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Programme on Man and the Biosphere (MAB) of Unesco

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Regional meeting on the establishment of co-operative programmes of interdisciplinary ecological research, training and rangeland management for arid and semi-arid zones of Northern Africa

Organized jointly by Unesco, FAO and UNEP

Final Report

Unesco

Previous reports in this series:

1. *International Co-ordinating Council of the Programme on Man and the Biosphere. First session. Paris, 4-10 November, 1971.*

2. *Expert panel on the role of systems analysis and modelling approaches in the Programme on Man and the Biosphere (MAB). Paris, 16-20 April, 1972.*

3. *Expert panel on Project 1: Ecological effects of increasing human activities on tropical and subtropical forest ecosystems in the Programme on Man and the Biosphere (MAB). Paris, 10-18 May, 1972.*

4. *Expert panel on Project 12: Interactions between environmental transformations and genetic and demographic changes in the Programme on Man and the Biosphere (MAB). Paris, 23-25 May, 1972.*

5. *Expert panel on Project 5: Ecological effects of human activities on the value and resources of lakes, marshes, rivers, deltas, estuaries and coastal zones. London, 19-22 September, 1972.*

6. *Expert panel on Project 3: Impact of human activities and land use practices on grazing lands: savanna, grassland (from temperate to arid areas), tundra. Montpellier, 2-7 October, 1972.*

7. *Expert panel on educational activities under the Man and Biosphere Programme (MAB). Paris, 5-8 December, 1972.*

8. *Expert panel on Project 6: Impact of human activities on mountain ecosystems. Salzburg, 29 January-4 February, 1973.*

9. *Expert panel on Project 13: Perception of environmental quality. Paris, 26-29 March, 1973.*

10. *International Co-ordinating Council of the Programme on Man and the Biosphere. Second session. Paris, 10-19 April, 1973.*

11. *Expert panel on Project 7: Ecology and rational use of island ecosystems. Paris, 26-28 June, 1973.*

12. *Expert panel on Project 8: Conservation of natural areas and of the genetic material they contain. Morges, 25-27 September, 1973.*

13. *Expert panel on Project 11: Ecological aspects of energy utilization in urban and industrial systems. Bad Nauheim, 16-19 October, 1973.*

14. *Working group on Project 6: Impact of human activities on mountain and tundra ecosystems. Lillehammer, 20-23 November, 1973.*

15. *Consultative group on Project 9: Ecological assessment of pest management and fertilizer use on terrestrial and aquatic ecosystems. Part on fertilizers. Rome, 7-9 January, 1974.*

16. *International working group on Project 1: Ecological effects of increasing human activities on tropical and subtropical forest ecosystems. Rio de Janeiro, 11-15 February, 1974.*

17. *Task force on the contribution of the social sciences to the MAB Programme. Paris, 28 February-2 March, 1974.*

18. *Regional meeting on integrated ecological research and training needs in the Sahelian region. Niamey, 5-15 March, 1974.*

19. *Expert panel on Project 2: Ecological effects of different land uses and management practices on temperate and mediterranean forest landscapes. Paris, 16-19 April, 1974.*

20. *Task force on pollution monitoring and research in the framework of the MAB Programme. Moscow, 23-26 April, 1974.*

21. *International working group on Project 5: Ecological effects of human activities on the value and resources of lakes, marshes, rivers, deltas, estuaries and coastal zones. Paris, 16-17 May, 1974.*

22. *Task force on criteria and guidelines for the choice and establishment of biosphere reserves. Paris, 20-24 May, 1974.*

23. *Regional meeting on integrated ecological research and training needs in the Andean region. La Paz, 10-15 June, 1974.*

24. *Expert consultations on Project 9: Ecological assessment of pest management and fertilizer use on terrestrial and aquatic ecosystems (Part on pesticides).*

25. *International working group on Project 3: Impact of human activities and land use practices on grazing lands: savanna and grassland (from temperate to arid areas). Hurley, 2-5 July, 1974.*

26. *Regional meeting on integrated ecological research and training needs in the South East Asian region. Kuala Lumpur, 19-22 August, 1974.*

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27. *International Co-ordinating Council of the Programme on Man and the Biosphere. Third session. Washington, D.C., 17-29 September, 1974.*

28. *Regional meeting on integrated ecological research and training needs in Latin America. Mexico City, 30 September-5 October, 1974.*

29. *Expert panel on Project 4: Impact of human activities on the dynamics of arid and semi-arid ecosystems, with particular attention to the effects of irrigation. Paris, 1-5 March, [illegible].*

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S Y N O P S I S

This report concerns a regional meeting for five North African States (Algeria, Egypt, Libya, Morocco and Tunisia) some of whose territory comes within the arid and semi-arid mediterranean bio-climatic zone. Its objective was the formulation of co-operative programmes for ecological and interdisciplinary research, training and pastureland management in the region.

