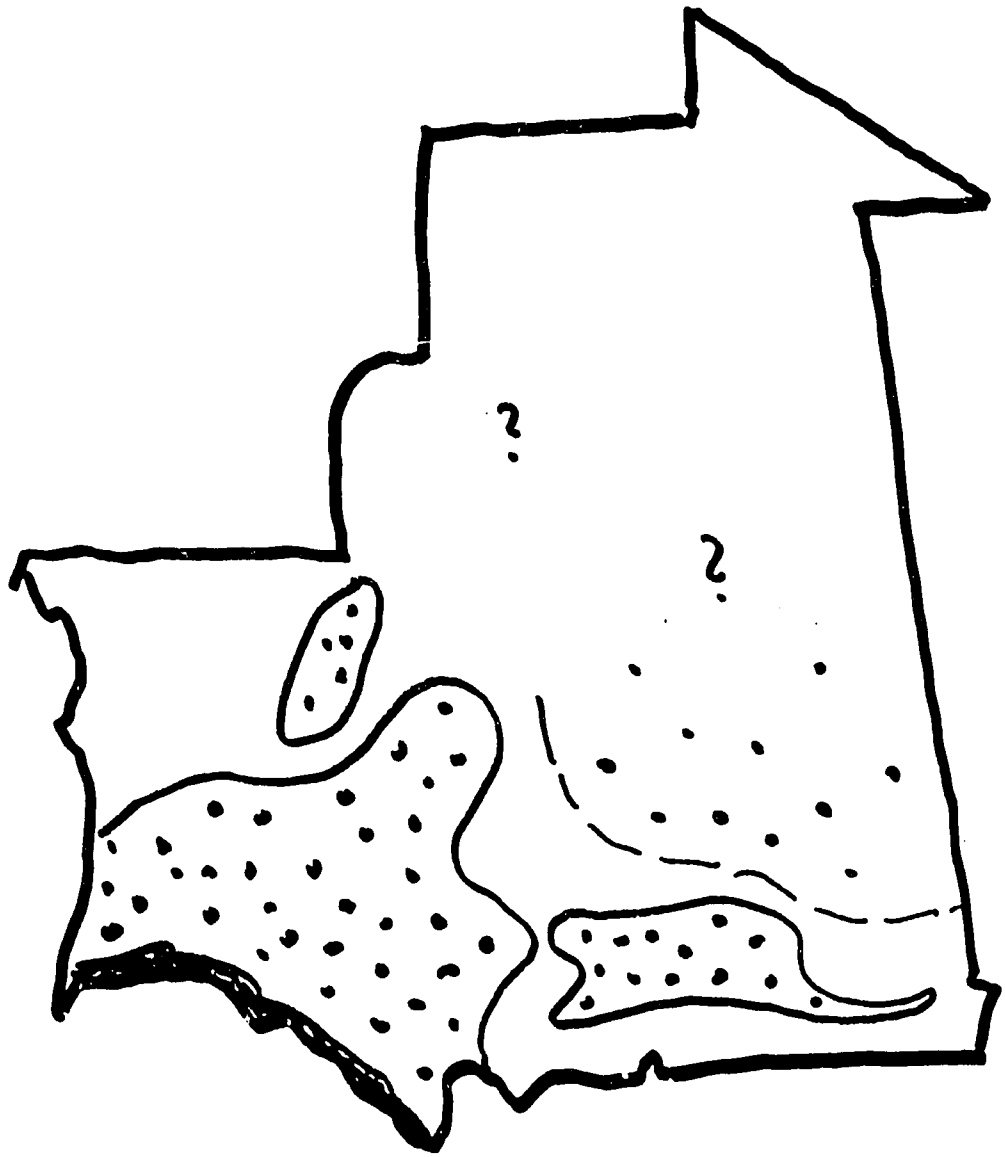


Fig 4

42

DECLINING FERTILITY OF TRADITIONAL FARMLAND

HIGH

MEDIUM

Fig 5

-- Loss of fertility of traditional farm land. This is an important issue in the south, for both dryland and irrigated farming. (Figure 5); and,

-- Other elements, for which no specific information seems to exist, i.e., sheet and gully erosion, channel erosion, and lowered groundwater tables.

