# THE GLOBAL ENVIRONMENT MONITORING SYSTEM

GEMS
SAHEL SERIES
NUMBER 1

NAIROBI
1988

## Inventory and Monitoring of Sahelian Pastoral Ecosystem

## ANNEX 1:
## INTRODUCTION TO SAHELIAN PASTORAL ECOSYSTEMS PROJECT


UNITED NATIONS ENVIRONMENT PROGRAMME
FOOD AND AGRICULTURAL ORGANISATION
GOVERNMENT OF SENEGAL

**SAHEL SERIES**

1. Introduction to Sahelian Pastoral Ecosystems Project
2. Rainfall in the Ferlo (Sahelian Region of North Senegal) since 1919
3. Use of Light Aircraft in the Inventory and Monitoring of Sahelian Pastoral Ecosystems
4. Sampling the Sahel
5. Monitoring Pasture Production by Remote Sensing
6. Inventory of Water Resources in the Ferlo
7. Woody Vegetation in the Sahel

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Global Environment Monitoring System Program Activity Centre
Sahel Series No 1

Title:
Introduction to Sahelian Pastoral Ecosystems Project

Author: M. Sharman

Target audiences: Development agencies
Range managers
Ecological monitoring projects
Remote sensing projects

Objectives of this document:

(1) Presentation of Pilot Project for the Inventory and Monitoring of Sahelian Pastoral Ecosystems
(2) Presentation of pilot zone
(3) Brief presentation of other organizations active in the pilot zone

Title of Project:

Pilot Project for the Inventory and Monitoring of Sahelian Pastoral Ecosystems

Objectives of the project:

Demonstration and assessment in the context of West Africa of the recommended GEMS methodologies for the inventory and monitoring of Sahelian rangeland ecosystems. Provision of a national ecological monitoring service to give decision makers relevant data on natural resources. Reccomendations for rational management of arid rangelands based on an understanding of the dynamics of their renewable resources.

UNEP Project Number: FP/4101-79-01 (2024)

Implementation: FAO
FAO Project Number: EP/SEN/001

Started: July 1979
Ended: June 1985

Introduction to Sahelian Pastoral Ecosystems Project

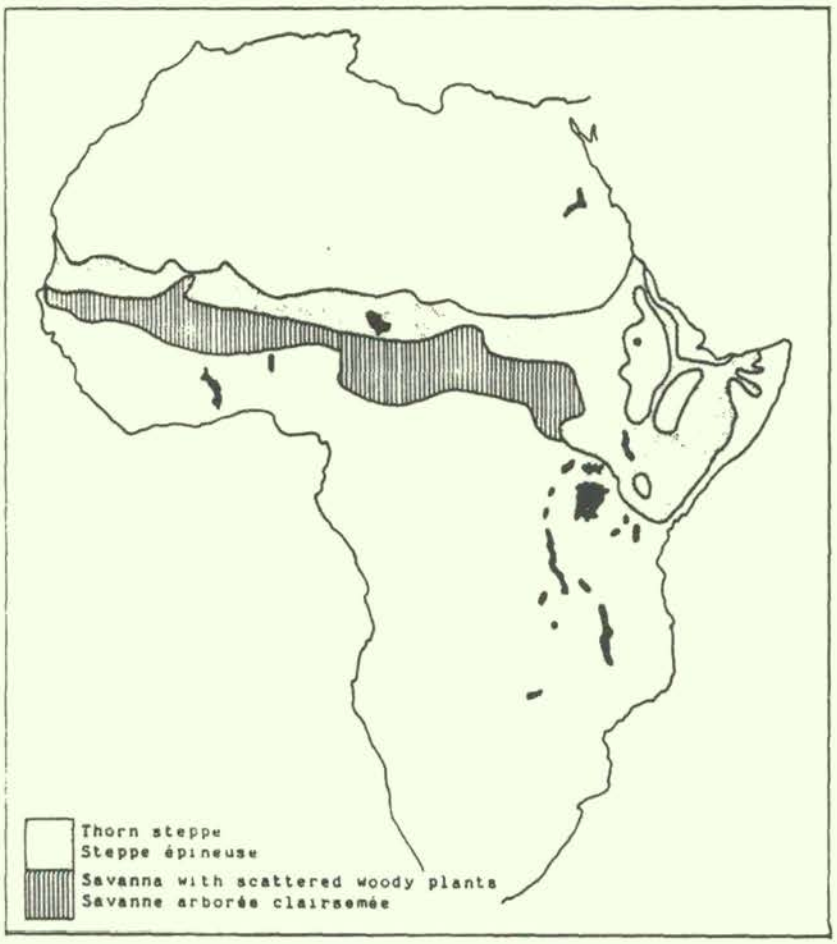
Executive Summary:

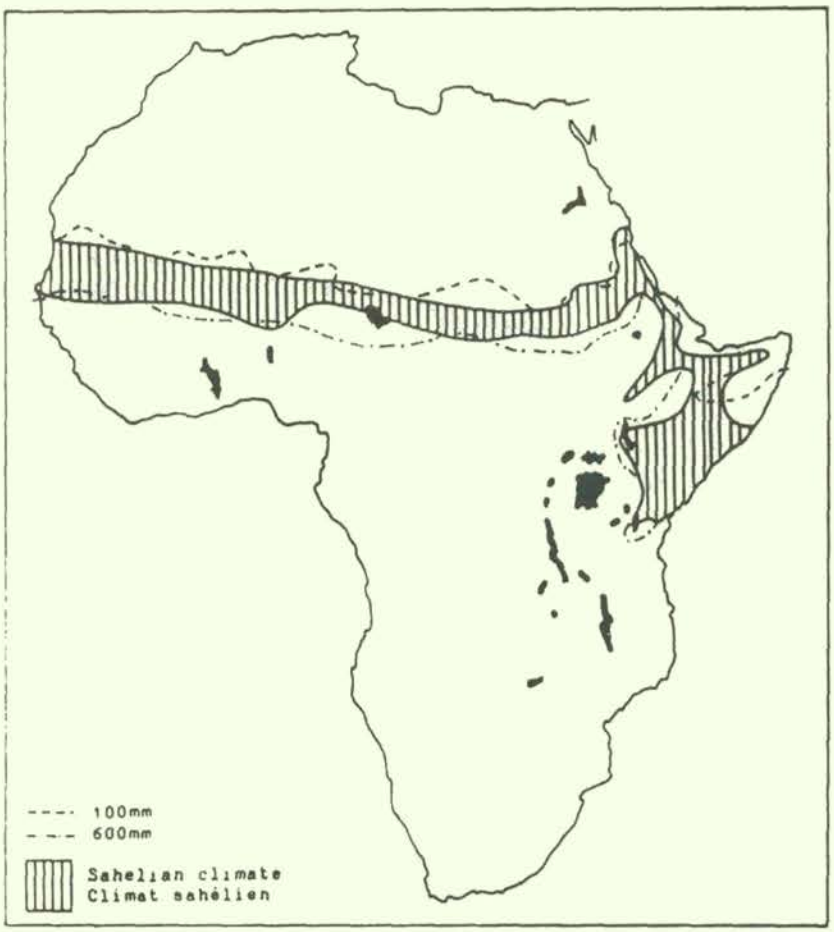
The GEMS Sahel Series is a product of the Pilot Project for the Inventory and Monitoring of Sahelian Pastoral Ecosystems. This project was set up to demonstrate and assess the GEMS methodology for ecological monitoring in a West African pastoral ecosystem.

