

Sand encroachment control in Mauritania

Text prepared by René Grojean in cooperation with the Technical Support Division of UNSO

UNSO ADDRESSES

UNSO Headquarters

For correspondence:

One United Nations Plaza, New York,
N.Y. 10017, USA

Street address:

304 E. 45th Street, FF-9FL New York,
N.Y. 10017, USA

Telephone: (212) 906 5288

Telex: 23 62 86 - 42 28 62

12 59 80

Fax: (212) 906 6345

UNSO Regional Office for Western and Central Africa

Address:

Avenue Dimdoloobsom (sect.3)
B.P. 366 - Ouagadougou
Burkina Faso

Telephone: (226) 30 63 35/37

Telex: 5262 BKF

Fax: (226) 31 05 81

UNSO Regional Office for Eastern Africa

Address:

Gigiri A-125/127
PO Box 30552 - Nairobi
Kenya

Telephone: (254-2) 52 02 89

Telex: 22068 UNEP KE

Fax: (254-2) 52 08 74

About UNSO

Following the disastrous drought that struck the western Sahel in the late 1960s and early 70s, the Secretary-General of the United Nations established the United Nations Sudano-Sahelian Office (UNSO) in 1973, to assist in the rehabilitation of the drought-stricken countries of the region.

In 1976 the Office was transferred to the United Nations Development Programme (UNDP) as a special fund. In 1978 the mandate of the Office was expanded to include responsibility for the 22 countries in the region and the implementation of the Plan of Action to Combat Desertification on behalf of the United Nations Environment Programme (UNEP).

UNSO's current activities embrace a wide spectrum of United Nations medium- to long-term recovery and rehabilitation activities as well as drought-related and desertification control efforts. These include cooperation

with governments in planning and coordination; resource mobilization of external assistance for the affected countries; the establishment of appropriate projects and programmes; service as the United Nations focal point for such regional organizations as the Permanent Inter-State Committee on Drought Control in the Sahel (CILSS) and the Intergovernmental Authority on Drought and Development (IGADD); and the furtherance of information on and public awareness of the ecological and human factors involved in drought and desertification control.

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In working on the establishment of UNSO's institutional memory, the thought has occurred that others - individuals, organizations or institutions - might also be interested in drawing upon the experience which we have made - good or bad.

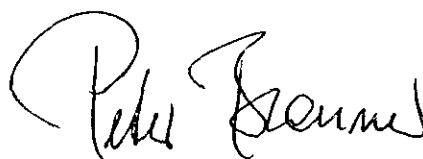
The area in which UNSO is mandated deals mainly with the long-term conservation of productive resources, sometimes termed "desertification control" and which is one of the main components of sustainable development. In terms of development efforts, this is probably one of the most complex and, therefore, challenging areas. Efforts have to be multidisciplinary, dealing with human as well as physical issues and with a long (in principle unending) timespan. It follows that there is considerable scientific uncertainty with regard to the causes, the implications and the cures to be prescribed.

Against this background, we have decided to establish a series of UNSO technical publications in the hope that others may find them useful.

Although the subject matter dealt with here is relatively technical, an attempt has been

made to use vocabulary which is understandable to the non-expert and to avoid unnecessary jargon, in order that the results of the project carried out in Mauritania should be made available to the widest possible readership. This publication is intended for decision-makers, administrators, development workers, researchers, teachers and the interested public.

In publishing this document, UNSO gratefully acknowledges the contributions of the author of this document, of Mr. Axel Martin Jensen and Mrs. Helena Jensen as well as of all staff and Government authorities associated with the preparation of the text.



Peter Branner
Director

New York, June, 1991

INTRODUCTION

Mauritania occupies a unique geo-climatic position in the heart of the Sahel. It is located in the transition zone between the Sahara, occupying the major part of the land area, and the fringes of the Sahelian zone in the south. The irregular and unpredictable rainfall variations have a predominant influence on the stability of the fragile ecosystem. These fluctuations account for the shifts in the climatic boundaries and their impact on economic life.

The persistence of drought during the two 5-year periods 1968-1973 and 1981-1985 has made the natural environment very sensitive to economic and population pressure. The effects of the reduction in biological productivity — degradation of the herbaceous plant and tree cover, decimation of livestock herds and falling agricultural output — have understandably driven the ever-increasing population to over-exploit the natural environment merely to ensure survival.

The sedentarization of more than 60 per cent of the Mauritanian population between 1965 and 1988 resulted from the insecurity of extensive pastoralism which is dependent largely upon rainfall patterns. Precarious settled conditions and the continued existence of the

family herds have contributed greatly to environmental degradation in the areas where these traditional herders have settled. The absence of an agricultural tradition and the difficulty of mastering the techniques of rain-fed agriculture under increasingly unpredictable rainfall conditions have caused a new wave of rural migration to the deceptively attractive urban fringe areas.

United Nations Sudano-Sahelian Office (UNSO) intervention since 1981 has been based on a programme of study, research and experimentation to develop technical tools and methodologies for combating desertification. The approach has concentrated on raising awareness of the relationship between cause and effect in environmental degradation and on providing the population with techniques adapted to combining control of the environment with the development of the production potential.

Throughout the decade, the development of UNSO activities has been consistent with an applied research approach. At the outset, scientific, technical and sociological knowledge of the numerous and varied impacts of desertification was not sufficient or complete enough to provide effective responses to this

Mechanical stabilization along the Route de l'Espoir in Trarza region.

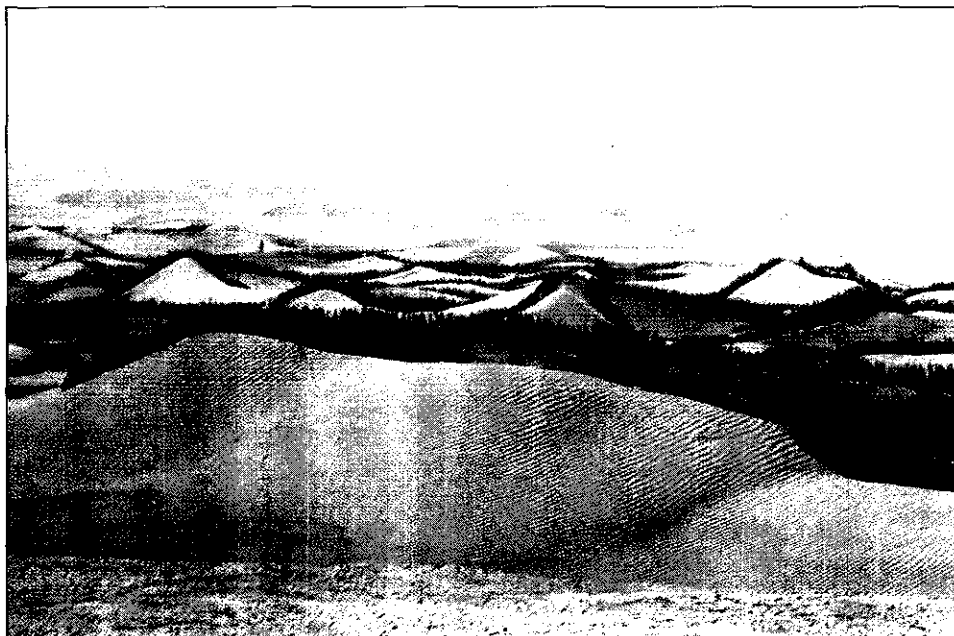


Photo: René Grojean

alarming ecological phenomenon. Rural people subject to difficult living conditions, saw and experienced desertification primarily as part of a hopeless situation of powerlessness in the face of the severity of the drought.

Field research and experiments have tested the effectiveness of techniques adapted to the new climatic conditions and ascertained the degree of interest and level of adoption of the new methods by the population. The principal stages in the implementation of the UNSO programme were:

1981-1983:

General study of the phenomenon of desertification at national level;

1983-1986:

A sand-dune stabilization and fixation project at 15 priority sites representative of the principal types of sand encroachment (an experimental, sectoral, pilot project in curative sand encroachment control);

1987-1990:

A sand encroachment control and integrated rural development project, with

two main components:

- consolidation of technical experience from the 1983-1986 phase and extension to 60 sites, by means of developing a methodology based on the contractual participation of the local population;
- an experimental pilot project on integrated land-use management designed to increase the economic viability of agro-sylvo-pastoral systems and improve human living conditions (preventive desertification control);

1988-1990:

Elaboration of a master plan for desertification control, made up of regional programmes.

Desertification is neither a fixed condition nor the result of a simple physical or climatological phenomenon. It is part of a systematic process of environmental degradation, dependent partly on the unpredictable and uncontrollable deterioration of climatic conditions and partly on the capacity of the people and their economic systems to adjust to such circumstances.

CHARACTERISTICS OF THE DESERTIFICATION PROCESS

Impact of drought

The drought map, which was drawn up using rainfall data for the periods from 1941 to 1970 and from 1971 to 1987, shows that the limit of desert climate conditions (the 100 mm isohyet) has moved southwards during the past 15 to 20 years, over a belt between 100 and 200 km wide. There has been a progressive disappearance of the Saharo-Sahelian vegetation which has not been replaced through natural colonization by Saharan-type vegetation. Ecologically, this buffer zone has become a desert, subjected to intense wind erosion because of the sandy soils.

During the 1970s, rapid degradation of grazing lands throughout this entire belt resulted in a great concentration of pastoral activity in the southern part of the country. The delicate balance between the carrying capacity of the rangelands and the natural regenerative capacity of the herbaceous plant and tree cover was disrupted by drought and pressure from the additional livestock.

This climatic deterioration has had major repercussions on the structure and operation of economic activities. According to national statistics, the cattle population — the livestock most sensitive to the effects of drought — declined by 50 per cent between 1968 and

1981, from 2.1 to 1.2 million head. Whereas in 1970 Mauritania was the second largest exporter of gum arabic in the world, with a production of 7,300 tons, it produced only 200 tons in 1981.

Disruption of the socio-economic equilibrium

Desertification is not the result solely of lack of rainfall. It is a process resulting from the deterioration of a whole series of interactions between man and his environment, which is liable to lead to a major disruption of the ecological balance unless the movement is checked. Such a scenario is likely to arise when the quantity of vegetation removed by man in the course of his economic activities is greater than the productive and regenerative capacity of the natural environment.