The meeting was organized by Unesco and FAO with the support of UNEP. It comes under Unesco's Man and the Biosphere Programme (MAB) and is closely linked with MAB Project 3 entitled "Impact of human activities and land use practices on grazing lands". It is also connected with FAO's programme on the Ecological Management of Arid and Semi-arid Rangelands in Africa and the Near and Middle East (EMASAR). The meeting thus followed on in logical sequence from the recommendations of previous MAB Project 3 meetings in Montpellier in October 1972 and in Hurley in July 1974 and those of the third session of the International Co-ordinating Council of MAB, held in Washington D.C. in September 1974. It is also in line with the recommendations of the EMASAR meeting held in Rome in February 1975, as well as those of the regional meeting organized in Tehran in February/March 1975 on de-desertification and the ecology of arid zones.

Three days preceeding the meeting were spent visiting Tunisian projects in which different methodological approaches (research methods applied to the establishment of pastoral improvement areas, systems analysis, etc.) were seen in action. During the meeting three committees met to discuss research, training and development and drew up recommendations and practical, often highly integrated projects.

In fact it could almost be said that "integration" was the motto of the whole meeting : integration of research, training and development; integration of the various disciplines involved in the programmes; and, lastly, integration of the countries, which submitted a series of national projects each complementing the other within a regional framework.

Results of the meeting included first and most importantly the will to expand the pilot projects already chosen in order to make them more relevant to the region as a whole and to perfect training of specialists and technicians in the field. An effort was also made to achieve regional complementarity in research with a view to covering the maximum number of ecosystems in the region. New projects are also to be introduced, some to generalize and extend results already obtained and to continue observation of the zones brought under pastoral management. Most of the countries were willing to receive students and trainees from neighbouring countries for courses in ecology and pastoralism where suitable structures and facilities exist. Many recommendations dealt with ways in which information could be circulated to the different countries. In the projects concerned with development, emphasis was placed on the need to encourage linkage and complementarity between steppe-land stock-raising and other types of agricultural production.

1. INTRODUCTION

The regional meeting for the establishment of co-operative programmes of ecological and interdisciplinary research, training and rangeland management for arid and semi-arid zones of Northern Africa was held in Tunisia from 3 to 12 April 1975. It was organized jointly by Unesco (MAB), FAO (EMASAR) and the United Nations Environment Programme (UNEP) at the invitation of the Tunisian Government.

The terms of reference of the meeting were linked with areas of activity of Unesco's Man and the Biosphere Programme (MAB) and of FAO's Programme on Ecological Management of Arid and Semi-arid Rangelands in Africa and the Near and Middle East (EMASAR). These links are particularly close in the case of MAB Project 3 entitled "Impact of human activities and land use practices on grazing lands".

The specific objectives of the meeting were as follows :

(1) to submit to participants for discussion the pilot study "Research and Development Project for Rangelands in Southern Central Tunisia" and other ecological research projects launched in Tunisia, using them as case studies for the improvement of pastureland use in other arid and semi-arid zones;

(2) to establish a regional network of pilot projects for integrated research with the framework of MAB Project 3;

(3) to identify needs for the training of research workers, technicians and those responsible for the management of such areas and to propose practical measures to meet these needs;

(4) to apply research data to development projects and formulate an integrated regional development programme under EMASAR, on the basis of the national priorities of each country;

(5) to examine certain methodological approaches to the study of arid and semi-arid mediterranean ecosystems and ensure the comparability of research data;

(6) to ensure complementarity between the MAB and EMASAR programmes and other programmes for research, development and training.

The meeting was attended by representatives responsible for research, training and ecological and rangeland management planning in five North African countries (Algeria, Egypt, Libya, Morocco and Tunisia). Observers from other countries with similar ecological conditions (Jordan and Lebanon) were also present. There were also observers from countries outside the region which had expressed an interest in bilateral and multilateral activities in this region, as well as

representatives of several international organizations. A full list of participants is given in Annex 1.

The opening session was held at the Boughrara Centre near Sfax under the chairmanship of Mr. Abderrahman Ben Messaoud, Secretary of State to the Minister of Agriculture of Tunisia, who stressed his country's interest in ecology and rangeland management. Referring to the present world food crisis, the Secretary of State also expressed the hope that the meeting would be a success and would help the countries concerned to obtain a clearer picture of the problems which hold back development in arid regions.