The present document, the first in the series, defines the use of the term "Sahel" in the rest of the series, gives a brief justification and presentation of the Project, describes in outline the pilot zone in northern Senegal, and summarises the activities of other relevant organizations active in the zone. A short bibliography of reports containing useful background information on the area, and a complete list of reports published by the Project are included.

The document ends with a list of titles and contents of the reports in the GEMS Sahel Series.

Frontispiece: The sahelian zone




Source: Van Chi-Bonnardel R. (1973)
L'Atlas de l'Afrique. IGN, Paris.
Editions Jeune Afrique, Paris.

## 1 Introduction

The Sahel, a tract of land bordering on the southern edge of the Sahara Desert, extends some 5000 km across Africa (Frontispiece). Its width varies from 100 to 500 km from north to south. Its soils are generally ferralitic, either sandy or gravelly, and the erratic rainfall is too meager to provide sufficient water for rain-fed agriculture except in the southern margin of the area. Some irrigated agriculture is possible near the major rivers that run through the Sahel, including the River Senegal, the River Niger, and the Nile. For the most part, however, the economy of the peoples of the Sahel depends almost exclusively on livestock, and hence on the well-being of the pastures.

During the great sahelian drought of 1968-1973 widespread human suffering and livestock mortality was accompanied by severe deterioration of the environment. In the succeding years, during which the sahelian countries have become the most "aided" in the world, livestock numbers have increased steadily. Although reliable data are lacking, it seems probable that their numbers have reached pre-1968 levels almost everywhere in the Sahel. At the same time the condition of the rangelands has improved only slightly, if at all. Furthermore, in some areas of the Sahel, extension of agriculture has displaced the pastoralists from the richer southern pastures.

As is the case for most populations, the pastoral peoples of the Sahel have experienced a demographic increase over the last decades. More and more people are trying to live on land whose productivity is not keeping pace. Attempts by the pastoralist to satisfy his needs by increasing his herds is likely to lead to further pressure on the land, and eventually to its degradation and sharply reduced productivity.

International aid frequently takes the form of emergency operations. Such operations are not designed to provide a solution to the fundamental problem of establishing a system of exploitation in which long-term offtake can be maintained. On the contrary, emergency operations often help to prop up an artificial, unbalanced system, highly vulnerable to drought. In the Sahel such a system of exploitation is inevitably dependant on outside aid for its existance, because drought is a natural feature of sahelian life.

If the future of the pastoral peoples is to be assured, the rangeland must be protected and if possible improved. Unfortunately the protection of the pastures poses well-nigh intractable social and complex ecological problems. The ecological problems alone cannot be solved unless the dynamics of the ecosystem are understood, and understanding can only be achieved by approaching the ecosystem as a functioning whole. To this end, the Pilot Project for the Inventory and Monitoring of Sahelian Pastoral Ecosystems was set up by UNEP, to be executed by FAO as part of the Global Environment Monitoring System's network of monitoring projects.

A detailed summary of the activities of the Project and the main results is given in Le Houérou (1986). The following pages give a brief resumé.

## 2 Objectives

The objectives of the project were threefold. Firstly, the project was to choose and test methods for the inventory and monitoring of sahelian pastoral ecosystems. There were to be three levels at which data were to be collected; on the ground, from the air, and from satellites. The data were to be collected using methods designed to encourage a systems approach in their presentation and use. The methods recommended by the project would contribute to a standard methodology for the inventory and monitoring of rangeland. Secondly, the data collected by the project would be such as to improve our understanding of the renewable resources in the world's arid lands, and to this end the project would use its experience to devise means of creating and maintaining a data bank on national, regional and global rangeland resources. Thirdly, the project would solve any practical problems of monitoring the ecology of the Sahel.

In carrying out its objectives the project was expected to map, tabulate and report on the productivity of the ecosystem. This description would include a retrospective analysis of changes in vegetation and in animal production. Further, by analysing correlations between abiotic, plant and animal data collected by the project, it would describe the current dynamics of the ecosystem. The project was expected to assemble a list of indices of degradation or desertification of rangeland and to report any degraded or desertified parts of its test areas. In the light of its experience, the project would assess the relative contribution to its aims of data collected by satellite, light aircraft and fieldwork, and would point out any modifications to its methods which would be necessary before they could be used elsewhere. It would make recommendations intended to help when planning range management programs and when setting up other ecological monitoring units.

## 3 Choice of Test Area

Senegal was chosen as a suitable host for the project partly because data were already available on its sahelian zone and partly because the sahelian north of Senegal is relatively easy to reach from either of its major towns, Dakar and St Louis.

## 4 Administrative and technical support

The Government of Senegal designated the Laboratoire National d'Elévage de la Recherche Vétérinaire, of the Institut Sénégalais de Recherche Agricoles, to be the counterpart agency for the project. The Director of LNERV was appointed co-Director of the project. Since LNERV has its administrative offices in Dakar, and since office space was available there, Dakar was chosen as site of the project headquarters. This was also convenient for international communication, for supplies for the project, and for the convenience of project personel. Its principal drawback was its distance from the field area, in which respect St Louis would have been preferable.