The predominantly pastoral lifestyle and production system of Moorish society was abandoned not because of the attractions of modernization, but because of the system's inability to ensure the biological survival of its members.

Increases in needs and levels of exploitation, combined with rapid population growth (2.4 per cent, per annum), considerably exacerbated pressure on the fragile ecosystem. Over the past 20 years, the total population of the country has increased by more than 60 per cent, from 1.1 million in 1968, to 1.8 million in 1988.

Reductions in area of the economically viable Sahelian zone, together with increasing population pressure and inappropriate production practices have resulted in a number of land use conflicts, which have been aggravated because legislation is out of line with current realities. During the past two decades, systems of land occupancy and management have changed profoundly; from a land of nomads, Mauritania has become settled. Legislation has been slow to reflect the consequences of this major social upheaval. The resulting insecurity of land tenure has not encouraged a greater, popular, individual or

Low water in the Senegal river in May 1985 in Bogho, Brakna province. The river can be crossed dryshod by walking on the shoals.



collective responsibility for more careful environmental management.

Land use transformation

The ecological crisis has disrupted the Moorish pastoral lifestyle and economic system and has resulted in a massive settlement of small-scale pastoralists, the redistribution of herds to town-dwelling owners on a speculative basis, the weakening of social bonds and alliances and changes in patterns of management and pastoral migration.

Percentage distribution of population

	1965	1988
Nomads	73	12
Sedentary rural dwellers	18	48
Settled urban dwellers	9	40
Total	100	100

Source: Islamic Republic of Mauritania.
National Statistics, 1989

Sedentarization has entailed a real revolution in lifestyle and land use pattern, which has affected over 60 per cent of the total population. Initially, the nomads set up camps in close proximity to the main roads, particularly along the *Route de l'Espoir* (the Road of Hope), in order to benefit from food aid programmes. Although deprived of their customary subsistence resources, they still hoped to be able to reconstitute their herds and resume a wide-ranging nomadic lifestyle.

Marginalized in an ecological and socio-economic environment ill-adapted or prepared to absorb them, they eventually establish "temporary-permanent" settlements on the outskirts of urban centres. The precariousness of their situation and the remote possibility of social integration result in a nostalgia for the past. The socialization of children in the urban and semi-urban environment, however, is a token of the permanence of the change.

The uncertainties of rain-fed agriculture and the difficulty of access to land for reces-



Photo: René Grojean

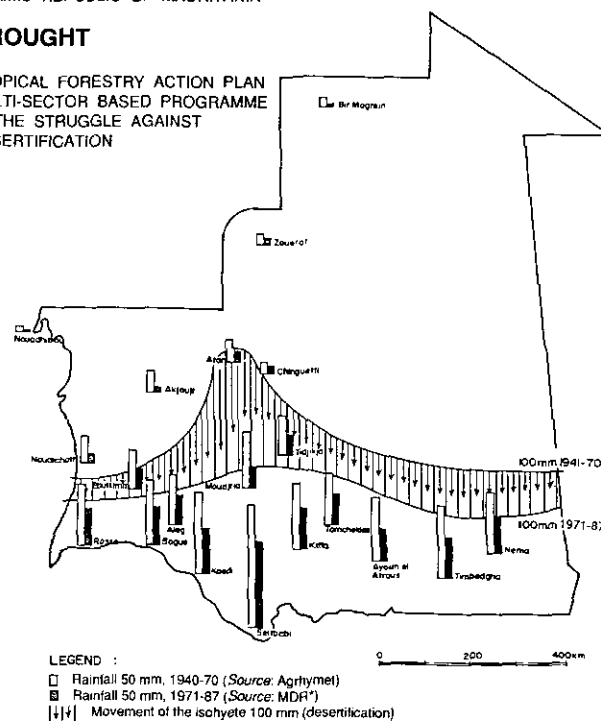
sion agriculture, causes an increasing concentration of sedentary settlement along trunk roads which is an important factor in the environmental degradation caused by firewood collection and overgrazing.

Fodder for domestic cattle in the settlement centres takes strange forms.

ISLAMIC REPUBLIC OF MAURITANIA

DROUGHT

TROPICAL FORESTRY ACTION PLAN
MULTI-SECTOR BASED PROGRAMME
IN THE STRUGGLE AGAINST
DESERTIFICATION



Drawing: Bureau d'Etude et Programmation, Direction de la Protection de la Nature, 1989.

TOWARDS AN INTEGRATED APPROACH TO THE PROBLEMS

The regional seminar on desertification control for Sahelian countries, organized by CILSS and the *Club du Sahel*, and held in Nouak-chott in 1984, recommended that the sectoral approach be abandoned in favour of developing an integrated and multisectoral strategy. Such a change in orientation enables the protection of natural resources to be linked to the economic development of the population. The approach aims to facilitate the transfer of environmental protection techniques to producers anxious to increase food security in their communities.

The key words defining the major emphases of this new strategy — integrated approach, land management, popular participation — seemed unlikely to be easily translated into operational terms, since the new concepts could be interpreted in various ways and field experience was lacking.

The implementation of the curative sand encroachment control project was the first field activity in the UNSO assistance programme and was based on the recommendations set out in the study of the desertification process nationwide (1981-1983). The sectoral content orientation, conceived in 1982, aimed at experimenting with and developing

appropriate techniques of protecting economically important areas threatened by sand encroachment. At the time, this posed a dual challenge: introducing biological protection techniques under extreme climatic conditions and raising awareness among the insufficiently motivated, newly sedentary population who were without training in environmental conservation practices.

The results obtained at the different demonstration sites rapidly showed the potential for protective activities in the rural areas. Given the considerable financial investments necessary, however, the population was only likely to be motivated to adopt these techniques if they could be seen to improve living standards.

The series of corrective measures introduced by the desertification prevention project go beyond the initial sectoral and technical approach. The linking of environmental protection with the development of productive systems responds to a major popular concern. The function of the programme to improve the agro-sylvo-pastoral system is to permit greater control over local natural resources, in order to increase labour and soil productivity. The improvements introduced have led to increased yields, crop diversification and the reduction of human and animal pressure on the environment. Such positive short-term results have given rise to a genuine willingness on the part of the communities to replicate the techniques involved. The implementation of a participatory strategy, based on a contractual arrangement between the people and the project, allows the acquisition and transfer of relevant know-how so that it can be assimilated and integrated into daily practice.

*Planting tamarisk to protect
a palm grove, Adrar.*

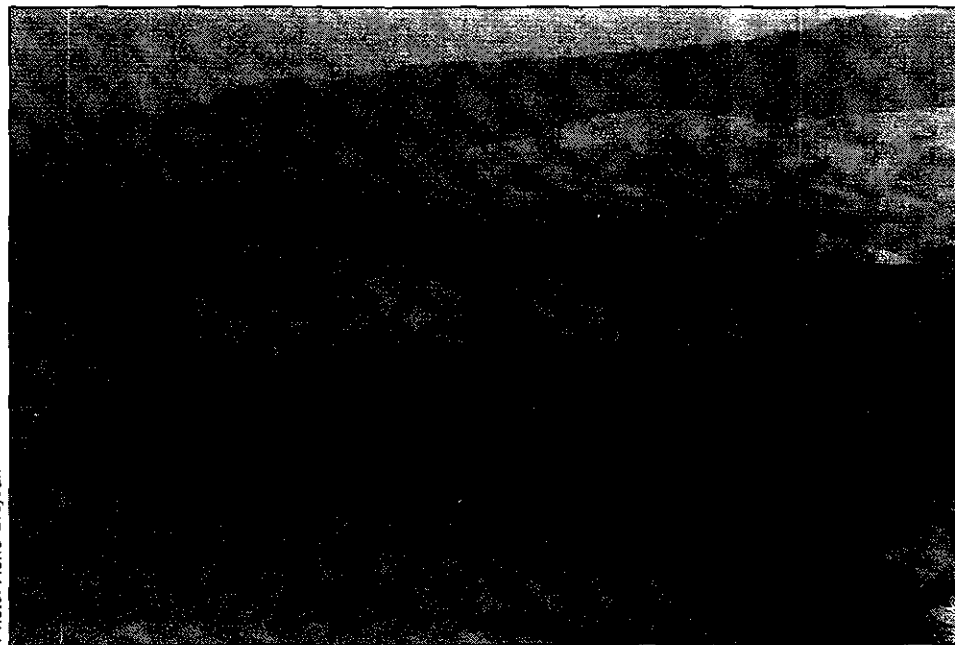


Photo: René Gréjean

A CURATIVE APPROACH TO COMBATING SAND ENCROACHMENT

Project objectives

The programming of this pilot activity is the operational response to the directional decisions taken during the general study of desertification at national level (1981-1983). The choice and distribution of the 15 field sites include the specific characteristics of most regions. The project "Stabilization and Fixation of Dunes in Mauritania" (1983-1986), however, neither aimed nor had the means to solve the serious problem of sand encroachment throughout the country.

The experimental and pilot nature of this sectoral programme aimed at validating protective technical tools as a function of the degree of encroachment and nature of the zones to be protected: urban areas, agricultural lands, palm groves and infrastructure.

The three elements in the vicious circle — degradation, wind erosion and sand encroachment — had reached such critical levels that the continued possibility of human occupancy was in jeopardy in many places. The scientific knowledge and techniques required to undertake the rehabilitation of such a degraded ecosystem in the Saharo-Sahelian zone were almost nonexistent before project activities began.

The work and project execution plans focused on three main aspects:

- study and research programme to be undertaken at the Boutilimit Centre on the mechanisms of sand encroachment and the selection and adaption of species to be used in protection work;
- testing of dune fixation techniques at 15 sites judged to be both of high priority and representative of the principal types of sand encroachment;
- the development of a methodology for ensuring the dissemination of this knowledge and its assimilation by both the national technical services and the population at large.