Mr. di Castri, Mr. Le Houérou and Mr. Baumer in turn set forth the views of Unesco (MAB), FAO (EMASAR) and UNEP on the meeting. A summary of these four texts is given in Annex 2. Mr. Zakaria Ben Mustapha (Tunisia) was elected chairman of the meeting, Mr. Mohamed El Mahdi (Egypt) vice-chairman and Mr. Salah Djebaili (Algeria) rapporteur.

Three days preceeding the meeting were devoted to field visits and case studies in Central and Southern Tunisia, giving the participants an opportunity to inspect :

(1) arrangements for measuring vegetation, soil and domestic animals (sheep and goats) in the Gabès area. Primary and secondary production on the main types of rangeland in Southern Tunisia are being measured for the Research and Development Project for Rangelands in Southern Central Tunisia (UNDP Project TUN 69/C01).

(2) two grazing land improvement areas near Gabès which were studied under the previous UNDP project (see Annex 4). One of them, El Adala, which covers quite a small area (1300 ha) has been in operation for two years. The other, Oglat Merteba, covering 100,000 ha, is now being organized. Arrangements made for the management of these areas have taken into account measurements referred to above.

(3) various measurements of the components of an ecosystem in the Médenine region carried out under the US/IBP Desert Biome Tunisian presaharan project (see Annex 4), a feature of which are its programmes of research into human bioenergetics and that of insects and sheep within the ecosystem.

(4) a grazing land improvement area in the Sbeitla region (central Tunisia) which is being studied for the TUN 69/001 project and has been in operation for three years. Attention was drawn to the improvement of both pasturage and herds (sheep) which has been achieved as a result of this project. The area is also used for demonstration and extension work with farmers in the region.

(5) dry-land fodder crops (*Cactus inermis*, *Acacia*, *Atriplex*) planted in central Tunisia by the World Food Programme (WFP).

The meetings and discussions were held at Boughrara after these field inspections. The conclusions reached by the three committees on research, training and development were discussed and approved at the last plenary session of the meeting.

2. REGIONAL FRAMEWORK

Despite their diversity the five North African countries (Algeria, Egypt, Libya, Morocco and Tunisia) form an undeniably homogeneous group with regard to natural conditions and population. All have a mediterranean climate, with short days and rainfall concentrated in the cold season.

The meeting was concerned with the zone which lies between the 100 and 400 mm isohyets. Zones with more than 400 mm rainfall are considered as semi-arid, sub-humid or humid depending on the amount of precipitation, whereas those with less than 100 mm annual rainfall are classified as desert or saharan zones. By this definition the arid zone covers the following areas in each of the five countries :

Country	Surface area in 10^3 km^2
Algeria	200
Egypt	30
Libya	90
Morocco	120
Tunisia	55
Total	495

Climate. With the exception of the occasional summer storm, rain falls in the main between October and April. Variation in the amount of precipitation is another factor which contributes towards aridity. In this zone the maximum annual amount of rainfall recorded is more than 10 times as high as the minimum. The amount of rain falling in any given month is also extremely variable : any month of the year may be either bone dry or exceptionally wet.

There is much less variation in temperature, the averages over five year periods being close to those obtained for periods of fifty years, but temperatures do vary considerably with altitude and distance from the sea. Frost practically never occurs near the sea, where the average temperature for the coldest month is + 7°C or above. Inland this average may be 0°C or less, with 40 to 60 days of frost. The average maximum temperature for the hottest month ranges from 30°C near the sea to 40°C or more inland. Plant growth therefore depends mainly on rainfall near the coast whereas inland the growing season is shortened by the winter cold and the summer droughts of one to two months in autumn and two to three months in spring.

According to one of the systems of bio-climatic classification in current use (that of L. Emberger) the region falls within the arid mediterranean bio-climate which different authors have subdivised as follows :

upper arid	300 to 400 mm
medium arid	200 to 300 mm
lower arid	100 to 200 mm

Remarkable values for the average minimum temperatures of the coldest months give the following categories :

cold winter	less than 0°C
cool winter	0°C to 3°C
temperate winter	3°C to 5°C
mild winter	5°C to 7°C
warm winter	more than 7°C.

Soils. Skeletal soils cover vast tracts of land both in mountain and hill areas and in foothills where calcareous or gypseous crusts frequently occur. Most soils of any depth are formed of an accumulation of colluvial/alluvial or aeolian deposits. Salty soils also cover wide areas of the lowest lying land.