## 5 Description of test zone

The zone chosen as a test area for the project, some 30,000 sq km of low-lying pastoral land (Figure 1), is bordered to the west by the shallow Lac de Guiers, to the north and east by the River Senegal, to the southwest by the fossil valley of the Ferlo, ending at Linguere, and to the south by the road between Linguere and Matam (on the River Senegal). These two small towns are both near airstrips. One other airstrip lies to the north of the area, at Podor, and a fourth lies to the west of the zone, in Richard Toll, which also provides a small hotel. A major surfaced road runs from Dakar to Linguere, and a second such road from Dakar via St Louis to Richard Toll and thence, parallel with the river, to Matam. Petrol is normally available at Richard Toll, Linguere, Matam and Dagana, a town on the road between Richard Toll and Matam.

This area corresponds roughly with that known traditionally as the Ferlo du nord, or north Ferlo. In this and other documents in the GEMS PAC Sahel Series the test zone is known simply as the Ferlo.

Its limits being a river, a lakeside and a major unsurfaced road, the test area is easily defined on the ground, from the air, and on certain Landsat Multi-Spectral Scanner (MSS) images. This oval test area, some 150 km from north to south, and 300 km from west to east at its widest points, is nowhere higher than 60m above sea level.

It includes three major ecological sub-zones, principally defined by their respective soil types. The largest in area is sandy, with ancient aeolian dunes easily visible under the grassy steppe. The second largest area is characterised by woodland over shallow gravelly soils, with occasional outcrops of the underlying iron-rich hardpan. The third ecological sub-zone lies along the River Senegal. Its soils are hydromorphic. The test zone thus contains the three major soil types found in the Sahel.

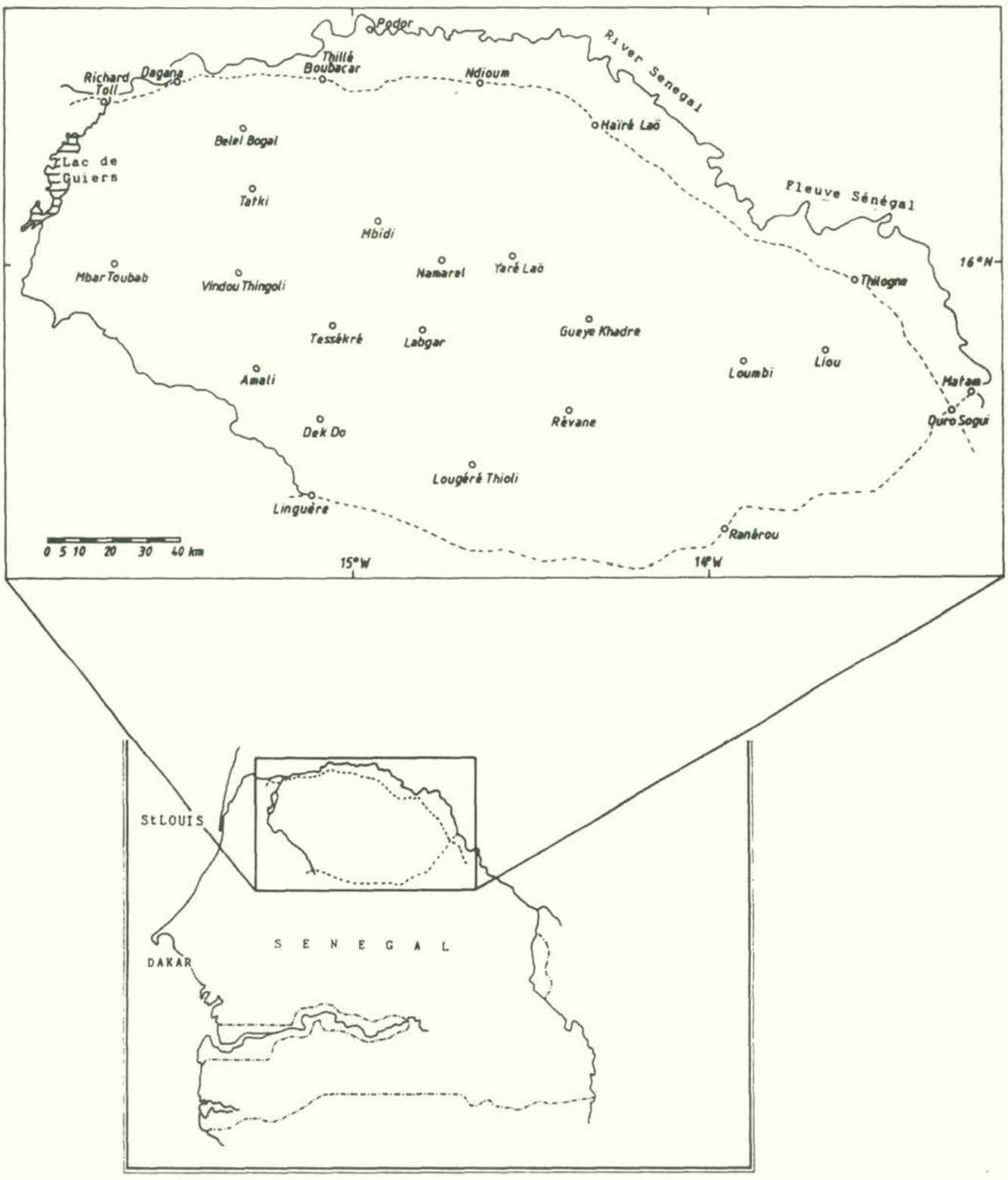
Rainfall has been measured at Richard-Toll, Dagana and Matam since 1919, and at Linguere since 1934. These long-term records show that the north of the zone lies near the 100mm isohyet, and the south near the 500mm isohyet. The rainfall in the test zone thus spans the rainfall typical of the Sahel (Table 1).

## 6 Atypical aspects of the Ferlo

In many respects typical of the rest of the Sahel, the Ferlo nevertheless differs in three major respects.

Firstly, the western limit of the zone lies less than 100 km from the sea, and unlike the rest of the Sahel, might be expected to experience a climate influenced by the ocean. However, the moist ocean winds blowing from the northwest in January and February have little effect on the area, their influence only being felt up to about 30 km inland (Giffard 1974). Thus, despite its proximity to the sea, the climate of the area can indeed be considered as typical of the rest of the Sahel, insofar as a typical sahelian climate exists.

Figure 1: Location of the test zone of the Pilot Project



Secondly, the area has been well-studied in the past, and its recent history is well documented (eg Barral 1982). This literature provided the members of the project an immediate insight into the area which they might have been hard-put to find elsewhere in the Sahel.