The forestry situation along the Senegal River is special planning problem. It is Mauritania's prime area for forest production. The forest reserves that had been established during the colonial period still exist in bits and pieces. Much could and, indeed, should be done to make them more productive. Additional areas could be reforested. Some exotic, rapid growth species may add to the productivity of reserves for which the main management aim should be to provide the base for sustainable domestic charcoal production.

Most of these efforts, however, will have to wait until the presently planned dams have become operational. The water regime of the river plain areas will change dramatically. The Diama dam will bring about significant changes along practically the entire Mauritanian shore line. Backwater effects will be felt far upstream owing to the extremely low natural gradient of the system. Under the influence of this salt intrusion dam, the operational waterflow regime will result in one set of site conditions for trees. Then, after the Manantali dam becomes operational, water regimes along the river will change once again depending on operational priorities of flood control, irrigation, energy production, etc.

Irrigation perimeters can meanwhile be built and written off in a relatively short time: 10 to 15 years. Forest production operations, however require a longer time frame. Even using a relatively rapid rotation with exotics (Eucalyptus, for example), at least 20 years are needed for effective management: three rotations of seven years each, for instance.

"Temporary" forestry activities can be undertaken taking into account that some day the stands will be lost. Of critical short term importance is the early planning of wood salvage operations in those areas that will be flooded. On the other hand, dam construction may be substantially delayed. Perhaps only Diama will be operational in the short run, while it may be years before Manantali's effect is felt.

Thus, little can be undertaken, or even suggested, in specific, practical terms unless present plans, the most likely water management schemes, and OMVS policies on these complex subjects are carefully analysed and then monitored. Planning-level suggestions can be developed but must be based on further study of the possible and most likely effects of forthcoming construction activities.

VII. PUBLIC INSTITUTIONS AND REGULATIONS

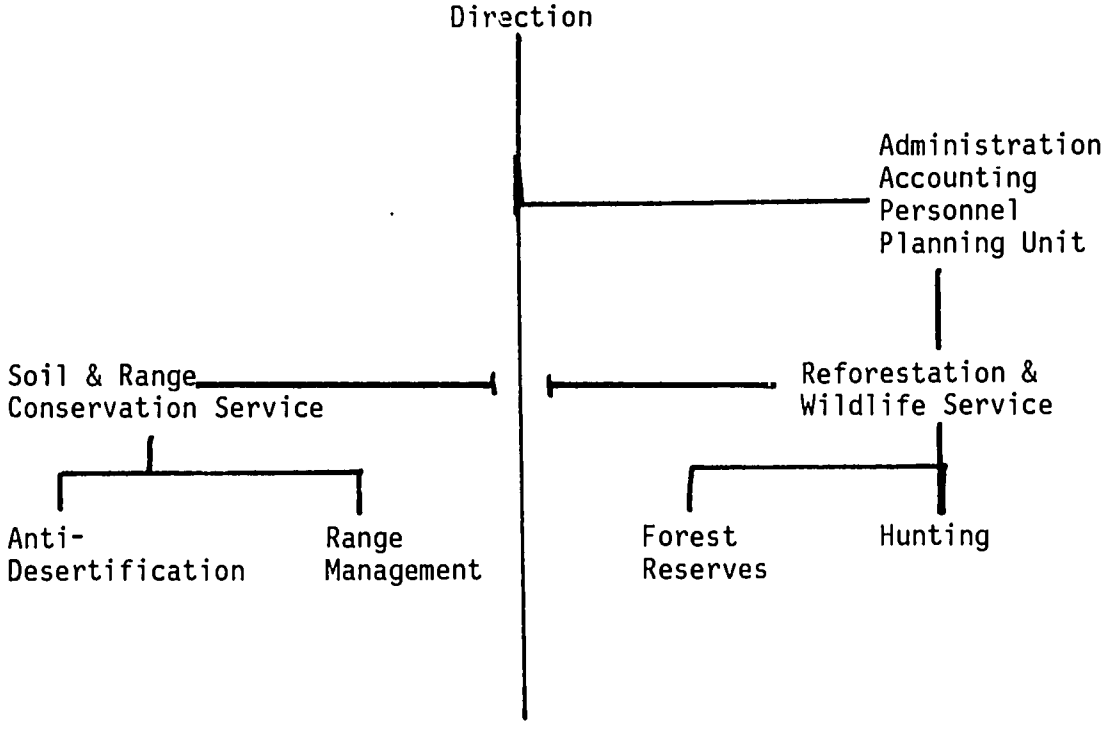
A. Personnel, Training and Organization

The Nature Protection Service operates under the Ministry of Rural Development and consists, according to their latest payroll records, of the following personnel:

- -- Level A--11 persons. 2 additional "A's" are presently assigned to outside activities: one is at the CEAO, Ouagadougou, the other has just been named Ambassador to W. Germany. (3 M.S. equiv., 8 B.S.)
- -- Level B--43 persons. (Of whom two are in the US to return mid '83 when they automatically become "A's"). Mainly Bambey or Katigougou graduates (high school plus minimum 2 years technical school.)
- -- Level C--13 persons. Mainly Bambey or Kaedi graduates.
- -- Level D--43 persons. Grade School + 2 years Kaedi or former police or military.

In addition, there are about 100 forest guards outposted throughout the country, most of them former police or armed forces personnel.

In connection with the UNSO dune fixation program, Algeria recently committed itself to train 20 persons (probably recruited from the B and C ranks). Upon their return they will all advance one grade. Ostensibly to gain strength and responsibility, the service is presently being reorganized in accordance with MDR directive (Arreté) No. 030 of April, 1982. Two separate services will be created and their organization charts will look as follows:



45

One inspection for each Region

One cantonnement for each Department

Several postes forestiers according to importance.

Police measures are the main tools for making the general public abide by the laws and regulations. This leaves little or no incentive for local or private initiative. Moreover, the service is para-military in nature. Field agents normally wear uniforms and carry arms "to be able to defend themselves against certain irresponsible elements."

B. Laws and Regulations versus Custom

One of the major present problems is the conflicts between modern and traditional laws and standards over land and tree ownership. Natural vegetation (except inside areas that are currently being farmed or otherwise used by private individuals) is generally regarded as a common good. As such, trees are "protected" by laws, and it has never been established that improvements (conservation efforts, including tree planting or vegetation protection) made by individuals or communities become theirs to manage (and to use) exclusively.[1/] It is thus entirely possible that if someone plants trees on a piece of land that he is presently cultivating, he could be fined if caught cutting some branches or thinning the stand a few year later when the field has been left in fallow.

The basic legal concept that all land belongs to the government unless it is being used causes additional long-range conservation problems in that only active cropping is regarded as "use". Land left as pasture or fallow tends to be considered as having returned to common status.

In recognition of these conflicts, the government is in the process of rewriting two texts: the property laws (code foncier) and the forestry law (code forestier). The CILSS "Bilan" comments on the latter and cites some innovations. However, although improvements are forthcoming, there will still be numerous problems and uncertainties even with these new texts. One of the major problems is the way they will be interpreted in the field. Years could probably be saved through orientation and training sessions for all field personnel. In any case, a transition period of several years will be required until new views have been crystallized. Additional revisions and interpretation will then be necessary to provide incentives and economic/social interest for herders or farming families to actively undertake long-range conservation and restoration activities on their own land or territory.

[1/] The notable exception: Boumdeid where people set up their own protection laws and enforcement.

VIII. PRESENT PLANS AND PROGRAMS

A. Ongoing

(1) Reconstitution of gum stands. The fifth FED grant contains a two year project (approximately $1,000,000) to regenerate lost stands of A. senegal in several areas; e.g., Trarza, Gorgol. A French forestry technician has arrived: project activities are beginning to take place.

(2) Nouakchott Greenbelt. One of the most active and agressive foresters is now director of the greenbelt projects, of which this is the most important. Funding levels are around $1,000,000/yr. According to Lutheran World Relief, their contribution is around $85,000 this year. The project has been extended to 1985. Good progress has been made in developing relatively inexpensive (approximately $500/ha) techniques using essentially access control, natural regeneration and no irrigation after planting.

(3) A CEAO-funded nursery installation program is nearing its end after two years. Nurseries have been establisehd in Nouakchott, Rosso, Kiffa and Aioun. A total of about $340,000 will have been spent.