Photo: René Grojean

Study and research programme

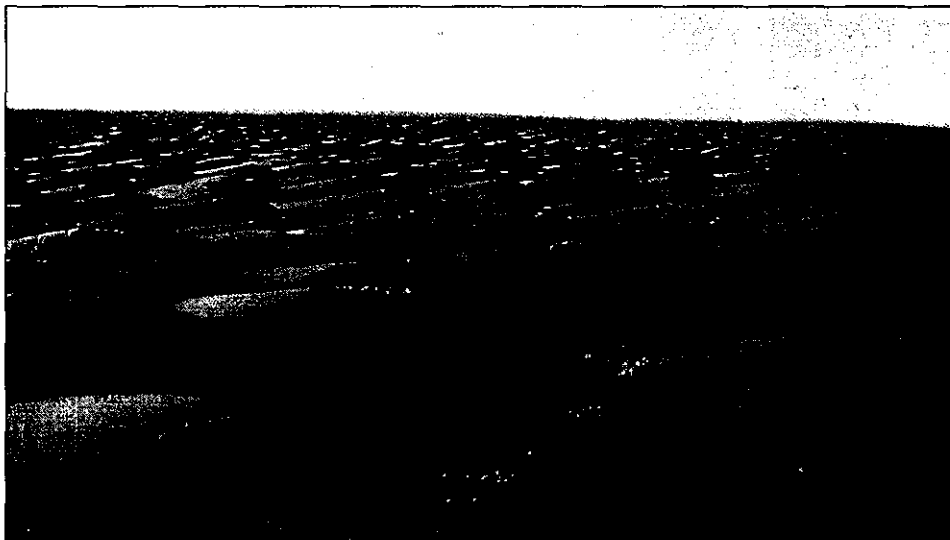
The mechanisms of sand encroachment

As a result of the progressive stripping away of the vegetative cover, the predominantly sandy soils are laid bare. This encourages wind erosion, which has considerable adverse effects for the population.

The number of days when Nouakchott experienced wind-borne sand increased from 41 days/year between 1959 and 1968, to 200 days/year between 1979 and 1983. Sand encroachment along the *Route de l'Espoir* between Nouakchott and Aleg is becoming increasingly critical. In 1981, 21 sites of very localized sand encroachment were recorded, but in 1984, 25 per cent of this 250 kilometre road was covered with sand from January to August. In 1987, it was estimated that an annual budget of \$US 1.5 million would be required to clear the sand from the road. The road between Nouakchott and Rosso is in equally critical condition. In addition, countless houses have been destroyed, villages abandoned and agricultural fields and palm groves are in imminent danger of disappearing if no action is taken.

House threatened by dunes at Aghchovguit, Brakna.

Photo: UNESCO



A field of isolated dunes (barkans).

Photo: René Grojean



*Threat of sand encroachment at
Toungat oasis, Adrar region.*

Sand encroachment is the result of wind erosion dynamics. The displacement of sand grains by wind is a diffused movement over flat, denuded surfaces. Studies carried out in the region of Trarza, which has a serious sand encroachment problem, estimate the volume of sand transported in this manner to be equivalent to 4 m³ per month across an imaginary 1 metre line on the ground. Fortunately, this diffused movement changes to mass movement if the sand is slowed down by an obstacle.

The resulting sand accumulation leads to the formation of isolated barkans and linear dunes. Measurements taken in Trarza show that sand in a linear dune 4 m high is displaced in an oscillating movement from east to west of an amplitude of 18 m and with an annual southward advance of 15 m. The annual volume of sand transport is estimated at 6 m³ per linear metre.

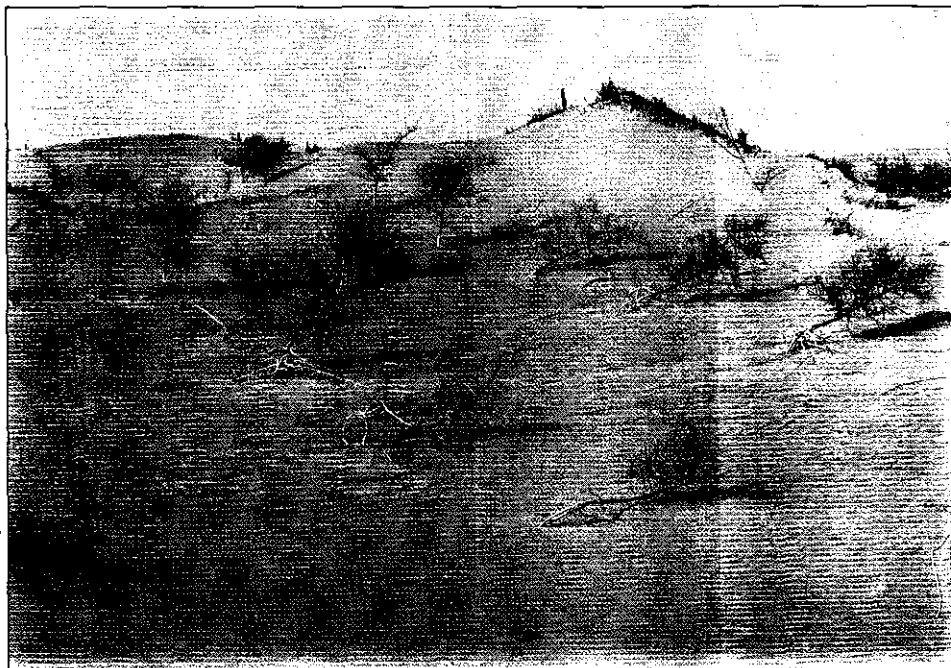
This oscillatory movement causes the lines of dunes to seem to be "marching on the spot". Nevertheless, the southward transport of 6 m³ per linear metre constitutes a source of concern and a constant threat to infrastructure, dwellings and agricultural lands.

The explanation widely publicized in the media, of the spread of desertification as a continuous wind-driven wave of sand transported southwards from the Sahara at a speed of 5 km per year, does not accord with actual measurements that have been taken. In the great majority of sand encroachment situations, the source of the sand grains is usually associated with the presence of a denuded sandy substratum located upwind. The widespread ecological death of large areas, mainly in the northern part of the Saharo-Sahelian zone, could, however, lend credence to the existence of such a continuous wave of sand.

Selection of species for reforestation

In the great majority of cases, mechanical soil stabilization is an indispensable preliminary to the reforestation of moving dune systems. This operation, which is time-consuming and difficult, considerably increases (triples) the cost per unit area. In addition, the difficulty of obtaining plant materials for wind-break construction in the Saharo-Sahelian environment, substantially limits the surface area which can be treated. Research at the Boutilimit Centre has been directed mainly towards the development of reforestation techniques which would obviate, as far as possible, the prior step of mechanical soil stabilization.

The principal biological constraints to re-



Baring of tree roots: within the space of a few months, wind erosion has stripped off the former sandy layer to a depth of more than 30 centimetres, laying bare the roots.

forestation in the dune environment are:

- the abrasive effects of wind-driven sand grains, which destroy the leaves and young shoots of transplanted trees to a level of 30 cm above the soil surface [90 per cent of sand grains moved by saltation (bouncing) are transported at a height of less than 30 cm];
- the risk of uprooting plants (by progressive exposure of the roots) following a large displacement of sand (the deflation effect);
- the danger that plants will be buried in sand deposition or shifting dune areas;
- the limited capacity of transplanted seedlings to grow without secondary watering.

The principal factors favouring reforestation in the dune environment are:

- rainfall run-off is limited and almost all the water infiltrates the soil;
- surface evaporation has no effect on soil dessication below a depth of 40 to 60 cm;

- on bare soils there is no loss of water through transpiration from all competing annual vegetation.

The water balance of dune soils in arid zones is often better than that of other types of soils. In stable dunes, residual moisture is generally found at a depth of 40-60 cm, even at the end of the dry season.

Working hypotheses

On the basis of these various parameters several theories were developed to facilitate the adaptation to and growth of forest species in a dune environment. Among these, the nursery production of large plants (80-100 cm tall) and deep planting (with the root collars placed 20-40 cm below the soil surface) offer a number of important advantages:

- the terminal shoot of the plant is above the reach of the abrasive effects of sand grains;
- placing the roots in the permanently moist soil layer facilitates the self-sustained growth of the trees;

- the risks of root exposure and plant burial are greatly diminished.

Finally, fast-growing species are used in the hope that the trees will develop quickly enough to be able to withstand winter sandstorms.

Results

In the nursery, the addition of nutrients to the planting material used to fill the plastic bags had a very positive effect on the growth of *Balanites aegyptiaca*, *Leptadenia pyrotechnica* and *Parkinsonia aculeata*; a moderate effect on *Prosopis juliflora*; and no effect on the growth of *Acacia albida*, *Acacia senegal* and *Acacia tortilis*. The heights of 3.5 month old plants raised in 2 litre plastic bags (16 cm x 30 cm flat dimensions) filled with windblown sand collected from under large *Acacia tortilis* trees were as follows: *Acacia senegal*, 20 cm; *Acacia tortilis*, 30 cm; *Balanites aegyptiaca*, 50 cm; *Calotropis procera*, 40 cm; *Leptadenia pyrotechnica*, 80 cm; *Parkinsonia aculeata*, 60 cm; and *Prosopis juliflora*, 90 cm.

At the transplantation stage, the species tested — namely: *Acacia holocericea*, *Acacia senegal*, *Acacia tortilis*, *Leptadenia pyrotechnica*, *Parkinsonia aculeata*, *Prosopis juliflora*, *Zizyphus lotus*, and *Zizyphus mauritania* — all stood up well to having their root collars buried in the sand. Direct biological fixation of disturbed sandy soils using the technique of deep planting is particularly possible with *Prosopis juliflora* and *Leptadenia pyrotechnica* because of their initial rapid growth.

The trials showed the complementary aspect of the two species: *Prosopis juliflora* grows badly on interdunal soil from which overlying loose sand has been removed, whereas *Leptadenia pyrotechnica* establishes itself quite well. Eleven months after planting, a growth comparison gave the results shown in the table above.

Comparative analysis of the results ob-

Above-ground green biomass (kg/ha)		
	Soil cleared of loose sand	Sand deposit
<i>Prosopis juliflora</i>	165	1,544
<i>Leptadenia pyrotechnica</i>	539	718
Source: Estimates by A.M. Jensen, 1989		

tained using different planting methods in the reforestation plot adjoining the Boutilimit Centre provides data on the performance of *Prosopis juliflora* and *Leptadenia pyrotechnica*. Planting was carried out without prior mechanical stabilization. Rainfall was 144 mm in 1985 and 125 mm in 1986. The plants were each given 10 litres of water at planting. This is not strictly necessary in such an area, but was done in this case because of delays in putting the experimental planting system into operation.