Vegetation. The zone's natural vegetation is considered to be steppeland vegetation. The more or less degenerate remains of the original forest covering can still be found, however, on hills and mountains. The main types of forest tree which grow in this area are : *Pinus halepensis, Juniperus phoenicea, Tetraclinis articulata, Argania spinosa, Acacia raddiona, Pistacia atlantica,* and *Colligonum sp.* The total area covered by these forest remnants is not more than 2,000,000 ha.

The zone comprises many different kinds of steppe which can be divided into the following categories : alfa steppe (*Stipa tenacissima*) which probably covers more than 8,000,000 ha; wormwood steppe (*Artemisia herba alba*) which probably covers approximately 10,000,000 ha; sandy steppe (*Artemisia campestris, Thantherium suaveolens, Aristida pungens*), the removal of which leads to the movement of vast quantities of sand; and salt soil steppe.

Several million hectares of steppeland have been cleared for cultivation or for use as firewood and examples of all stages of degeneration or regeneration are to be found.

Animal stocks. The whole of the arid zone may be considered to be more or less intensively grazed. Despite the shortage of accurate statistical data on these zones it can be estimated that the number of heads exceeds 16,000,000 for sheep, 6,000,000 for goats, 1,000,000 for donkeys, 800,000 for camels and probably 100,000 for bovine animals. This would mean an average of 1.5 ha per animal, which is excessive, being two or three times more than the estimated carrying capacity.

Population. The total population of the countries concerned is about 80,000,000. It is very difficult however, to give a precise estimate of the population of the arid zone, which may be in the region of 14,000,000 and which is growing at the rate of 3 to 3.5 per cent per annum. Approximately 80 per cent of these people earn their living either directly or indirectly from agriculture. It is thus clear that natural resources are under severe pressure from both human and animal populations and that rapid deterioration in the ecological balance may ensue, with an extension of desertification and a gradual decrease in productivity. One of the objectives of the meeting at Sfax was to examine measures that must be taken to halt this process.

3. GUIDELINES FOR RESEARCH, TRAINING AND DEVELOPMENT PROGRAMMES

The meeting bore in mind the recommendations on arid zones adopted by previous MAB Project 3 meetings in Montpellier in October 1972 (see MAB Report Series No6) and in Hurley in July 1974 (see MAB Report Series No21). These recommendations had been approved by the third session of the International Co-ordinating Council of MAB in Washington in September 1974 and by the eighteenth session of the General Conference of Unesco in November 1974. The programmes proposed are also in line with the recommendations of the EMASAR meeting held in Rome in February 1975, and those of the regional meeting organized by UNEP on de-desertisation and arid land ecology in Tehran in February/March 1975. These recommendations can be found in Annex 3.

Each of the five countries concerned (Algeria, Egypt, Libya, Morocco and Tunisia) gave an account of the progress made in ecological research on their rangelands and described the approach adopted towards management and development in arid and semi-arid areas of their territory as well as existing structures for the training of specialists in these domains (see Annex 4). It thus became clear which priorities should be established for future programmes.

In all the statements made by the representatives of the countries concerned and in all the opening speeches the need for integration on several levels was emphasized. First, it is necessary to integrate individual research, development and training projects at all levels. The importance of involving the population in development programmes directly affecting them was also stressed. Second, integration is needed among the different disciplines involved in the study and management of rangelands : sociology, economics, human biology, zoology, animal breeding, phyto-ecology, agricultural technology, etc. Third, it is necessary to integrate on the one hand projects affecting the five North African countries and on the other projects chosen by other countries in the same bio-climatic zones.

General principles. The participants were in agreement on the following principles.

(1) An interdisciplinary and integrated approach to the co-operative programme is necessary, including all the various factors which could contribute towards the improvement of plant and animal production, as well as human aspects.

(2) Research and training are closely linked with development. Existing structures in these domains should be strengthened with a view to making them operational at the regional level.

(3) The co-operative programme must cover as many of the ecosystems of North Africa as possible in order to represent all the bio-climatic zones of the area.

(4) The first priority is that the co-operative programme should be based on existing projects which are of interest to the whole region. These projects should be strengthened with a view to the establishment of co-ordinating machinery.

(5) Particular attention must be given to exchanges of research workers, technicians and trainees among the countries of the region and, if necessary, with countries outside the region.

(6) In the countries concerned, priority should be given to information and documentation centres on rangelands in arid zones.