B. Planned

Foremost, a UNSO-orchestrated desertivication control project is presently taking shape. Algeria reportedly has assumed responsibility for training 20 Mauritanian foresters. Denmark has committed $2,000,000 and UNSO (with assistance from the forestry department of FAO) is presently arranging detail design and is actively seeking funding.

In addition, the Nature Protection Service has prepared a lengthy list of other projects. Some, judging by their title, are already on the list of CILSS "First Generation" projects; others are new.

The Italian government has offered to engage in some wildlife conservation endeavours.

IX. CONSTRAINTS TO DEVELOPMENT INITIATIVES

A. Environment

A basic point in the implementation of conservation and resource management efforts in this part of the world is still often overlooked when setting goals and designing implementation plans: because of the physical difficulties, efforts must be kept small and uncomplicated.

B. GIRM Absorptive Capacity

The Nature Protection Service is ill-equipped, understaffed and has very little operational funding to carry out their assigned functions. As donor interest increases in this sector, they are even more hard

pressed to provide the counterpart personnel that each funding source requires. Also, as long term training is offered to their staff, their effective manpower force is reduced in the short and medium-run.

C. GIRM Policies and Approaches

As in neighboring Sahel countries, the Nature Protection Service and its agents are by history, tradition and training locked into a top-down, law enforcement-oriented operational mode. The ostensible orientation towards participation by rural people of official rhetoric is negated by these attitudes and views. Attempts to bring about the needed changes have been very slow and discouraging. While it is relatively easy to upgrade skills and provide behaviorial training it is more difficlut to change outlook, habits and attitudes of government agents. This implies inter alia, a layering of western resource management values over those acquired through training and experience in a very different physical and sociocultural environment.

D. Resource Pressures

The present carrying capacity of Mauritania's natural resources (soil, water, natural vegetation, game, etc.)--with the possible exception of the marine fisheries--is already strained beyond the limits of its sustainability. It is extremely difficult under these conditions to undertake any rural development without, in the long run, adding to the problem instead of alleviating it. The capacity of nature to regenerate, though astonishing, tends to be overexploited at every opportunity. Cultural values, social stratification, basic beliefs that shape people's use of natural resources, and steadily increasing population pressure make it extremely difficult, but not impossible, to move individual, group, and institutional behavior towards a balance between resource use and resource conservation that fits western models.

E. Technical Packages

The main problems are not of a technical nature. To be sure, there are many unanswered questions regarding the best and most efficient ways to implement successful resource conservation/restoration projects. The basic components of such priority actions as dune fixation, range revegetation, fuelwood producion and improvement of soil fertility (in the south) are well enough known. Examples exist in Mauritania that show what could be done, how it can be done and how much it would cost (e.g. Boumdeid). Many more examples now exist in the rest of the Sahel (the Ferlo, Mbidd; and Logbar in Senegal, Kayes in Mali, Dovi in Upper Volta, and Maggia in Niger).

F. Donor Conceptualization

European experts have adopted the position that techniques are not the main problem, as shown by the recent CILSS review (Ref. F). In the past, many outsiders had emphasized training and research. Much has been done along these lines. It should not be surprising that the larger training, studies, research, etc. efforts are still not providing the hoped-for relief.

The latest thinking is that the critical factors in all this are social and political. AID's own review and reporting apparatus picked this up years ago and is continually adding data, facts and experience. Questions of ownership and use rights of natural resources (especially trees, but also water and pastures) are still in such a state of flux and conflict that little can or will happen until they have been settled. Top priorities are:

-- a better, more people-oriented definition of ownership and use rights;

-- revisions of natural resource texts, rules and regulations;

-- reorientation of government technical and administrative agents; and,

-- decentralized resource planning, decision-making and local control.

G. USAID/Mauritania Track Record

Most of AID's project implementation and management efforts in Mauritania's rural sector over the past five years have not taken these constraints sufficiently into consideration. Where projects, at the beginning, have been conceived on relatively small and uncomplicated scales, they were "upgraded", made "more significant" and more extensive (and technically more complex), often at AID/W's insistence. This has led to unrealistic targets. Unachieved expectations, of course, have led to disappointments, frustration and--in the case of several projects managed through the MDR--to personal conflicts and complete disillusion. Working relationships with host country agencies have suffered.