Thirdly, deep mechanical boreholes are scattered throughout the Ferlo, which is therefore an area in which livestock are unlikely to want for water, although the plants may. The consequence of this is that while animals elsewhere in the Sahel may die of thirst in a drought, the animals in the Ferlo are more likely to die of hunger, having eaten all the available food for 15 or 20 km around the boreholes. Certain ecological problems, especially those brought about by overgrazing and by lack of vegetative ground cover, may therefore be more severe in the Ferlo than they are elsewhere in the Sahel.

## 7 The boreholes

The boreholes have been of crucial importance in the development of the Ferlo. Before the first borehole went into service in 1949, livestock could not survive the dry season in the "desert of the Ferlo". As a result, pastoralists spent the wet season in the Ferlo with their herds and vacated the zone in the dry season, transhuming either to the vicinity of the River Senegal or to areas with permanent wells to the southwest. This seasonally enforced movement probably meant that the grasses in the pastures were never eaten to the roots, and that the soil had a near-permanent cover of vegetation.

Since the early 1950s, the installation of the boreholes has continued steadily, so that in 1984 each mechanised water point in the Ferlo served an average of fewer than 400 sq km. This dense scatter of assured water has led to the relative sedentarisation of the pastoralists and their livestock. If a borehole breaks down or if the pastures in its vicinity are exhausted, the pastoralists move with their herds to a neighbouring borehole. Long-range transhumance is no longer the norm, an every-year occurrence, but is now the exception, to be undertaken in years of disastrously poor pastures.

## 8 Migrations of herds

In these bad years, of which 1972, 1983 and 1984 were examples, the herdsmen drive their animals south, going as far as the delta of the Saloum or even the Casamance. At the same time, herds of camels and cattle from Mauritania migrate south across the River Senegal.

Frequently the livestock owners delay their departure, hoping for rain, until their animals are weak from starvation. In this weakened state many die on the march. The herdsmen prefer to stay as long as possible in the Ferlo because they say that in the southern pastures the animals are exposed to trypanosomiasis and that in 1972 many died. Conflicts also arise with the southern agriculturalists and livestock owners. While the herdsmen travel south, their families tend to move to the

River Senegal with the smallstock. In these exceptional years, the Ferlo in the dry season is almost empty of livestock, with only a few families staying on with small herds of goats and sheep.

9 Continuous pressure on the pastures

In most years, however, the animals remain in the Ferlo throughout the dry season. In some environments it is unlikely that overgrazing at the end of the dry season has serious consequences (World Bank 1972). In the Ferlo, extreme overgrazing results in naked sand which is subject to wind erosion, and seedlings of woody plants are browsed and killed. The consequences are carried over into the start of the wet season, when hungry animals eat and kill the young shoots of early grasses.

Local habitat destruction around the boreholes is sometimes so extensive that the site of the borehole can clearly be made out on Landsat Return Beam Vidicon (RBV) imagery as dark smudges, frequently with a clearly defined stellate form representing livestock trails radiating from the central scour.

10 Patterns of human settlement

The boreholes may also have served to impose a structure on the present distribution of human population. In the past, wet-season camps were constructed near large waterholes, and the pastoralist moved with his family and livestock to a new camp when the waterhole dried up or the productivity of the nearby pastures lessened. Today, permanent villages are sited to lie at a convenient distance from the nearest borehole. Some villages are sited so that they lie equidistant between boreholes, apparently so that if one borehole breaks down, the other can still be used. Many of the boreholes are now themselves centres of population. In the case of the boreholes drilled early in the series, this is as a direct result of the policy of those responsible, who chose to sink boreholes near established wells, and therefore usually near established villages. Some of these village-boreholes have developed weekly markets, and shops, clinics and schools have been set up at others.

11 Water rights

Traditionally, the water in a well was the property of the person who had dug the well, and others who wished to use the water would pay in kind. Wells dug communally belonged to all those who had helped dig them. Water in waterholes or in lakes and rivers was common property. The policy of the organisations which installed the first boreholes was to provide free water to all those who brought their herds to the troughs. This policy has continued, with the exception of certain boreholes where the herders are expected to contribute to the diesel fuel for the pumps. Recent attempts to restrict the damage to pastures by imposing a sliding scale of fees for the use of the water has met with great, and sometimes violent, opposition by the pastoralists, who feel that their traditional rights to free communal water are being infringed.

## 12 Organisations active in the test zone

The Direction de la Santé et de la Production Animale (DSPA) has the responsibility throughout Senegal for veterinary health care, for the establishment of official prices for livestock, and for the monitoring of the technical and economic aspects of the herds and of the livestock industry. Unfortunately the data on livestock numbers furnished by this organisation, which form the basis of all official estimates of livestock populations, are established by assuming that their numbers increase by a fixed amount each year. Thus, for example, official cattle numbers in any given Department increase by exactly 3% per year. Furthermore, where previously figures, based on estimates from vaccination campaigns, were rounded to the nearest 1000 head, a spurious accuracy has now been introduced, and official data give animal populations apparently accurate to the nearest animal. In view of the importance of livestock to the economy of Senegal, it is obviously necessary that the Government has access to realistic data.

The administration and repair of some of the boreholes has been taken over by the Société pour le Développement de la zone sylvo-pastorale (SODESP), a mixed-economy company for the development of meat cattle ranching. The company buys calves from the herdsmen at preferential prices in exchange for vaccine and supplementary feed. These calves are transported to a ranch in the south where the animals can grow rapidly, and from where they are moved to a fattening zone and finally to market in Dakar. Although one of the other boreholes in the test area is privately owned, the maintenance of the remainder of the boreholes is the responsibility of the SOMH. A few mechanised water points and many of the modern wells are maintained by the local Brigade de Puits (Wells Brigade).