Co-ordination. To ensure co-ordination and follow-up the recommendations of the meeting, representatives from each country (a member of the MAB National Committee, the EMASAR working group or some other body) will meet once a year and in each of the countries concerned in turn. Representatives of Unesco, FAO and UNEP will also sit on the Co-ordinating committee, whose chairman until the next meeting will be Mr. Zakaria Ben Mustapha (Tunisia). At the invitation of the Libyan delegate the Co-ordinating Committee will meet in Libya before June 1976 on the initiative of its present chairman.

It was recommended that for North Africa a trilingual newssheet on pastoral activities be published by the MAB/EMASAR Secretariat.

4. PROPOSED RESEARCH PROGRAMME

4.1 General principles

After examining the state of research in the different countries, the delegations formulated a series of concrete proposals based on two main principles :

(1) Priority will be given to integrated rather than sectoral research.

(2) An effort will be made to achieve regional complementarity to ensure that the field of research covers as many of the natural ecosystems of North Africa as possible and that the majority of the various bio-climatic zones are represented. The region concerned is very extensive and includes bio-climates which range from near Saharan (100 mm mean annual rainfall) to semi-arid (350-400 mm).

Various kinds of programmes were proposed :

(1) Some highly integrated pilot projects bring in many research disciplines and provide for regional management and training at all levels.

(2) In some projects integration is less marked and fewer disciplines are involved (for example, the study of fencing and dune fixation techniques). Such projects can be regarded as providing validation for results obtained elsewhere.

(3) Still other projects are concerned with the generalization and extrapolation of the results obtained. This is the case of some mapping programmes and also of programmes based on the continuing observation of zones under management in which the results of research are now being applied.

The desire to have ideas for research and research results circulated is reflected in many of the recommendations : exchanges of research workers, the organization of seminars, the establishment of a documentation and information centre for the five countries which would keep in contact with other centres in the mediterranean area such as the Arab Centre for Arid Zones (ACSAD) in Damascus and the "Ecothèque méditerranéenne" in Montpellier.

Different methodological approaches are used in different countries and by different teams. Some examples of these different approaches are given in the annexes of this report. Annex 5 concerns data processing by means of systems analysis, Annex 6 demonstrates certain aspects of methods used by the social sciences and Annex 7 describes the methodology adopted for research applied to rangeland development and management.

4.2 Proposed projects

The recommendations approved by the regional meeting regarding these proposals and research needs of the different countries were divided into the following four categories.

4.2.1 Strengthening of existing integrated projects

These projects are situated in different bio-climatic zones. They are being carried out in three countries which are mentioned here in an order of increasing rainfall.

4.2.1.1 Egypt. The existing project is entitled "Systems Analysis of Mediterranean Desert Ecosystems of Northern Egypt (SAMDENE)". A short account of its aims and procedures is given in Annex 4. Measurements in this project are being carried out in the bio-climatic region with an average annual rainfall of 150 mm on the different components of two types of natural ecosystems, coastal dunes and non-saline depressions.

Support needed is mainly financial, since Egypt has personnel at all levels required to carry out research projects of this type, except in certain limited aspects. These needs are :

(1) support for a study of the socio-economic structure of the population similar to the Desert Biome Research Project in Southern Tunisia;

(2) support for extending the measurement of various components of natural ecosystems that have not yet been dealt with, for example the ecosystem occurring near the end of the salinity gradient, and the ecosystem to be found on ridges of skeletal soil;

(3) support for extending the measurement of various components of ecosystems managed by man in order to gain insight into the changes caused by human manipulation (for example, orchard plantations and crop and vegetable cultivation, both of which are under dry-farming, as well as the ecosystems irrigated by Nile water which has now reached the Eastern part of the region;

(4) support for the study of the effects of different degrees of grazing pressure on the structure and functioning of the ecosystem.

4.2.1.2 Tunisia. It was requested that the Research and Development Project for Rangelands in Southern Central Tunisia be strengthened. Disciplines now covered by the project are animal breeding, phyto-ecology and management models. These

will be strengthened, and research will be extended to cover new disciplines such as sociology, economics, the study of small mammals, the study of wild animals, the economics of water management and agro-meteorology.

This project will act as a pilot project for regions with the same natural environment. It will co-ordinate research into the rational management of the zone concerned, regardless of what body undertakes the research, such as, for example, the Tunisian National Institute for Forestry Research, the Desert Biome, etc. (see Section 5.3.1).