Also, USAID's usual standards of project quality (such as conventional economic feasibility) are difficult to apply to the local realities of implementaion of environmental projects, particularly in highly degraded habitats where rehabilitation may be of decades. As the GIRM is finding out for itself, the concept of a modern nation managing its public resource domain is extremely difficult to apply in the Mauritania context. Outside goodwill, funds and technical assistance can only achieve so much. Additional doses of outside aid not only tend to be wasted, but can quickly and unexpectedly become counterproductive and lead to additional social or political tensions and increased pressures on natural resources.

If a donor nevertheless puts additional resources into such projects, immediate, positive, tangible and measurable impacts in terms of increased economic productivity, more private initiative, etc. should not be expected. Otherwise, frustrations, disappointments and dissatisfaction will continue. And, evaluations will continue to highlight "failures".

X. A POSSIBLE FRAMEWORK FOR AID COOPERATION

If, in face of past unsatisfactory experiences, a donor decides not to concern himself with assistance in this field, chances are very great that by pursuing production activities in the agricultural sector--he can in the future be (perhaps deservedly) accused of having contributed to resource deterioration (desertification) instead of helping to reduce it. It is extremely difficult in an environment as fragile and under as much pressure as Mauritania's to do anything in the agriculture sector that does not directly lead to serious long term negative impact on the country's "environment" (physical, health, economic, social, political, etc.)[1/]

If inputs into resource management are envisaged, progress by usual donor standards, at best, will be slow, insignificant and restricted in terms of increased agricultural productivity. They will probably not be much appreciated by the more production oriented government agencies, at least for the first five or ten years.

Assuming USAID decides to commit part of its resources to such efforts, what are the objectives, and in what way should the available inputs be used to achieve these goals?

The problem, the present situation and the constraints have been outlined above. As far as GIRM objectives are concerned, their commitment to food self-suffiency and one of its essential conditions, "reestablishment of the ecologic balance" (redressement de l'equilibre écologique) covers the general scene. More specifically, the draft fourth five year plan calls for "regeneration of the physical environment" (régeneration du milieu naturel). With a slight adaptation to accomodate US (and, thus AID's) concepts and terminology the following objective for future planning and programming efforts is proposed:

> To assist Mauritania in developing models permitting optimal management of its natural resources with primary emphasis on sustainability.

A local farmers and pastoralists know only too well, basic and far-reaching trade-offs between maximizing for short term production and the long-range sustained yield option are important. Donor agencies must face the problems as well. USAID's position, at least for the next five to ten years, might be to fully commit itself to the concept of sustainability, even if this means that short and medium-range productivity is lowered. Part of the difference could perhaps be made up by offering PL 480 commodities. This basic decision must obviously be made before detailed programming and planning for agricultural development can be undertaken in a productive way.

[1/] It is now beyond question that some agricultural development projects which have been implemented in response to the recent drought have already caused serious additional deterioration of natural resources in the Sahel or are beginning to do so. Compared to other donors, USAID's track record is relatively good.

The only way to avoid further resource depletion is to adhere rigidly to sustained yield principles. This is not a popular view and is especially difficult to promote or support where chronic food and water shortages are as severe as in Mauritania. Applying this principle specifically to Mauritania would mean:

-- Do not use more ground-water than is naturally recharged.

-- Farm in such a way that crop yields do not decline.

-- Cut no more than annual growth.

-- Graze to avoid retrogression.

-- Harvest only the annual increment of wildlife and fish.

Improving the natural resource capital requires even more restraint. Starting from the sustained harvest principle, future productivity in many of the existing situations could be substantially increased by simply allowing the natural capital to grow. This would require that, for a certain number of years, part of the increment, instead of being harvested, would be allowed to be added to the capital stock. (Denser vegetation would allow higher annual yields; fish and wildlife population would increase, which in turn would permit a higher offtake rate, etc.) However, the kind of large scale "mise en reserve" (rest) of vegetation, soils, water and wildlife is practically unthinkable in view of the ever increasing needs for producing basic food requirements just to stay above the survival level.

The following options represent different positions and attitudes that a donor could assume in view of the inescapable fact that natural resources can produce only a limited amount of goods regardless of whether at present, future higher or lower levels.