Of the other organisations operating in the Ferlo, the Société d'Aménagement et d'Exploitation du Delta (SAED) is principally involved in irrigation projects near the River Senegal, although it is now establishing integrated development projects in this area. The Centre de Perfectionnement des Eleveurs is based at Labgar, a village-borehole in the south centre of the Ferlo. A French volunteer de progrès is stationed here. The Centre National de la Recherche Forestière has established a gum-tree plantation (Acacia Senegal) near Mbidi, and the Direction des Eaux et Fôrets, under the tutelage of the Ministre de la Protection de la Nature et de l'Environnement, has undertaken reafforestation projects near several of the boreholes, notably at Labgar and Revane. Several countries have bilateral aid projects operating in the Ferlo, notably the creation of maternity clinics and schools by the Dutch government, a reafforestation research project funded by West Germany, and the installation of a borehole by the People's Republic of China. Canada has launched a major project (OFADEC) to establish irrigation schemes near the river and to sink more than 1000 wells in the Ferlo. The US Peace Corps has volunteers working in Podor and nearby villages along the valley of the River Senegal. The European Development Fund has built hospital in the area. Non-governmental organisations with project in the Ferlo include CLIMAF

Previous ecological studies of the Ferlo have been undertaken by the Institut Sénégalais de la Recherche Agronomique, the Groupe de Recherches Interdisciplinaires en Zones Arides and by the Lutte contre l'Aridité en pays Tropicaux-Ferlo. The Office de Recherche Scientifique et Technique Outre-Mer (now renamed the Institut Français de Recherche scientifique pour le Dévéloppement en Coopération) has carried out several ecological, pedological and social studies of the area, concentrating principally on the valley of the River Senegal.

## 13 Maps

Apart from the 1:000 000 road map of Senegal, there are also two IGN 1:500 000 sets of topographic maps of Senegal, including the Ferlo, and a set at 1:200 000. The River Senegal is mapped at 1:50 000 on 65 sheets. A soil map at 1:1 000 000 (ORSTOM), and geological and hydrological maps at 1:500 000 (BRGM) are also available. A vegetation map of the Ferlo, at 1:200 000 scale, was constructed by IEMVT in 1972, but is now out of print. Two sets of aerial photographs are available for almost all of the test zone, the first dating from the mid fifties and the second from the early seventies.

## 14 Background information

Further relevant background information on the Ferlo is given in the following documents:

BARRAL H. 1982 "Le Ferlo des forages. Gestion ancienne et actuelle de l'espace pastoral." ORSTOM. Direction Générale de la Recherche Scientifique et Technique. Dakar.

GRIZA documents (1983)

LE HOUEROU H.N. (1986) Inventaire et surveillance continue des ecosystèmes paturés sahéliens Rapport technique rédigé pour le compte de la FAO et du PNUE. FAO/UNEP technical report.

NAEGELE A.F.G. (1971) "Etude et amélioration de la zone pastorale du nord Sénégal" FAO

POUPON H. (1979) "Structure et dynamique de la strate ligneuse d'une steppe sahélienne au Nord du Sénégal" ORSTOM. Thèse de doctorat en sciences.

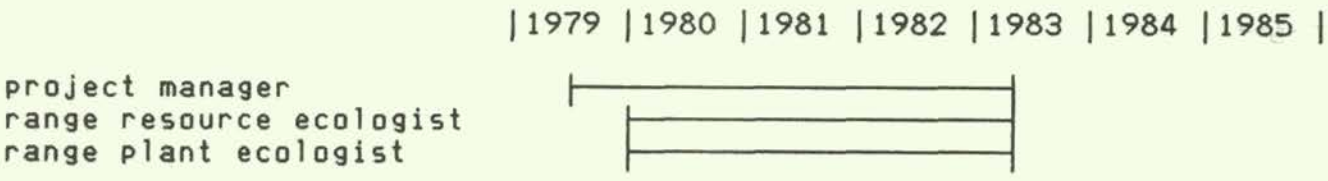
SANTOIR C.H. 1983 "Raison pastorale et developpement. Les problèmes des Peuls sénégalais face aux aménagements: 1ère partie: Sédentarisation de nomades hydraulique pastorale dans le Diolof." ORSTOM. Paris.

## 15 The Project

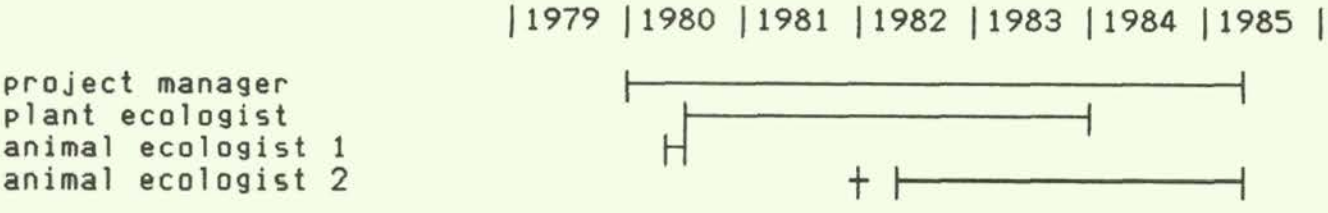
15 The Project

The Pilot Project for the Inventory and Monitoring of Sahelian Pastoral Ecosystems was 73% financed by UNEP, and 10% by FAO. The cost was initially estimated at $2 083 680 spread over 4 years. Three full-time UN experts were budgeted, giving a total of 132 man-months. The three posts were to be: (1) a range ecologist and project manager; (2) a rangeland resource ecologist; and (3) a rangeland plant ecologist. The final cost was $1 926 151 spread over 6 years.

Planned UN personel schedule:




Actual UN personel schedule:




16 Project equipment

The project used one Land Rover, two Peugeot 404 pickups and a Peugeot 504 Break in the field and in Dakar. A 25cc mobylette was also bought for use in Dakar by the project's messenger. Other major materiel included five air conditioners, a refrigerator, two photocopiers, a blueprinting machine, four typewriters, two Nikon cameras, one pair of binoculars, four calculators, and one micro-computer.

17 Training

The project sent the national counterpart to the animal ecologist on a post-graduate course in dryland ecology at the University of Dakar. It also sent one technical assistant to Bamako for a training course in sahelian ecological monitoring. On-the-job training was also given in cartography and the interpretation of satellite images and aerial photographs, in field work in plant and animal ecology, and in scientific method, data analysis, statistics and computer programming.

18 Output of project

The practical application of the GEMS methodologies used by the project was demonstrated in a report (Diop et al., 1984) used by the USAID to assess the impact of a mixed-economy national development project

(SODESP). An international workshop on the "Methods of Inventory and Monitoring of Sahelian Pastoral Ecosystems", held in Dakar in November 1983, served to promulgate and show the usefulness of these techniques in ecological monitoring programs. Biomass maps published each year by the project were distributed to government agencies and used by them in support of requests for international aid in drought-relief. At the request of the Government of Senegal the project sent a special mission to assess the degree to which the grass crop had failed in the test area in the catastrophic year of 1984.