4.2.1.3 Algeria. The reinforcement of the programme of research now being carried out at the Wilaya of Saïda was requested. The programme is co-ordinated by the Research Centre for Biological Land Resources in Algeria (Centre de Recherches sur les Ressources biologiques terrestres d'Algérie (CRRBT). Three regional centres have already been equipped and staffed (ten research workers).

Support is requested for one specialist on management and grazing (four years); one interpreter of photographs (three years); and two consultants (six months each), one to measure the different ecosystem components and the other to help establish a methodology for the study of socio-economic structures.

4.2.2 Creation of new research projects

These new projects are designed to ensure that among them the countries cover all the major bio-climatic zones from the pre-saharan to the semi-arid zone.

4.2.2.1 A new integrated project is to be launched in Libya. This project will be of the same type as the Egyptian SAMDENE project, but will be situated in an even more arid bio-climatic zone. There will be collaboration with the Egyptian Desert Institute.

4.2.2.2 Morocco requested aid for the development, integration and extension of forestry and grazing land research to rangelands used in association with crop-farming in arid and semi-arid zones. This aid would be particularly helpful in the study of phyto-ecology, wildlife and the management and rational improvement of rangelands and also for the in-service training of staff and the circulation of research results.

4.2.2.3 Algeria requested the services of a consultant for one month to draw up a research project on eco-types of the semi-arid bio-climatic zone which could be used as fodder. Work on this subject has already been started in Algeria.

4.2.2.4 Libya also recommended referring to a group of specialists the synthesis of our present knowledge on sand dune fixation in order to :

(1) recognize areas of possible immediate application;

(2) define areas where further research is needed and formulate research programmes on a regional basis.

4.2.3 Launching of new projects to monitor zones under management and generalize results where appropriate

These projects involve on the one hand the monitoring of zones under management in which the results of research are already being applied and on the other the generalization of the results of existing pilot projects by means of mapping.

4.2.3.1 In view of the fact that several important development projects have been or are now being carried out in some of the countries in the area (for example, protection of range areas by fencing, re-seeding and dune fixation in Libya), the Libyan delegation stressed the importance of establishing a system of continual and systematic monitoring of such projects and of making findings available to all the countries in the area.

4.2.3.2 Algeria requested aid for thematic mapping (scale : 1:500,000) of vegetation and the main environmental factors, in particular those related to degradation of soil and pastureland, with a view to the rational exploitation of 20 million ha of rangeland. The services of one phyto-ecologist and those of one photo-interpreter would be required, each for two years.

4.2.3.3 In order to encourage the dissemination of the results obtained, the meeting recommended that phyto-ecological maps should be drawn up for the whole of the arid and semi-arid zones of Northern Africa, and in particular of Libyan and Egyptian territory, in accordance with methods already used in the Maghreb countries.

4.2.3.4 Egypt requested aid for this type of mapping for which the Desert Institute in Cairo would be responsible.

4.2.4 Other recommendations

It was recommended that in order to encourage the flow of ideas and research results, working parties, seminars or "pastoral weeks" should organize once yearly and in each of the countries in turn to discuss subjects fixed in advance by the *ad hoc* co-ordinating committee.

It was also recommended that :

(1) all necessary measures be taken to ensure the circulation among the countries in the region of data on ecology and range management. These measures would include :

- the exchange of written information on results obtained, perhaps in the form of a periodical review, with proper translation into Arabic, English and French;

- the encouragement of personal contacts through seminars and workshops to be organized every year;

(2) documentation centres already existing in the region should be carefully examined and assessed with a view to :

- unifying systems of documentation;

- strengthening existing documentation centres;

(3) the possibility of/or need for establishing a documentation centre in one of the countries in the region should also be considered.

It was recommended that research workers, technicians and trainees be exchanged between the countries of the region and if necessary with countries outside the region. Consultation between research workers in the different disciplines was felt to be particularly desirable.

5. PROGRAMME FOR TRAINING

5.1 General principles

In the course of the meeting it was emphasized that training at all levels was a key to the success of programmes for research and development.

To begin with, the general public should be made more aware of the ecology of rangelands, of the problems connected with their present state of degradation and of their potential. The results of new methods of land management should be publicized by means of extension work.

At a different level altogether, that of the decision-makers, information could be provided in the form of comprehensive reports and through seminars.The possibility of using the "case study" method at such seminars should be considered.

The main contribution of the meeting was a series of practical proposals for training specialists on arid and semi-arid rangelands at the undergraduate and post-graduate levels, as well as at the technical assistant level.