(A) Token Recognition of an optimal resource management model. Put a small amount of the total package into an ecology/forestry project like village woodlots or dune fixation which can be cited, when necessary, as "interest" in this subsector.

(B) Basic, Sectorial Recognition. Cooperation would consist of undertaking some (perhaps several) ecology/forestry oriented projects in some ratio to other agricultural paoduction oriented efforts. For each "development dollar", a certain amount (between ten and 40 cents) could be earmarked for "ecology/forestry" projects. This is basically what most AID missions are presently doing.

Advantages are that specific projects can be designed and carried out as individual packages, not related to other project development. A "forestry project" can always be planned, designed and negotiated as a separate entity and a contract let. Not much, if any, integration with other agriculture sector activities is necessary; funding, implementation, evaluation, etc. are independent.

The rather obvious disadvantage of this approach is that while something positive is being done for the environment, conditions on the other fronts continue to deteriorate, unhindered and unaffected by the assistance provided to the "environmental sector".

(C) Integrated, Horizontal Approach. Recognizing the need to address the fundamental priorities of producing more food, a conscientious effort can nevertheless be made to insure that agriculture sector initiatives are carefully analyzed and evaluated for likely negative long term impacts on the natural resource base. Experience has shown that, had they been considered at the beginning, many of the problems of past projects were not only predictable but to a large extent avoidable by relatively minor, additional inputs. (See CILSS/CLUB "Ecologic Guidelines", 1980).

Work done by the CILSS forestry/ecology unit (Winterbottom, Stabler and Weber) has furnished enough experience across the Sahel to show that if a certain amount (between 25 and 50%) of the budget for agriculture project had been spent on conservation, 90 to 95% to the otherwise unavoidable, negative long range impacts could have been prevented. In many instances, a net gain in resource capital might well have been possible in addition.

(D) Purely Environmental Approach. GIRM presently is receiving assistance from many sources. Many of them are already aiming at increasing agriculture production e.g. the many donors funding irrigation schemes along the river. In addition, new wells are being funded in the pastoral zone, more roads are being financed, etc. The U.S., being concerned about the continuing deterioration of Mauritania's resources, sand invasion, degradation of vegetation around rapidly growing population centers and along major roads, etc., could dedicate its full assistance portfolio to the regeneration of the physical environment, completely in line with the new draft five year plan. The other donors would assist in the development of the agriculture and other sectors. AID could commit itself to help Mauritania reestablish an ecologic balance in order to stabilize the natural renewable resource base and restore its full production potential.

On the basis of discussions with Nature Protection Service officials, it appears that the option that would best meet both their and AID's concerns is Option C--the integrated, horizontal approach. The common ground of interest for both GIRM and AID includes the following priority problem areas:

-- Sand Invasion;

-- Deterioration of the natural plant cover;

-- Declining fertility of traditional farm soils; and,

-- Water erosion: sheet, gully, etc.

This basic approach would allow USAID to contribute to environmental protection. To ensure the full participation of the local population (farmers, pastoralists, people living in urban centers, etc.) and the Nature Protection Directorate AID would provide inputs to support two implementation approaches, to wit:

(1) Horizontal Aspects (60-90%). Integrate conservation, protection and restoration interventions with the secondary purpose of growing a certain amount of forest products on a sustained yield basis into all future rural development programs or projects. Agroforestry and other conservation activities can be made part of the overall efforts in line with established practices and existing experiences.

(2) Vertical Aspects 10-40%). Although dune fixation is not always directly linked to agricultural or rural development programs, local populations should be supported in these efforts. Techniques recently developed by the greenbelt project can be replicated and carried out through local participation.

Specific, well defined and described popular activities should be supported, which could be carried out by PVO's acting as technical and administrative, as well as socio-political, intermediaries. The food-for-work concept could be effectively incorporated into such projects. This could be turned into food relief, if and when the need arises.

AID may wish to consider whether the cause of rational resource management is better served by integrating optimal use principles directly into any and all agriculture sector interventions (irrigation, dryland farming, range management, etc.) than through separate "forestry/ ecology" projects, especially in view of the many serious and compelling constraints AID is facing in Mauritania at present in this sector. This does not mean that specific reforestation or revegetation actions should be totally excluded. Many of the on-going AID agriculture projects could well contain various conservation and production components along these lines. Moreover, such efforts could possibly be grafted onto on-going projects if the managerial and administrative problems that are often entailed by such procedures could be overcome.