The project had close ties with several national organisations, in particular, with its host Institut Sénégalais de Recherche Agricole (ISRA), the Direction de la Santé et de la Production Animale (DSPA), and the Société pour le Développement de la zone Sylvo-Pastorale (SODESP). Its main service was to provide these organisations with information on the annual production and quality of the rangelands and on livestock distribution and numbers. It was frequently visited by individuals from a wide range of organisations, including the University of Dakar, the Institut Français de Recherche scientifique pour le Développement en Coopération (ORSTOM), the Département Systèmes of the Laboratoire National de l'Elevage, and various European Universities, seeking information and advice difficult or impossible to obtain elsewhere. The project also enjoyed a close and fruitful cooperation with the National Space and Aeronautical Administration (NASA) of the United States of America.

## 19 Follow-up to project

As a direct result of the activities of the project, a national project, entitled the "Centre de Suivi Ecologique pour les Ecosystèmes pastoraux sahéliens" funded by the Danish Government (DANIDA) through the United Nations Sahelian Organisation, has been established. Its headquarters are in Dakar. Some of the staff of the UNEP/FAO project have been recruited to the new centre to provide a continuity in expertise. This project will continue to use the proven GEMS three-tier approach to ecological monitoring, and may extend its activities across most of Senegal. Negotiations are under way for cooperation between the Centre and GRID.

Table 1: Definitions of the Sahel by various authors

Authors: 1 = World Meteorological Organisation No.459
2 = Keay (1959)
3 = Trochain (1952)
4 = Chevalier (1933)
5 = Le Houerou (1976)
6 = Boudet and De Wispelaere (1976)

| RAINFALL (mm) | 700 | 600 | 500 | 400 | 300 | 200 | 100 | 50 |
|---|---|---|---|---|---|---|---|---|
| NOMENCLATURE | | | | | | | | |
| 1 | Sudan-> | <-Sahel-> | | | | | <-Sahara-- | |
| 2 | -----Sudan-----> | <-Sub-Sahara-> | | | | | <-Desert-- | |
| 3 | | <-Sahelo-Sudan-> | <-Sahelo-Sahara-> | | | | | |
| 4 | | | <-Sahel-> | | | <-Sahara-> | | |
| 5 | -----Sudan-----> | <-Sahelo-Sudan-> | | | <-Sahel-> | | <-Sahara/ Sind---- | |
| 6 | | | <-Sahel-> | | | | <-Desert- | |
| | | <-Sahelo-Sudan-> | | <-Sahel-> | | <Sahelo> Sahara | <-Sahara- | |
| PHYSICAL | | | | | | | | |
| 1 | water-> erosion | temporary waterholes | <-dunes in areas of wind erosion-> | | | | <-sandy/rocky dunes | |
| VEGETATION | | | | | | | | |
| 1 | wooded savanna-> | <-savanna-> | | <-bushy> steppe | <-open-> steppe | | <-some plants in hollows | |
| 4 | | <-thorn steppe-> | | | | | | |
| 5 | --sudan----> savanna | <-combretum savanna-> | | <-open (Mimosacae)-> thorn scrub annual grasses | | | <-con- tracted vegetation | |
| 6 | | perennial grasses | | | | | | |
| | | <-mesophillic-> steppe | | <-xerophyllic-> steppe | | <-contracted-> steppe | | |

Table 1 (continued): Definitions of the Sahel by various authors

Authors: 1 = World Meteorological Organisation No.459
2 = Keay (1959)
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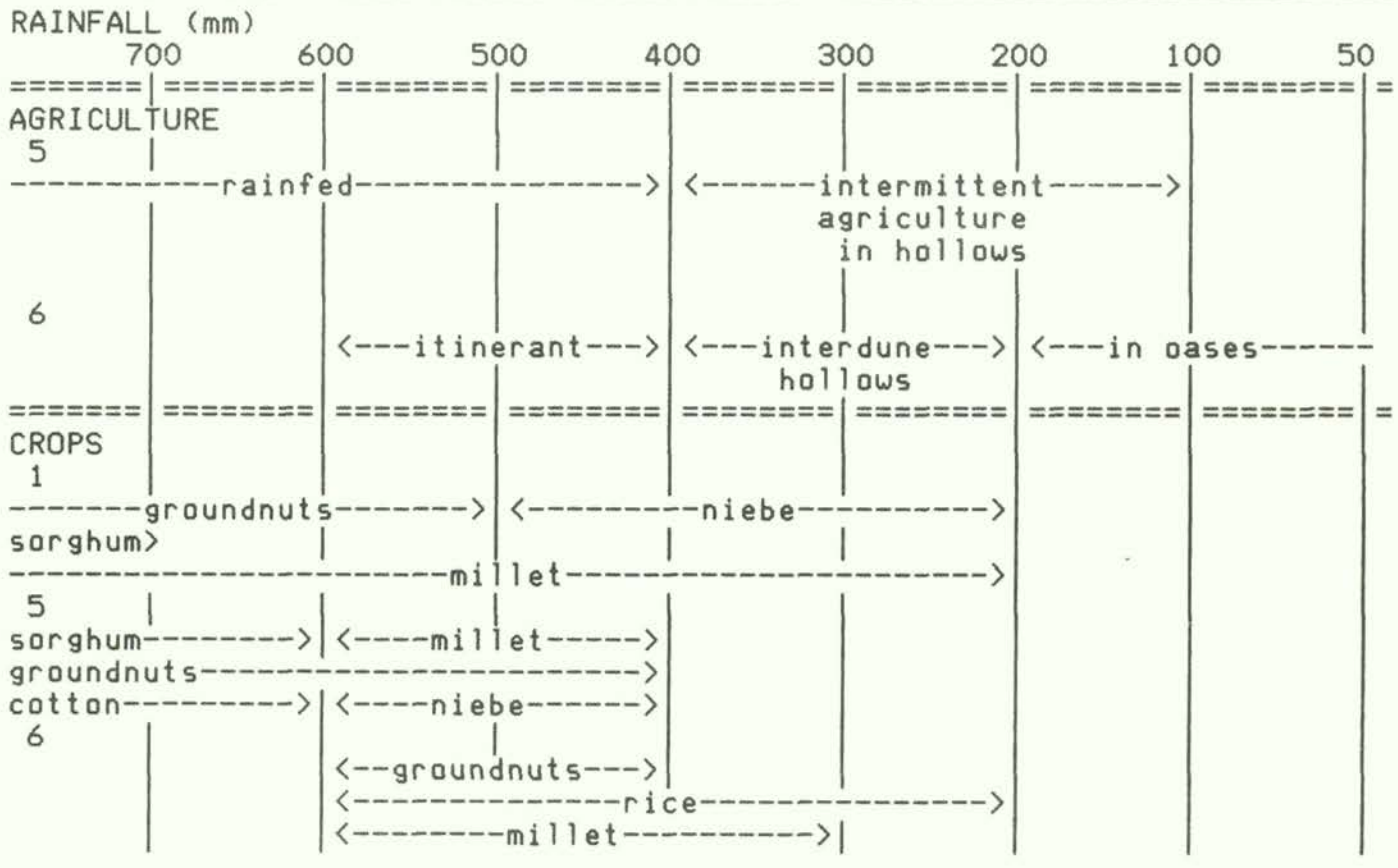