The importance of using tall plants and of deep planting is clearly shown in the table comparing planting methods for *Prosopis juliflora*. The maximum success rate of 99 per cent was obtained using 90 cm tall, 4 month-old seedlings, planted with the root collar at a depth of 20 cm. Such a result depends more on the size of the container than on its contents. The best results were obtained using 2 litre bags. In comparison, the same plant grown in a 1 to 1.7 litre bag had a success rate of only 64 per cent, despite the use of an enriched potting mixture.

Leptadenia pyrotechnica, a native species, has high success rates whatever plant raising technique and planting method are used, when planted in zones of deflation (without dunes) as at Boutilimit. It is, however, possible to accelerate initial plant growth by using enriched sand as the potting mixture. The advantages of deep planting are not particularly great for this shrub, which is very well adapted to arid conditions.

Owing to their particular applied research

METHODS OF PLANTING: August - September 1985					RESULTS: October 1986		
Age in months	Bag volume (litre)	Sand	Height of plant (cm)	Depth of root collar (cm)	Success rate (%)	Height (m)	BAV* kg/plant
<i>Prosopis juliflora</i>							
3	1.25	Collected under the trees	50	Surface	39	0.66	n.a.
4	2.00	"	90	10	87	0.83	n.a.
4	2.00	"	90	20	99	1.04	n.a.
4	2.00	"	90	30	86	1.06	n.a.
4	2.00	"	90	40	80	1.21	n.a.
4	1.0-1.7	Wind deposited	51	10	37	1.18	n.a.
4	1.0-1.7	Enriched	61	20	64	1.18	n.a.
<i>Leptadenia pyrotechnica</i>							
2	1.25	Collected under the trees	40	Surface	89	0.94	n.a.
4	2.00	"	80	10	86	1.07	n.a.
4	2.00	"	80	20	88	1.10	n.a.
4	2.00	"	80	30	92	1.16	n.a.
4	1.0-1.7	Wind deposited	62	10	93	n.a.	1.0
4	1.0-1.7	Enriched	83	20	94	n.a.	3.0

Source: Estimates by A.M. Jensen, - Boutilimit Centre 1984-1986, Mauritania.
***BAV:** Above-ground green biomass (kg/plant), 2.00 litre bag: 16cm x 30cm flat dimensions.

nature, the other conclusive results of the study programme will be discussed later in the text, as the different phases of activity are presented.

TECHNIQUES FOR COMBATING SAND ENCROACHMENT

Overall, the technical advances and trials effected under the project have the distinctive advantage — from the point of view of extending the results — that they were initiated under the most hostile climatic conditions and in the most degraded parts of the Sahel. The degree to which the condition of such a degraded ecosystem is permanent or reversible was a major question at the start of the project.

In theory, the techniques for combating sand encroachment seem relatively simple; a question of re-establishing a sufficiently dense vegetation cover on areas of moving sands. Biological techniques such as prohibiting grazing, planting belts of herbaceous plants and reforestation are the principal means of encouraging the ecological restoration and soil fixation of such areas.

Such seemingly simple activities are not easily adopted by the population, because they do not form part of their existing environmental attitudes and behaviour. Concern for the restoration of renewable natural resources has only recently become of vital interest to the nomads.

The free ranging of household domestic

livestock, with consequent overgrazing, is one of the principal causes of land degradation around settlement areas and is a significant threat to the viability of reforestation measures. Under the system of "common-land grazing", control of livestock is very difficult to enforce without fencing the areas to be protected. This major constraint is very difficult to overcome and prohibitively costly, given the size of the areas to be enclosed. The involvement and organization of village communities are indispensable prerequisites in ensuring the protection of the measures taken against sand encroachment.

Mechanical soil stabilization

Biological fixation methods in a sandy substratum are possible only when the soil is stable, so that the disastrous effects of wind erosion — burial of seedlings and root exposure of seedlings and plants — are avoided. Sites subject to sand encroachment are usually surrounded by live dunes. Direct reforestation of live dunes more than 1.5 m high is

Laying of a wind break with Euphorbia branches at the Mederdra site, Trarza. Euphorbia also has the advantage that it can be propagated from cuttings.



Photo: René Grajean

biologically non-viable and necessitates the preliminary step of artificial, temporary soil stabilization.

Mechanical stabilization involves establishing some protective system against the transport of wind-driven sand by means of a network of screens or fences constructed of local materials (e.g., *Euphorbia*, *Leptadenia*, *Calotropis*, palm fronds, branches of thorny bushes or trees, etc.). The function of such windbreaks is to halt the movement of sand grains within the enclosure temporarily, thus permitting the development of vegetation. The windbreak should remain effective until the trees planted can take over the function themselves (in 2 to 3 years depending on the site).

In order to reduce the strong and destructive effect of the wind on the stability of the windbreak system, the individual screens should be so constructed as to let some wind pass through, with the aim not of halting, but rather of disrupting the dynamics of the sand transport. As 90 per cent of the moving sand grains are transported at a height of less than 30 cm above the soil surface, the windbreaks should be 50-75 cm above the ground.

Construction standards for the system vary, depending on wind patterns and the intensity of wind erosion. In the eastern part of Mauritania, where prevailing winds are from one direction, the installation of parallel lines of windbreaks is sufficient. In the western part of the country, where winds blow from various northerly directions, a gridiron pattern of barriers is more appropriate. The distance between them varies according to wind intensity and the configuration of the dune. It can range from 10 to 20 metres.

Windbreak system construction and maintenance requires a substantial financial investment. Obtaining construction materials locally is very difficult in some regions. At several sites, natural vegetation often had to be gathered several hundred kilometres away. The fences, which cannot easily be raised, are rapidly covered by trapped sand. Over the first two years, they will need to be replaced three or four times. Natural material substitutes have been tested using fibreglass panels,

but the results have been disappointing.

The cost per hectare of mechanical stabilization ranges between \$US 500 and \$US 2,500, depending on the degree of sand encroachment, the intensity of erosion and the availability of construction materials for the windbreaks. Such activity is beyond the financial and technical means of a village community wishing to install this type of encroachment protection. Logistical and technical assistance must be provided to the people, both in the design and organization of activities. Training and familiarization with techniques of cutting the required materials are essential in order to prevent the disappearance of the scarce remaining natural vegetation stands.

Infrastructure protection

In some situations, for example the protection of roads or isolated houses, the aim is not to stop the sand, but to halt the advance of the dunes. For these specific cases, the project successfully tested a less expensive method, which uses natural wind action to clear sand away from the infrastructures to be protected.

The principle of the technique involves exploiting one of the mechanisms of wind dynamics. A reduction of wind speed leads to sand deposition; conversely, wind acceleration causes sand to be picked up. If an artificial obstacle is set up in the path of the wind at a distance such that the infrastructure is in the zone where the wind picks up speed again, a sweeping effect is created which progressively clears the sand from the infrastructure solely by the mechanical action of the wind.

The tested section of the Nouakchott-Boutilimit road most seriously threatened by dune invasion, was completely cleared of sand in 18 months, by creating a counter-dune 5 m high, 45 m from the road. Initially, the counter-dune was raised to a height of 2 m using a dump-truck, after which it was continually built up by installing windbreaks as sand gradually accumulated.

The construction of a counter-dune does

not prevent the passage of sand, but since it is higher than surrounding dunes, the mass movement of dune advance is transformed into diffused movement, which helps to protect the infrastructure. This method is very useful in areas where the rainfall is too low to permit biological fixation. In the experiment carried out between 1970 and 1984, (located 23 km east of Nouakchott at the 50 mm isohyet), plantations of *Prosopis juliflora* and *Leptadenia* survived fairly successfully, but they were not capable of fixing the soil.

This technical experiment does not imply any undertaking by UNSO to implement a wider programme to protect the road network, particularly the *Route de l'Espoir*. Bearing in mind the importance of the task of rehabilitating the environment and the limited resources available, the objectives of the action programme are concerned primarily with the protection of inhabited areas and productive lands.



Young *Balanites aegyptiaca* plant, about 6 months old.

Biological soil fixation

Re-establishing a vegetation cover (grasses and trees) is a key element in the restoration of desertified land. Planting trees effectively combats the sand encroachment process. Certain species can enrich the soil, resulting in an increase in agricultural yields and pasturage. In the medium-term, reforestation will also provide an energy supply source for the population.

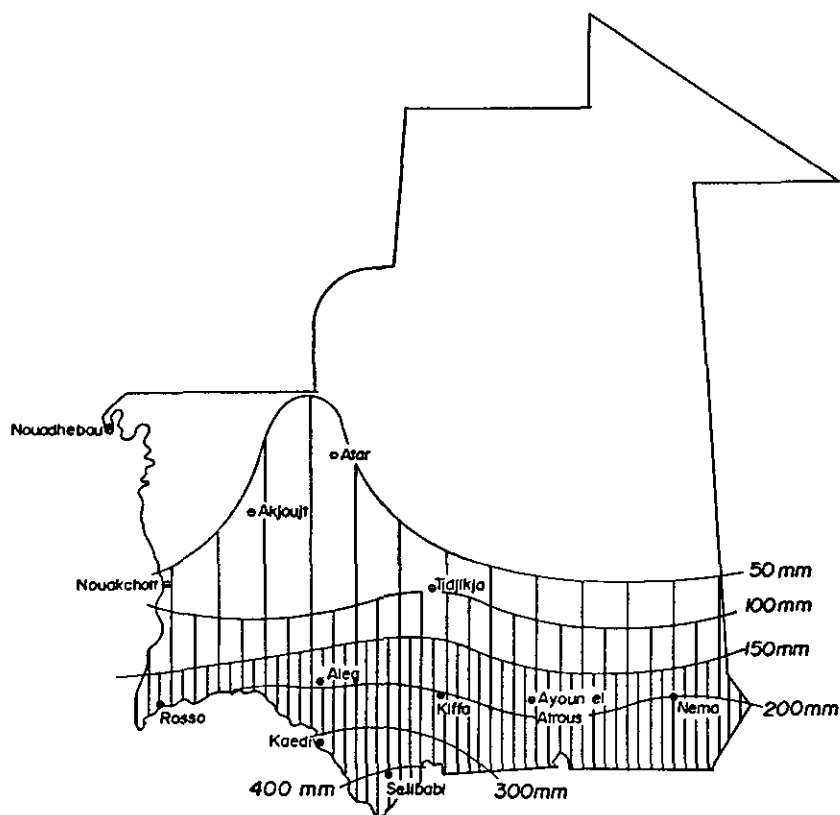
Reforestation in this particularly arid and ecologically degraded Sudano-Sahelian zone poses a number of specific problems in view of the low rainfall, increasingly serious wind erosion and activities of a population to whom survival is more pressing than combating desertification. In the minds of the people, trees and the renewal of natural resources are "gifts of God". At the outset, raising plants for reforestation purposes did not seem as if it would receive enthusiastic popular support.