In the five countries concerned, some training courses for research workers and technicians in ecology and pastoralism already exist. Certain countries expressed their willingness to accept research workers, technicians and trainees from the other countries.

The following requests and recommendations, which were approved by the regional meeting, reflect in general the desire for a flow of information between the countries through periodical publications, seminars, training sessions and further training at all levels.

5.2 General recommendations

5.2.1 The need to use existing structures to train those with responsibility for arid zones (sociologists, economists, animal breeders, ecologists), giving priority to administrative staff and teachers who are nationals of countries in the region.

5.2.2 The need for integrated training at all levels and particularly in further training and the continuous education of those responsible for the management of arid zones.

5.2.3 The need to encourage any action taken to strengthen or introduce courses in ecology and pastoral studies at undergraduate and post-graduate levels and in schools of agriculture.

5.2.4 The need to systematically invite the specialists of the countries concerned to participate in any training and information activity concerning arid and semi-arid zones.

5.2.5 The need to make the public at large and pastoral communities in particular aware of the projects for the management of arid and semi-arid rangeland through all effective channels (audiovisual media, extension work, special school curricula, seminars, etc.).

5.2.6 The need to name and provide the address of a national institution or body in each country to act as a correspondent, to ensure distribution of documents and information and to receive the teachers, research workers and students working on arid and semi-arid zones.

5.2.7 The need to request the five participating countries to assess the ultimate quantitative and programmed requirements in the field of training.

5.2.8 The need to ask ALECSO, with the help of international organizations, to undertake an exhaustive inventory of educational structures which could provide training for both generalists and specialists called upon to work in the arid zones of each of the five North African countries. A questionnaire designed to establish the different levels, the fields of study and the actual or expected number of students should be standardized and addressed to the different countries.

5.2.9 The need to ask international organizations to undertake surveys with a view to standardizing the terminology referring to various levels of training and to promote equivalence for the recognition of studies and diplomas in order to achieve comparability between levels of training in the five countries concerned.

5.3 Proposed projects

5.3.1 Within the framework of the Research and Development Project for Rangelands in Southern and Central Tunisia it was proposed that a regional centre for pastoral

studies be established which would offer further training and continuing education for administrative staff at all levels. Financial and logistic support from international organizations was requested for this purpose (see Section 4.2.1.2).

5.3.2 Should the countries accept the invitation extended by Algeria to welcome each year up to five students from each country to study ecology and to prepare the DES diploma ("Diplôme d'Etudes supérieures"), specializing in the management of arid and semi-arid rangelands, financial assistance would be requested for travel and subsistence allowances for the students and for the services of two consultant teachers.

5.3.3 Assistance was requested for the formulation of a training scheme for specialists in the mathematical and systems analysis of arid zone ecosystems for the five countries concerned.

5.3.4 Financial and logistic support was requested for short or long courses for students specializing in pastoral studies or in arid land management (see Section 4.2.4).

5.3.5 Financial support was sought for travel and subsistence allowances to enable teachers and research workers in the five countries concerned to take stock of the opportunities effectively offered by each of the countries for training and research in the development of arid and semi-arid zones (approximately ten to fifteen missions per country per year).

6. PROGRAMME FOR DEVELOPMENT

6.1 General principles

The degradation of the rangelands of North African countries has increased the risk of flooding, erosion, salinization and, above all, desertisation.

This alarming situation, coupled with the need to devise a rational system of management and exploitation for grazing lands, has led the countries concerned to take various measures, in particular the acquisition of basic data on steppeland environments and methods of improving them.

The development of grazing lands is to be seen, however, in the context of a complex series of actions for which the basic objective remains the improvement of the living conditions of the people concerned.

The improvement of rangelands and stock-raising involves the integration of three distinct lines of approach : the improvement of grazing, of fodder and of animal breeding. Grazing potential which is obvious but at the same time limited calls for supplementation with irrigated or dry-land cultivated fodder if regular and normal feeding of herds is to be ensured.

The desired ecological approach to development is based on the study of ecosystems in the arid and semi-arid zone.

This obviously implies a knowledge of all environmental factors (climate, soil, water), of the various links in the trophic chain (plants, animals, men) and of the energy balance. The first step, therefore, is to carry out research, which should cover the gamut of possible activities, from phyto-ecological inventories and the measurement of primary and secondary production to experimentation with techniques for improvement. In this respect, it should be recalled that ecosystems evolve and that ecological balance, while an end in itself, should at the same time be one of the main objectives for the conservation of natural resources.