The nomenclature of the various zones is clearly somewhat confused, partly reflecting the difficulty of determining ecological boundaries on the basis of rainfall alone. The majority opinion of the above authors may be interpreted to give the following classification:

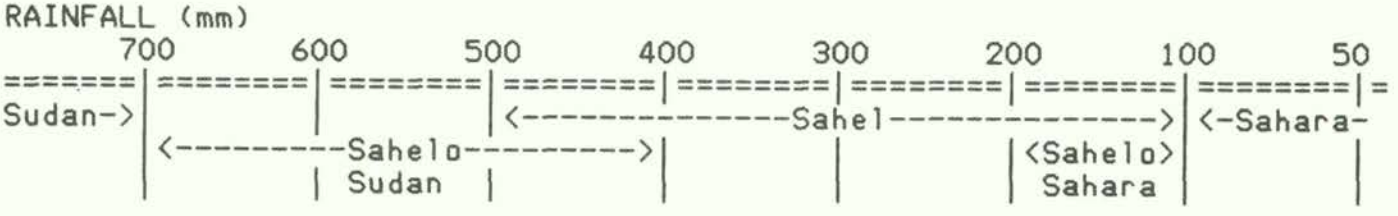

Table 1 (continued): Definitions of the Sahel by various authors

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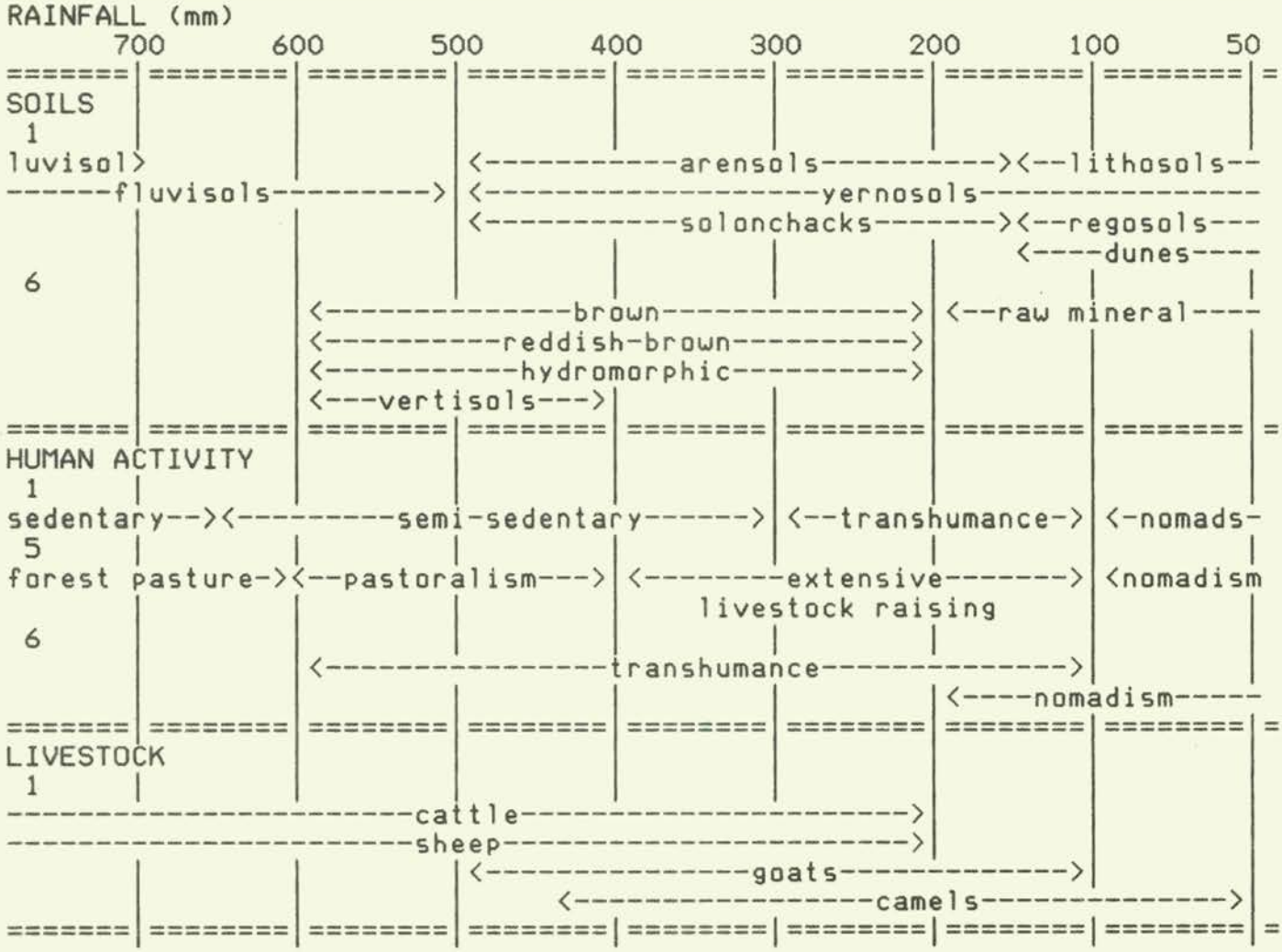

Project Publications

Bellocq A. (1985) Rapport de mission de Consultant. Dactylographié. No copy in files.

Boelcke C. (1981a) Systematic Reconnaissance Flight Data Analysis. I: Rainy Season October 1980. Roneotyped.