Choice of species

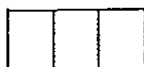
Given the intensity of wind erosion in Mauritania, biological fixation of live dunes is technically possible only if nursery stock (almost exclusively tree species in the project) is used. During the second phase (the preventive control project), direct seeding trials for reforestation were conducted at Chogar Gadel (Brakna) during the 1988-1989 season and an acceptable success rate was achieved. Although this result is encouraging, it should be qualified by pointing out that level and stable test sites were selected and that the rainfall distribution was particularly good.

The choice of forest species for biological dune fixation depends primarily on the capacity of the species to adapt to the environment (rainfall level and soil structure) and on the end-use of the reforestation products. Except for naturally occurring local species in the area, data on the ability of exotic species to adapt to this environment were almost nonexistent. Research carried out enabled the selection of species best suited to achieving the

Photo: René Grojean



ZONE



On dunes

Prosopis juliflora



Around the garden

Parkinsonia aculeata



Around the house

Prosopis juliflora



PERMANENT IRRIGATION

Acacia senegal
Acacia tortilis
Calotropis procera
Leptadenia pyrotechnica
Parkinsonia aculeata
Prosopis juliflora

Acacia senegal
Calotropis procera
Parkinsonia aculeata

Prosopis juliflora



20 LITRES GIVEN AT PLANTING

Acacia senegal
Acacia tortilis
Calotropis procera
Leptadenia pyrotechnica
Parkinsonia aculeata
Prosopis juliflora

Acacia senegal
Calotropis procera
Parkinsonia aculeata
Zizyphus mauritiana

Azadirachta indica

1970-1984

Source:
 Ministry
 of Rural
 Development

RAIN-FED

desired objective.

The primary objective of the desertification control programme was to find fast-growing species to fix the soils and secondarily to yield by-products (forage, timber, etc.). The chosen local (*Leptadenia*, *Acacia*, etc.) and exotic species (*Prosopis*, *Parkinsonia*) responded rapidly and remarkably successfully to the dune fixation problem. Other research and experiments were conducted in response to the popular desire to plant specific species (forage and fruit trees) around fields and houses.

The map above summarizes the choice of forest species as a function of rainfall level and planting location.

Planting calendar

The major concern of the project team was to test and develop a body of measures and know-how to enable seedlings to grow without assistance, thus avoiding as far as possible, the difficult problem of watering.

The vast majority of soils in the Saharo-Sahelian zone have a sandy substratum. Despite this apparent inhospitability, which is particularly marked throughout the dry season (Octo-

ber to June), sandy soils have the advantage of effectively absorbing and conserving moisture from the light rains of the wet season (July to September). After 10 months of intense dry heat and very high evapotranspiration, residual moisture in stable soils is found at an average depth of 60 cm.

The planting season extends from August to September, during the rainy season. Ideally, planting should begin as soon as surface moisture from the rains penetrates as far as the residual moisture in the soil. This natural meeting of the moist layers occurs in areas where annual rainfall is more than 150 mm rainfall.

Techniques for growing and planting trees

The joining of surface and residual moisture is a constraining if not critical factor in reforestation activities. If the roots of a young plant reach a deep layer of dry sand, growth stops. Project technicians have successfully developed several efficient and well-adapted techniques to mitigate any moisture deficit at planting time: large plant production, deep

Villagers carrying seedlings to the reforestation area in the neighbourhood of Kiffa, Assaba region.



Photo: René Grojean

planting and supplementary watering.

It is recommended that plants in the nursery be raised in 25-30 cm high containers to promote both root system development and plant height. At the time of transplanting, this offers a double advantage; the longer and more vigorous the roots, the sooner the seedlings can establish an independent growth pattern; and the use of tall plants affords better protection against the abrasive effects of wind erosion.

Using the same sandy material as that of the future planting site when filling the planting bags yields good results during the three to five months that the seedlings are grown in the nursery. The several hundred thousand trees planted in the course of the project were grown in this way, without any significant negative effect on growth. Apart from the difficulty and extra work involved in finding enriched potting mixtures, this simpler technique facilitates the technological transfer of the process to the people. As demonstrated, bag size and the age of the plant are the critical factors influencing planting success.

For most species, deep planting yields much better results than surface planting. Burying the root collar 20-40 cm below the soil surface helps the plant to establish itself, by enabling it to reach the residual moisture layer more rapidly, whilst also offering greater resistance to root exposure by the wind or burial by moving sand. Different planting methods were tested, both at the research centre and on reforestation sites. The greatest successes were observed on plots where deep planting was employed.

Supplementary watering is a manual technique which involves adding water to the soil in order to facilitate contact with the residual moisture layer. To avoid lateral dispersal of water in the upper soil layer, a hollow cylinder 40 cm long and 30 cm in diameter is inserted in the sand. The cylinder is lowered automatically as the sand is manually cleared away from inside it. The quantity of water required per plant depends on the rainfall and the depth of the residual moisture. Generally, it ranges between 20 and 40 litres per plant.



Photo: René Grojean

Prosopis juliflora is the fast-growing exotic species most widely used for dune reforestation in Mauritania. The variety used is similar to those from Lake Chad and Cape Verde. The results obtained on the Boutilimit and Magta-Lahjar sites are shown in the table overleaf.

In an area with about 200 mm rainfall and a rich sandy substratum (clay content greater than 2 per cent), a tree survival rate of 70 per cent and an average annual production of 2 m³/ha can be expected in dune forestation, provided that the dunes are not more than 2 m high.

Plantation maintenance and protection

Because of the degree of ecological degradation in the areas to be reforested, maintenance problems focused on mechanical soil stabilization (the re-erection of windbreaks buried by the sand or blown over by the wind) rather than on the insignificant competition offered by herbaceous vegetation.

Reforestation with Prosopis juliflora after one year at the Magta-Lahjar site, Brakna region.

PLANTING METHOD					RESULTS				
Age (mo.)	Bag litres	Sand	Collar (cm)	Water l/pl.	Age (mo.)	Success rate (%)	Height (m)	Volume (m ³ /ha)	BA* (t/ha)
SITE: <i>Boutilimit</i> 100 mm isohyet (1970-84), poor sand (clay 1%), live dunes 0.5 - 2m, no mechanical soil stabilization.									
4.5	2.00	en-riched	40	no	31	70	2.4	1.5	2.1
SITE: <i>Magta-Lahjar</i> 150 mm isohyet (1970-84), rich sand (clay 3%), water table at 8 m depth, interdunal areas and live dunes 0.5-2 m, mechanical stabilization with artificial dunes 150 m away.									
5	1.25	rich garden soil	20		49	83	4.8	20.2	19.6
3	1.25	rich garden soil	10	20	36	56	4.2	10.5	10.3
3	1.25	rich garden soil	10	20	24	70	3.2	3.5	4.3
Source: Estimates by A.M. Jensen, 1989. *BA: above-ground biomass									

Protecting plantations from roving animals remains the major problem to be resolved, as it is throughout the Sahel. During the first reforestation field trials, popular scepticism, numerous land disputes and insufficient consultation on the advantages and benefits of plantations hindered the development of conservation-orientated attitudes and habits among the rural population.

Different methods were tested, with participation from affected village communities, to try to find technically and financially acceptable solutions. The employment of paid guards, establishment of livestock pounds and use of herdsmen to control village herds proved effective, but they were not always sufficiently reliable in the absence of external

technical supervision. In the interests of easing latent tensions between livestock herders and sedentary farmers and encouraging the dissemination of technical knowledge, the project finally decided to include the installation of protective fences as a fixed cost of sand encroachment control programmes, when the land in question is near urban areas.

Development of mass motivation and participation

During the first two years work at the 15 experimental sites, community relations with and reactions to the project basically consisted of polite indifference, or curiosity about the "mad scientists" who proposed to make trees grow on sand dunes.

This attitude was equally apparent in certain institutional circles, which challenged the advisability of "investing money and energy in sand" when the country had to face a multitude of other problems which were judged to be of higher priority.

For their part, the technicians, who were heavily involved in the difficult work of developing and testing techniques adapted to such an environment, seemed reluctant to evaluate or devise methods of enlisting mass participation - an element formally included in the operational plan. In retrospect, it must be admitted that this attitude does not seem particularly consistent with the experimental and pilot nature of an operation which was originally envisaged as part of a state contracted activity.

The varying status of the workers - hired under contract, recipients of food rations (food for work) and short-term voluntary participants from mass organizations (SEM) — was not conducive to any popular acceptance of the idea of participation, which in any case was more problematical and casual than really effective.

The development of a participation component presupposes community support and joint definition of freely contracted activities among the various partners. Such an approach involves establishing communication and dialogue in order to take the priority problems as expressed by the people fully into account.

The effect of demonstrating the technical results achieved at most of the sites quickly resolved any ambiguities concerning participation. Several village communities located

outside the project area spontaneously showed an interest in undertaking voluntary and independent action to protect their houses or fields against sand encroachment.

The project proposed to provide technical assistance to these communities by developing an implementation plan and programme, training village representatives at project sites, supplying tools and materials (watering cans, plastic bags, etc.) and providing logistical support for major tasks beyond the means of the local people.