What type of activities would be possible under this formula? The soil conservation "Tech Sheets" developed by USDA during a Sahel Soil Conservation Seminar (with two Mauritanians participating) give the necessary technical, economic, social and planning details (English copies from USDA/OICD/ITD, French from CLUB, Paris). A rough resume is given in Chart I.

The important role various PVC's have played in the forestry/ecology sector has already been pointed out. Apart from a few minor exceptions, the only really successful forestry projects across the Sahel to date have been PVC directed projects in activities such as:

-- the introduction of A. albida in farm fields;

-- windbreaks;

-- dune stabilization;

-- tree foodcrops (agroforestry);

-- small scale communal plantations;

-- live fencing; and

-- soil conservation.

U.S. PVO's have not been the only ones that have gained considerable experience in this field, but they are the most prominent. Some now have over ten years of experience along these lines. It is impossible to give due credit to all of them, but the most important successes have been managed by the following:

-- Africare (Senegal);

-- CARE, Inc. (Niger and Chad);

-- Catholic Relief Services (Upper Volta, Senegal);

-- Church World Service (Niger);

-- Lutheran World Relief (Niger) represented in Mauritania by LWF; and,

-- Save the Children (Upper Volta).

Possibly of foremost interest to USAID/Mauritania is the recently initiated Lutheran World Federation effort in the Nouakchott greenbelt which started about seven years ago (against great odds and with very little initial success). This way turn out to be one of the most meaningful reforestation efforts and certainly the one at the most arid site in the Sahel.

Many of these PVO's employ young technicians, most with previous experience in the field. Some use ex-PCV's with proven track records who already spent two years in forestry projects in the Sahel and who speak French and a local language. Using this type of personnel, PVO's have been to paly very important roles as go-betweens, negotiating and mediating among parties with different interests and priorities.

AID/Mauritania should not overlook opportunities to work with these PVO's, especially to carry out the "vertical" portion of the approach recommended above. Funding levels not exceeding about $100,000 for the first year at each site would be more than adequate. Unusual patience and low-keyed expectations during the first two or three years are a prerequisite for participation by a donor who choses to support PVO efforts in this field.

CHART 1

Soil, water & vegetation conservation Techniques	Irrig. Perimeters Gardens	Dryland Farming		Open Range		Sand
		sand wind	water erosion	Wind	Erosion	
1 Farm "management"/ rotation	rotate: not just rice, incl. forage crops					
2 Manure, compost, residue	intensive manuring & composting	X				
3 Contour farming	n/a		X			
4 Tree crops	along field boundaries	limited	Pabi Boae Tain			
5 A. Albida	n/a	most impo-rtant	impor-tant	acse		
6 Windbreaks/veget strips	include in layout. Useful species	2-3 volos mul-tipur	ou con-tour multi-purp.	browse ships		
7 Live fencing	along bound-aries	arou-und field	arou-nd field			
8 Wood/tree lots	on all un-used surfaces	all non-farm-able land	all non-farm-able land			
9 Shade, indiv. trees	around in-frastr. installat-	Compounds & Admin. Buildings				
10 Live plantations	along dr in ditches, roads, etc.	roads	roads			
11 Access control				X	X	medi. or liv fence & wato man
12 Seedbed/ground prep.	n/a			X	X	in zones I & II
13 Direct seeding pockets, lines, broadcast	n/a			X	X	" " "
14 Planting	n/a			X	X	" " "
15 infiltr. Ditches	around perimeters		X			
16 Terracing dirt level, graded	n/a		X		X	
17 Rock terraces/walls	n/a		X			
18 Gully plugs	around perimeters		X		X	
19 Duckdams			X			
20 Bank stab, mech.	supply can-als & ditches		X			
21 Bank stab. veget.	along drain-age ditches & canals		X			

22 Water spreading	n/a	X	(X)	X	
23 Mini-catchments, flat	N/a	X			
24 Mini-catchments, steep	n/a	X			
25 Mech. barriers (palisades)	n/a				dead or live I & II
26 Sand seeding	n/a	X			inside protected areas III
27. Sand planting	n/a		(X)	(X)	behind barriers III

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