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The remaining pages in this introduction give the titles and contents of the other documents in the GEMS Sahel Series.

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| 1 | Introduction to Sahelian Pastoral Ecosystems Project | 9 | 18 |
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| 8 | Monitoring human populations in the Sahel | 20* | |
| 9 | Preparing census data for a Geographic Information System | 15* | |
| 10 | Integrated Approach to Ecological Monitoring in the Sahel | 20* | |

*These figures are subject to major change as the documents are drafted.

Global Environment Monitoring System Program Activity Centre
Sahel Series No 1

Title:
Introduction to Sahelian Pastoral Ecosystems Project

Author: M. Sharman

Target audiences: Development agencies
Range managers
Ecological monitoring projects
Remote sensing projects

Objectives:

(1) Presentation of Pilot Project for the Inventory and Monitoring of Sahelian Pastoral Ecosystems
(2) Presentation of pilot zone
(3) Brief presentation of other organizations active in the pilot zone

Contents (Main headings only listed here):

Global Environment Monitoring System Program Activity Centre
Sahel Series No 2

Title:
Rainfall in the Ferlo (Sahelian region of north Senegal) since 1919

Author: M. Sharman

Target audiences: Government of Senegal
Other Governments in Sahel
Development agencies
Range managers
Data analysts for ecological monitoring projects

Objectives:

(1) To provide data on the rainfall in the Ferlo, north Senegal, for use by government and development agencies
(2) To present techniques for the analysis of rainfall data in the Sahel, including computer programs which can be adapted for the analysis of other time series data
(3) To make recommendations for the correct interpretation of long-term rainfall data

Contents (Main headings only listed here):

Global Environment Monitoring System Program Activity Centre
Sahel Series No 3

Title:
Use of Light Aircraft in the
Inventory and Monitoring of Sahelien Pastoral Ecosystems

Author: M. Sharman

Target audiences: Development agencies
Range managers
Managers of ecological monitoring projects
Projects intending to use reconnaissance flights
Observers on SRFs: manual and checklist
Remote sensing projects

Objectives:

To provide
(1) an introduction to ecological monitoring by use of the low-level systematic reconnaissance flight
(2) advice on the use and limitations of such reconnaissance surveys in the pastoral lands of the Sahel
(2) a comprehensive manual and checklist for managers of such flights and participating crew
(3) a case study of the sahelian region of north Senegal.

Contents (Main headings only listed here):

Global Environment Monitoring System Program Activity Centre
Sahel Series No 4

Title:

Sampling the Sahel

Author: M. Sharman

Target audiences: Development agencies
Range managers
Researchers in ecological monitoring projects
Remote sensing projects

Objectives:

(1) Define terms useful in ecological inventory and monitoring
(2) Discuss problems in designing a sampling strategy for vegetation with particular emphasis on:
    (a) problems particularly likely to be encountered in the Sahel
    (b) collection of data on grass-layer biomass for calibration of satellite images.
(3) Present and discuss methods applicable to vegetation sampling in the Sahel
(4) Examine use of computer simulation in testing sampling methods

Contents (Main headings only listed here):

Part I

Global Environment Monitoring System Program Activity Centre
Sahel Series No 5

Title:

Monitoring pasture production by remote sensing

Author: M. Sharman

Target audiences: Development agencies
Range managers
Ecological monitoring projects
Remote sensing projects

Objectives:

(1) Presentation of method of radiometry for the measurement of biomass
(2) Presentation and discussion of results of hand-held radiometers in the Sahel, with particular emphasis on the utility of various radiometric indices in the estimation of biomass
(3) Discussion of the use of radiometers in light aircraft
(4) Presentation and discussion of results of satellite-borne radiometers in the Sahel

Contents (Main headings only listed here):

Global Environment Monitoring System Program Activity Centre
Sahel Series No 6

Title:
Inventory of water resources in the Ferlo

Author: M. Sharman and A. Diop

Target audiences: Government of Senegal
Development agencies
Non-Governmental Organisations in north Senegal
Ecological monitoring projects in north Senegal

Objectives:
(1) To provide an inventory of water resources in the Ferlo
  (a) rainwater
  (b) superficial water: lakes and rivers
  (c) shallow aquifers tapped by traditional wells
  (d) deep aquifers tapped by mechanical boreholes or deep wells
(2) To present an analysis of data categorising these boreholes
(3) Examination of water in the ecology of the Ferlo
(4) To present a program to classify populations by hierarchy

Contents (Main headings only listed here):

Global Environment Monitoring System Program Activity Centre
Sahel Series No 7

Title:
Reduction of woody vegetation in the Ferlo

Author: M. Sharman

Target audiences: Government of Senegal
Reafforestation projects
Range managers
Ecological monitoring projects
Remote sensing projects

Objectives:
(1) Examination of a 25ha plot in north Senegal monitored after seven year interval

Contents (Provisional main headings only listed here):

Global Environment Monitoring System Program Activity Centre
Sahel Series No 8

Provisional title:
Monitoring human populations in the Sahel

Author: B. Debongnie and M. Sharman

State of completion of document: Planned

Target audiences: Development agencies
Ecological monitoring projects

Objectives:
(1) Discussion of methods and choice of parameters
(2) Methods and parameters for monitoring
(a) demography
(b) land use
(c) pastoral economy

Contents (Provisional main headings only listed here):

Global Environment Monitoring System Program Activity Centre
Sahel Series No 9

Provisional title:
Preparing census data for a Geographic Information System

Author: M. Sharman

State of completion of document: Planned

Target audiences: Development agencies
Ecological monitoring projects
Remote sensing projects
Census bureau
GIS services

Objectives:
(1) A case study of north Senegal
(2) Presentation of data available: format and content
(3) Preparation and transformation of data
(4) Demonstration of the use of the data in a simple GIS

Contents (Provisional main headings only listed here):

Global Environment Monitoring System Program Activity Centre
Sahel Series No 10

Provisional title:
Integrated Approach to Ecological Monitoring in the Sahel

Author: M. Sharman

State of completion of document: Planned

Target audiences: Development agencies
Range managers
Ecological monitoring projects
Remote sensing projects

Objectives:
(1) Discuss the sources of data for integrated monitoring of pastoral ecosystem
(2) Discussion of methods for the generalisation of point or localised data
(3) Discussion of scale
(4) The use of the Geographic Information System

Contents (Provisional main headings only listed here):