The results of these micro-experiments on the acquisition and adoption of technical know-how were encouraging. They provided a means of testing and measuring the capacity and limits of community commitment to initial environmental control activities. Concerted effort, dialogue and the careful monitoring of operations served to clarify the broad conceptual aspects of participation and to formulate a realistic methodology based on the people's capacity for involvement. All the data collected were used to draw up the contractual participation methodology developed in the preventive desertification control project.



The risk of sand encroachment on farming lands is substantial if nothing is done to halt the wind. Toungatt oasis, Adrar.

Photo: René Grojean

Financial and socio-economic evaluation

The choice of the 15 demonstration sites for the pilot sand encroachment control programme was dictated primarily by the need to represent all the various forms of sand encroachment and by the gravity of the threat (the Adrar palm groves, the *Route de l'Espoir*, etc). The costs set out below show, in decreasing order of magnitude, the large financial investment required for curative control methods.

	Range \$US/ha	Average cost \$US/ha
Mechanical stabilization	500-2,500	1,000
Biological fixation & fencing	500-1,000	750
Biological fixation	300- 500	400

*Source: Estimates by A.M. Jensen, 1988
(workers' wages were paid half in cash and half in provisions)*

The cost range is particularly striking and can be explained by variations in local conditions: rainfall, intensity of wind erosion and sand encroachment, remoteness or accessibility of the site to be treated, availability of

materials for mechanical stabilization and the existence of a well to supply the tree nursery.

A purely financial analysis is an insufficient, if not inappropriate, justification for intervention under such conditions of ecological degradation and crisis in traditional production systems. Other than in cases of protecting infrastructure (e.g., the *Route de l'Espoir*) where concrete data are available, an evaluation of the benefits in strictly economic terms (e.g., agricultural yields, houses saved) ignores the distress and disruption created in people's lives. The indirect social costs (for example, rural exodus, increased poverty) and the costs of ecological rehabilitation and land management need to be integrated into the analysis in order to derive a wider evaluation than one based on restrictive accounting considerations.

The impact of protection activities on local economic development was evaluated by studying two neighbouring and comparable localities in the Brakna region. Using a series of criteria, the study showed a positive economic growth rate of 5 per cent in the protected site at Magta-Lahjar, as against a decline of 6 per cent on the unprotected site at Cangarâfa. Protection also has a perceptible impact on behaviour, as reflected in a renewal of confidence: the level of income reinvestment is twice as high in Magta-Lahjar as in

Clearing sand from infrastructures by mechanized means is very expensive and has only a temporary impact - Route de l'Espoir.



Photo: René Grojean

Cangaráfa².

The technically and demonstrably successful curative sand encroachment control pilot project did not aim directly to promote socioeconomic development. It was primarily a necessary technical operation to ensure the perpetuation of lifestyles and livelihoods in village and urban communities.

The cost of a curative sand encroachment control programme may seem high in relation to the country's limited means and the growing number of sites to be protected. If such activities are to become widespread, however, it is essential that technical know-how be transferred and integrated into economic practices.



Photo: René Grojean

The use of old clothes to protect the small market-gardening plots shows the determination to combat wind erosion. Bareina village, Trarza region.

² Helles, F. and P. Joergensen, 1989; Socio-economic study on the towns of Magta and Cangaráfa, study prepared for UNSO project UNSO/MAU/85/X04: "Support institutionel à la direction de la protection de la nature"; (unpublished).

EVALUATION OF THE CURATIVE SAND ENCROACHMENT CONTROL PROGRAMME

The activities of the programme should be evaluated in terms of a sectoral, experimental and pilot intervention.

Technically, the indicators of success and effectiveness — that sand encroachment could rapidly be controlled — were achieved at almost all experimental sites. The greatest achievement lies in the development of techniques adapted to the environment and capable of ensuring unattended tree growth which are easily replicated by the people.

The possible need for secondary watering after planting was a major question and constraint on the viability and long-term success of an operation in such climatic conditions. The package of measures described in the section on the techniques of raising and planting trees resolved this key issue, by yielding a tree survival rate which was usually over 70 per cent.

On the socio-economic level, it must be remembered that the primary objective of the project was to define a set of technical measures to protect population centres and areas of economic activity against sand encroachment, as an essential prerequisite to sound development. The remarks of a villager from Kiffa represent the general feeling of the people about the measures undertaken:

"The implementation of the project in 1984 was of great benefit to our neighbourhood. My neighbours and I anticipated having to abandon our houses and settle elsewhere. Before 1984 when this project came to stabilize our dunes, I never realized how useful a tree could be. For a year we have not had to worry, our buildings are protected against sand encroachment and I personally intend to plant more trees".

The stimulation of people's awareness of the cause and effect relationship in ecological degradation was an important achievement which gave them renewed confidence in their ability to control and transform their own environment. Mass participation in the activities remained below project expectations for three major reasons: the experimental character of the project, the choice of freely contracted labour and insufficient joint discussion.

The experiments in disseminating technical knowledge to communities not originally included in the project, but participating voluntarily, served to test and assess the potential and limits for replicating such an operation on a larger scale. The lessons learned led to the definition of realistic guidelines for developing a methodology of contractual community

After two years, this Prosopis juliflora plantation has successfully protected Magta-Lahjar, Brakna.



Photo: René Grojean

participation for the second phase of the project.

The expansion and continuity of protection activities depend primarily on the political will and institutional capacity to promote and provide leadership for such activities. National technical services are perfectly capable of developing the technical operations, but they will probably have insufficient resources to continue when the project ends. Mechanical soil stabilization usually demands technical and financial inputs which are beyond the means of local communities. In addition, insecurity of land tenure does not induce the producers to take responsibility for and invest in the protection of their environment.

Weak capacity to mobilize national financial resources and concern to ensure a wider adoption of these techniques caused UNSO to develop a strategy for preventive action to combat desertification, combining environmental conservation with the development of the productive capacity.



Photo: René Grojean

Early learning and the development of behaviour patterns: a hopeful sign for the future.

A PREVENTIVE APPROACH TO DESERTIFICATION CONTROL

Project objectives

The general objectives of this desertification prevention pilot project (1987-1990) are stated in the operational plan:

- "to increase efforts to combat sand encroachment and reduce pressure on the environment caused by exploitation;
- to institute integrated management schemes so as to make agro-sylvo-pastoral systems more economically viable through more appropriate utilization of existing resources and the creation of new resources;
- to improve the standard of living of the rural population in order to slow down the exodus to the towns."

The ultimate goal of the second phase is to establish new socio-ecological equilibria by developing and popularizing production methods and practices which are better adapted to drought conditions and capable of ensuring greater food security for the population.

Implementation of this new approach involves going beyond the previous strategy of sectoral intervention to adopt the wider concept of development and the promotion of rural communities. By taking such a broad and multisectoral approach to the problems, a programme can be drawn up which simultaneously addresses the environment, production and the people. It hinges on two complementary conceptual approaches: voluntary popular participation and the consideration of village lands as the development unit of productive systems.

The project work plan has two major components:

- extension of the existing sand encroachment control programme to 60 sites by formulating a methodology for popular participation;
- research and testing technical developments in the productive systems, capable of

combining environmental rehabilitation with socio-economic advances for the people.

Development of a methodology for participation

Dissemination of the technical knowledge gained in the first phase of the project (1983-1986), by means of a programme to extend sand encroachment control activities to 60 sites, called for the definition of new relationships between the project and the people concerned. In response to strong demand from the communities for intervention, but with fixed human and financial resources, the project planned to develop an organizational method for governing local community participation.

The major difficulties

During the research carried out in the first phase, four major issues on the content and ways of implementing the concept of participation had been noted and studied: the organization of grass-roots partners, their capacity to accomplish the tasks, types of incentives and the management of reforested areas.

- Identifying a local organization representative of the community's socio-economic interests is a prerequisite for establishing dialogue and agreement with the technical services. Massive sedentarization and the crisis in productive systems have considerably modified social structures and old patterns of interdependence. Collaboration with the mass organizations did not reach the desired levels, because their major role was political orientation. The new decentralized administration which is currently being established, based on establishing communes as a territorial unit, should be more representative and responsive to the specific concerns of the population.
- The experiments in protection conducted

with volunteer communities during the first phase of the project enabled the capacity and limits of participation to be measured and evaluated. Setting up a seedling nursery, tree planting, maintenance and the management of reforested areas are easily replicable by villagers, given technical guidance and adequate training. The installation of mechanical soil stabilization structures is beyond the available means and resources, owing to the size of the task and the difficulty of supplying work sites with windbreak construction materials.

- Whether popular participation should be accompanied by incentives, or if consciousness-raising alone is enough, is a question which has long been debated and investigated in the field. The answer depends primarily on the socio-political context and the willingness of authorities to harmonize all action programme strategies in the same sphere of activity. In Mauritania, the precarious food situation led the authorities to set up an extensive food aid and security network. When there is no food shortage, however, previously freely distributed emergency aid is used in food for work pro-

grammes to motivate people to take part in development activities. This has led the people to consider that all participation deserves compensation, an understandable attitude in the case of environmental rehabilitation activities, which produce no short-term economic benefits. Compensation is claimed on the pretext that agricultural work clashes with that of reforestation, but recession cultivation behind dams is carried out after the rainy season, thus not during the time of tree planting.

- The management of reforested areas raises numerous problems directly related to the uncertainty over the land tenure issue. The superimposition of recent legislation, under which development of an area confers rights of use (while still remaining state property), in preference over respected customary land rights is the source of many conflicts. On several occasions, different local groups have claimed ownership of reforested land areas, by virtue of customary tribal rights. More often, people consider, not illogically, that if the land belongs to the State, then it is the Government's responsibility to take the necessary measures to

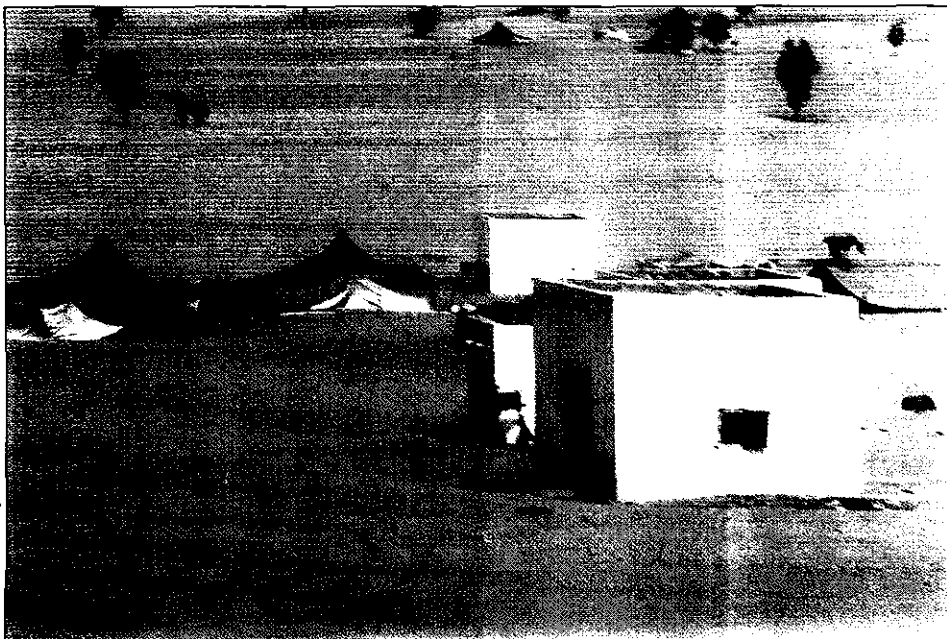


Photo: René Grojean

The absence of guaranteed land tenure is a disincentive to assuming responsibility for and investing in environmental protection.

maintain and protect it. Such debate, which is essential in strengthening new attitudes and behaviour patterns towards the environment and development activities, is beyond the scope of the project. The guarantee of individual and collective rights of usufruct (usage) is a prerequisite to land development and management.

Implementation of contractual participation

Experience acquired over the first three years of defining novel solutions to the four major constraints resulted in the choice of a participatory approach, based on a contractual arrangement between the people and the project. A standard written contract defines the forms and modalities of the reciprocal agreement between the two partners and sets out the nature of their relationship (rights and obligations) and the methods of work. Mutual responsibility for the actions to be undertaken is implied by the free acceptance of the terms of the contract.

Each community wishing to enter into a contract for protection against sand encroachment must organize itself into a group which will become the contact organization in dealings with the project. This group will include all the voluntary participants, thus becoming the decision-making and operational centre for the conduct of activities.

At the beginning of each annual campaign and in the light of its priorities and capabilities the group decides the amount of work it wishes to contribute to the project. The campaign programme is discussed on technical grounds and, once approved, constitutes the contractual basis for operations. The specifications define the apportionment of obligations and benefits between the two contracting parties. Project design, technical support, training villagers, supplying inputs and the logistics of the major work are the responsibility of the project. Raising the plants in the nursery, all reforestation operations and the management of reforested areas are carried out by the

village groups.

The project pays the group a few months after the end of the campaign, on the basis of the calculated seedling survival rate. Payment is made for each living tree on the basis of the cost price per tree under the state contracted system. This monetary incentive decreases over time: 75 per cent for the second season and 50 per cent for the third and last year. The group assumes responsibility for redistributing the money to the various participants.

The reforested area belongs to the group, which is also responsible for its management, in collaboration with the relevant services of the National Department for the Protection of Nature. The fencing provided by the project greatly facilitates maintenance and guarding operations. As a result of their awareness of the rapid impact of the plantations on the sand encroachment problem, the people consider trees primarily as a means of protection and secondarily as a source of forestry products.

Evaluation of the methodology

On-site observations at the end of the second season revealed a considerable degree of satisfaction among village groups and the project, both with project operation and the results obtained. The aim of the contractual approach was not only to achieve the quantitative operational targets, but above all, to transfer to village groups the responsibility for and control of the technical process. Continual dialogue and close monitoring by the forestry staff helped solve the initial problems involved in such a strategy. The village groups acquired confidence and working autonomy which will be very important in ensuring the continuity of the actions undertaken.

The success of this contractual approach hinges directly on the programme's ability to obtain the financial resources needed to fund incentives for the groups. It is doubtful whether national budgetary resources alone could sustain

programme extension after the project ends.

The progressive decrease in the incentives offered over the three-year period is a transition measure towards financial disengagement by the project in favour of a more consciousness-raising approach. It is still too early to measure the effects of the decrease in monetary incentives on the sense of responsibility and enthusiasm among village groups. The risk of a loss of motivation, however, is slight because the incentives are of secondary economical importance besides the saving of houses and agricultural land. The presence of the technical project management staff also guarantees food security for the people and creates an expectancy of development activities.

The role of women

In daily life, women play a fundamental role in the organization and conduct of social and productive activities. Their particular socio-cultural status, however, generally limits their desire to participate in decision-making and in sharing authority.

Sedentarization, the seasonal or semi-per-

manent migration of men to urban centres and the abolition of slavery have contributed to a more egalitarian restructuring of rural society and a redefinition of the gender-based division of labour. In many situations women now find that they are the prime movers in the community, both in productive and rehabilitation activities.

In development activities, it is not always possible or really desirable, to segment and differentiate between potential participants on the basis of sex or age. Nevertheless environmental protection is a concern of the community as a whole. Additional work and the deterioration of woman's socio-economic status caused by the destructive effects of ecological degradation — increased problems in firewood and water supply, food gathering and availability of cultivable land — must be borne in mind.

The formation of village groups open to all members regardless of gender, facilitates the discussion of ideas and the free expression of views. The project does not interfere directly in the various positions taken by the group. The period of active communication, however, when the annual contract is being negotiated, permits recommendations in the guise



Photo: René Grojean

Group of women responsible for the tree nursery in a village in Brakna.

of technical considerations, to be made for the improved integration of women into the activities.

The various experiments in stimulating and training women's organizations in plant-raising techniques were very successful during the first phase of the project. The number of women in village groups and the level of their contribution varies considerably from community to community, depending on the degree to which the hierarchical and compartmentalized social structure still survives. In most cases, women independently assume responsibility for raising forest plants for reforestation and maintaining the planted areas. The major work of mechanical stabilization and planting is generally carried out by men, since these tasks are laborious and too time-consuming to be easily compatible with the

numerous household and productive activities undertaken by women.

The advantages of the sand encroachment control extension programme, apart from the distribution of monetary incentives to all group members in proportion to their contribution, are essentially concerned with preserving a lifestyle which is important to all members of the community, regardless of gender. The experiments under way on the development of production systems have resulted in numerous opportunities to ease the daily workload of women and integrate them into the development process, with a share in the benefits derived from it. This orientation would be reinforced if the Forest Department showed a willingness to accept women into the ranks of the technical, field-level, extension staff, who are almost exclusively male.

EXPERIMENTATION WITH TECHNICAL DEVELOPMENTS IN PRODUCTION SYSTEMS

The deterioration of climatic conditions and increased resource exploitation have demonstrated how fragile the production systems are and how difficult it is to adapt them to the degraded environment. The superficial knowledge of agricultural techniques among most settled former nomads and the insecurity of farming based on increasingly unpredictable rainfall have made it impossible for rural communities to regain their dynamism. This degeneration of production practices in favour of attitudes and behaviour patterns focused on survival has had devastating effects on the environment.

The sectoral approach to sand encroachment control has changed the fatalistic attitude of the people by showing them that human investment in a degraded environment is capable of halting and even reversing the desertification process. The extension and dissemination of technical tools for rehabilitating the environment are viable only in conjunction with a supporting programme to help people regain control over their economic activities.

The project is oriented principally towards testing and popularizing technical developments of traditional know-how in order to adapt it to present environmental conditions. The designation of the village as the unit of

action is based on the concept of the village territorial entity, encompassing all the natural resources exploited and managed by that community. The development of techniques covers all three components of the dominant agrosylvo-pastoral economic system. Activities are so designed as to restore the complementary economic interdependence of practices which have become competitive and destructive, with the aim of achieving a balance with the environment.

This development and integrated land management programme is currently being tested in four zones: Chogan Gadel and Lemden in Brakna Province and Hassey Tine and Soudou in Assaba. The villages involved in each of the zones have the potential for development, provided that the two key factors — soil and water — are well managed.

The programme has two goals:

- to ensure greater food security for the people by increasing the biological productivity of the land (through crop diversification and increased yields) and establishing fodder reserves;
- to reduce pressure on the environment by planting forest and fruit trees for protection and production.



Photo: René Grojean

The survival of traditional livestock husbandry necessarily involves modification of extensive practices and the establishment of fodder stocks.



View upstream of a reservoir retained by gabions in the bed of a wadi. Chogar-Gadell, Brakna.

The agricultural component

The aim of the programme, which with the direct involvement of the villagers has become a really major exercise, is to popularize the technical tools needed to ensure better management of water and soil, as the factors that determine the vegetation cycle in the Sahel. In the Saharo-Sahelian zone, agriculture is dependent on the amount and regular distribution of rainfall to ensure normal crop development. For centuries, crops have been produced behind dams or small embankments to mitigate the effects of climatic fluctuations. The areas where natural or artificial flood-plain agriculture is practised are limited in size and have been occupied for generations by sedentary farmers. Hence the former nomads, driven by necessity to become sedentary, could not freely settle areas where economic activities depend on the limited development potential of recession agriculture.

At the same time, the nomads usually regarded settlement as a temporary expedient, during which the prospect of reconstituting their herds took precedence over investing in

agricultural infrastructure. The persistence of drought and the lack of viability of increasingly uncertain rainfed agriculture have not allowed them to fulfil this expectation, or even, indeed, to satisfy subsistence needs.

The experimental programme under way consists of popularizing appropriate techniques for water and soil conservation by creating small-scale village infrastructures, as well as teaching more productive cultivation techniques. The land management plan is determined by specific local problems. Usually it consists of:

- stabilization of catchment areas and wadis by the construction of stone gabions to curb water erosion and encourage the infiltration of runoff water into the soil;
- construction of a network of small embankments and crescent-shaped earth structures to promote water retention and infiltration on cultivable lands;
- restoration of soil fertility by applying organic animal manure to agricultural plots;
- crop diversification (wheat, barley) to ensure greater food security;
- popularization of new cultivation practices: deep ploughing and broadcast sowing.

The results obtained are still too recent and scattered for any real evaluation of the activities. Both the target population and the project are, however, very satisfied with the first improvements introduced. The use of gabions and small embankments has resulted in a sizeable increase in the cultivable land area, a decrease in water erosion and the conservation of runoff from the rainy season. Deep ploughing, the application of organic manure and broadcast sowing have resulted in a convincing increase in crop yields. The introduction and spread of the new techniques has helped to renew confidence among the farmers in their ability to control the stages of the vegetation cycle more effectively and assure

a greater security of food supply.

The effectiveness of the activities, both in technical terms and with regard to socioeconomic benefits, is recognized by all concerned. The groups' capacity to replicate and assimilate these techniques is, however, still in question. The technological gap between the virtually unmechanized traditional practices and the resources of the project - tractors, deep ploughs, trucks and loaders - is very wide.

At present, it seems unrealistic to hope that the village groups will have sufficient financial means and technical capacity to buy or rent such sophisticated and expensive equipment. The development of intermediate techniques, such as the use of draught animals, should be tested in order to reduce equipment costs and prevent the communities from becoming discouraged. The successful expansion of such a programme requires the institutional definition of appropriate ways of en-

couraging measures such as rural credit schemes or the establishment of revolving funds.

The livestock component

Overgrazing by sedentary herds (household livestock) is largely responsible for ecological degradation around villages. The animals - mainly goats and sheep - are let out each morning from pens adjoining the houses and left to find their own food. This practice explains the progressive development of concentric circles of degradation, spreading proportionally to the increasing distances over which the animals search for food.

Establishing food reserves for the animals is an important way of promoting natural vegetation regeneration around villages. During the period 1983-86, the project sought to initiate and gain acceptance for measures to mitigate the destructive impact of livestock;

Puzzled but attentive, the inhabitants watch a demonstration of new farming techniques: deep ploughing and broadcast sowing on a plot, shielded by an embankment. Chogar-Gadell, Brakna.



Photo: René Grojean

for example, the rotational use of surrounding pasture lands under the control of herdsmen, planting trees to produce forage and seeding degraded grazing land.

The project hoped to make further progress in this direction, by developing practices acceptable to rural thinking to diminish livestock pressure. These criteria were met by creating dried fodder reserves (hay) by harvesting natural rangelands in the rainy season.

Southern Mauritania contains excellent grazing lands. Given normal rainfall, grasses colonize this entire Sahelian zone within a few weeks. A significant proportion of the resource is not used by the transhumant herds. With the return of the dry season, this lush herbaceous cover may be instrumental in causing brush fires, thus contributing to the destruction of the tree cover and to environmental degradation in general.

The project conducted various trials of hay making, using similar methods to those used in temperate countries. Grass was cut mechanically by a mowing arm driven by a tractor. The intense heat facilitated drying, so that the hay did not require turning before

being compacted mechanically into rectangular, 20 kg bales.

Livestock like the mown hay and it relieves animal pressure on the environment, especially when fresh vegetation is most scarce. It is still too early to be able to measure the impact of this scheme on the management of village lands. As with the agriculture component, the spread of the practice will depend on the financial and technical capacity of village groups to procure mechanical equipment.

Dried fodder has good future potential, both because of the inexhaustible production capacity and for the marketing possibilities. Apart from the rapidly satisfied village needs, there is an ever increasing demand for livestock production in peri-urban areas. Various other applications are foreseeable: establishing large fodder reserves along transhumance routes, increasing the numbers of firebreaks by mowing the grasses and carrying out trials with hay as a substitute windbreak material.

The forestry component

This component is largely the same as in the sand encroachment control programme extension to 60 sites. When areas are not too degraded or directly threatened by dunes, the plantations can be designed partly to produce timber and its by-products. As a parallel effort, UNSO is also financing an operation to popularize and distribute improved cooking stoves which use 40 per cent less charcoal. The adaptation and improvement of fruit tree species (dates, guavas, mangoes, figs) is also being tested.

Relationship with the population

All the activities in the integrated land management programme are based on the contractual participation model. The project deals exclusively with village groups and not with individuals. Because of the experimental nature of the operations undertaken, espe-

Distribution of fodder stock to villagers during the bridging period. Chogar-Gadell, Brakna.



Photo: René Grojean

cially in the agriculture component, various incentives and food security measures are planned to encourage people to adopt the new techniques.

Under the technical supervision of the project, the participants are responsible for building stone gabions and supplying animal manure to help fertilize the soil. The project is responsible for the mechanised construction of embankments, deep ploughing and providing seeds for carrying out major works requiring a large labour investment, the village groups receive payment in foodstuffs, based on the amount of work accomplished.

Data on the village land development and management programme are still too scattered to enable contractual clauses for these various operations to be drafted. In view of the success of the experiments, the issues of extending and disseminating the new knowledge will not be a question of community motivation, but of their technical and financial capacity to replicate the techniques. The development of appropriate technology, access to credit, the organization of co-operatives for purchasing or renting equipment and the establishment of revolving funds are necessary supporting measures to ensure the success of the programme.



Photo: René Grojean

Cooking food on an improved stove designed to burn dead palm leaves in the oases.

LESSONS LEARNED FROM THE DESERTIFICATION CONTROL PROGRAMME

The desertification control programme developed by UNSO in Mauritania over the decade 1980-1990 aimed to formulate a conceptual, technical and methodological response to two major factors in helping to arrest the ecological degradation process:

- the capacity to control the dynamics of sand encroachment in such a heavily degraded Saharo-Sahelian ecosystem;
 - the development and introduction of techniques and practices, adapted from traditional knowledge, capable of combining environmental protection with an improvement in living conditions.
- The experimental curative approach, developed in the first phase of operations (1983-1986), provided various effective and convincing technical solutions to the problem of combating sand encroachment. The demonstrated effect of these measures substantially increased popular awareness of the cause and effect relationship in the ecological degradation process. The easily replicable technical options gave very encouraging results in a relatively short space of time. The people, anxious to see before believing, are now convinced of the value of the practices and spontaneously seek project assistance in protecting their lands.

The chosen strategy, based on contractual participation, developed with village groups, responds to the methodological need to organize and assign tasks as a means of ensuring the assimilation and continued use of the techniques acquired, given the increasing demand for action and the limited financial and logistic resources. This methodology has the advantage of making the community collectively responsible for solving its specific ecological problems. The organization of village groups is designed to assist in the acquisition and transfer of technical knowledge, with the ultimate aim that the communities

should assume sole responsibility for developing and managing their lands.

- The initial results of the experimental programme in preventive desertification control are promising. The field trials on the development of production systems rapidly fulfilled the twin objectives of conserving and improving the productive potential of village lands. Soil and water management, increased agricultural yields, crop diversification and the establishment of fodder reserves for livestock are arousing interest and winning the support of village groups. The implications of this integrated approach are the new prospects of more balanced management and an increased food security for rural populations.

The achievement of this body of results, obtained in a fragile environment and under difficult working conditions, demanded the investment of considerable financial, logistic and human resources. The future extension and success of the preventive desertification control programme are closely linked to the population's capacity to replicate the techniques. Future effort must concentrate particularly on the ways and means of making the necessary equipment accessible, or else on developing materials more appropriate to the financial and technical capabilities of rural society.

- The technical and methodological gains provide a very useful body of information and lessons which are relevant to the great majority of other Sahelian ecological situations. The techniques and activities described were carried out under extreme ecological and climatic conditions in the fragile and unstable Saharo-Sahelian zone. The publication of the results of these experiments is designed to enable ongoing or future projects to save a good deal of effort and expenditure on developing and learning techniques which have been successfully tested in the following spheres:

- the development of protection and planting techniques in a dune zone;
 - the adaptation and improvement of cultivation practices within the agro-sylvo-pastoral production system (the building up of dry fodder reserves, the use of manure, deep ploughing);
 - the development of a methodology for transferring and ensuring the adoption of techniques by means of contractual agreements with village groups.
- The sum total of the field operations and conceptual research carried out throughout the 1980s has been to provide a deeper knowledge and understanding of the mechanisms and socio-economic implications of the desertification process. The regional seminar held in Nouakchott in 1984, organized by CILSS and the *Club du Sahel*, showed a broad consensus in support of reorienting intervention strategies, abandoning the sectoral approach in favour of global integrated action.

The lesson for Mauritania from this change of strategic approach has been incorporated in a radical restructuring of the system for planning the action to be taken. The master plan for desertification control was drawn up in 1981-1982 under a centralized national programming system. The new pattern for activities during the 1990s is based on a decentralized approach at the regional level. Under this new concept, it will be possible to move on from the previous scattered pattern of sectoral activities, which were useful in the short-term but insufficient to give rise to any real dynamic action, to the basics of a land management and planning policy which takes regional development potential and the needs of the population into account.

This change in approach has the merit of reflecting more realistically the various problems that arise and are experienced on the ground. Desertification is now seen as a process arising out of the interaction between man

and his environment. Financial and logistic capacities have been reassessed in terms of effectiveness, integration and the dynamics of development on the basis of regional socio-economic potentials.

The political decentralization instituted with the establishment of communes in 1989 will have the means and economic tools to encourage the protection and development progress of the various regions. This body of measures,

Management of small village infrastructures to conserve water and soil is a decisive factor in the socio-economic advancement of the population.



Photo: René Grojean



The tent remains the prime focus of social life.

which are entirely positive in their forward-looking and logistic aspects, would have even more impact if, at the same time, the problem of the legal status of land could be addressed in order to ensure individual or collective investment by the people in their land.

Putting experience and field results to use and sharing techniques and know-how form essential links between those involved on a day-to-day basis and they are a means of avoiding a wastage of financial and human resources in the development and learning of techniques.

Such activities initiated within the Mauritania programme, have helped strengthen confidence and determination amongst technical staff, through visits, training periods and exchange of seeds with other Sahelian projects. The present account stems from this same concern for openness and communica-

tion about an ecological problem which goes far beyond the daily struggles of the Sahelian peoples.

The beauty and magic of dune forms has often inspired writers to portray a poetic, aesthetic picture of the desert. The details of desertification, the confusion and aspirations of the inhabitants are usually reduced to confused and media-centred journalistic generalities. It is to be hoped that this present work will contribute to a more objective perception of the problems and solutions.



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