In view of the fact that man is both an integral part and the most active component of ecosystems, it is strongly recommended that sociological and socio-economic surveys and schemes for training, education, extension work and legislation should be carried out in conjunction with ecological studies.

Annex 7 provides an example of a methodology applied to pastoral development in a steppeland area. Each country is, of course, free to choose its own type of development.

After examining various pastoral development measures undertaken in the various North African countries, the delegates drew up a series of practical proposals designed to improve the living conditions of the rural communities. These proposals are based on the following principles :

(1) integration of sociological, economic and technical factors;

(2) integration of research and training activities with development measures;

(3) formulation of projects of a regional nature.

6.2 General recommendations

6.2.1 The promotion of exchanges between the various countries to improve knowledge of common problems and techniques used (exchange of technicians, plant material, etc.).

6.2.2 The increase of staff and equipment for the various projects with a view to better dissemination of the findings of pastoral research.

6.2.3 The launching of projects for seed and fodder plant multiplication.

6.2.4 The study of problems of re-sowing rangelands.

6.2.5 The development of measures designed to promote the regeneration of the plant cover and prevent desertisation.

6.2.6 The study of the problems of achieving a balance between cereal cultivation, tree farming and the use of rangelands with a view to obtaining sustained long-term yields and protecting natural resources.

6.2.7 The study of the agro-technical problems related to cereal farming in the arid zone.

6.2.8 The promotion of linkage and complementarity between steppeland stock raising and irrigated agriculture.

6.2.9 The introduction of projects for the use of salt water and salt-affected land by planting new varieties, in particular salt resistant fodder crops.

6.2.10 The study of the possibility of using sea water in agriculture, whether or not desalinated.

6.2.11 The improvement of meteorological networks and the flow of meteorological information.

6.2.12 The investigation of possible correlations between climatic data and rangeland productivity.

6.2.13 The study of problems connected with grazing land legislation (pastoral code) and of institutions responsible for the co-ordination of pastoral development.

6.3 Proposed projects

6.3.1 The establishment in Tunisia of a regional centre for the production of seed and young plants of forestry and fodder plant species and for the training of technicians specialized in the production of seed and young plants. The establishment of regional sub-centres in the countries concerned.

6.3.2 The launching of a regional project for the inventory and mapping of the resources of the steppe zone, the siting of which would be decided upon after consultation with the countries concerned.

6.3.3 The launching of a regional study and demonstration project was proposed which would be designed to examine the interrelationship between irrigated land and rangeland in a realistic way.

7. CONCLUSIONS

The programmes proposed following this meeting on arid and semi-arid grazing lands in Northern Africa have the merit of being practical and are for the most part of based both on the integration of the different disciplines and on inter-country complementarity.

The meeting's main achievement was that it placed on-going national projects in a regional context, thus making it possible to avoid duplication and to use the resources available to the best possible advantage. Some of the proposed pilot projects are complementary as regards ecosystems while others complement each other in using different procedures and involving different fields of study. The advisability of considering research, training and development together was also stressed. A number of the programmes proposed do in fact integrate these three aspects.

Contacts and exchanges between the five countries concerned (Algeria, Egypt, Libya, Morocco, and Tunisia) will be intensified as the programmes are implemented. It will also be necessary to organize contacts and exchanges with other countries in the mediterranean region as well as other regions in order to provide support for the programmes.

The co-ordinating committee for the region, formed from the five countries concerned, will be responsible for checking on the implementation of the recommendations. Some projects can be launched immediately, as is obviously the case for programmes designed to strengthen existing pilot projects. Other high priority projects call for rapid action by the country concerned if they are to become operational. It was recommended that requests related to research, training and development be addressed to Unesco and FAO, which will seek the means required to carry them out.

The chairman of the meeting was made responsible for convening the next meeting of the co-ordinating committee, which will be held in Libya before June 1976. It was agreed in principle that the committee should meet during the first week of April 1976.

ANNEX 1

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ANNEX 2

SUMMARIES OF OPENING SPEECHES

1. Summary of the opening speech of Mr. Abderrahman Ben Messaoud, Secretary of State at the Ministry of Agriculture of Tunisia

The Secretary of State welcomed the participants on behalf of the Tunisian Government.

Seventy-five per cent of the surface of Tunisia is arid land and supports forty per cent of the population. The Tunisian Government has therefore made a considerable effort to improve the agricultural value of these territories. Many studies have been carried out, both to inventory natural resources (climate, soil, vegetation, water) and with a view to management (rangelands, improvement of stock-raising, reafforestation and prevention of desert encroachment).

At the moment these studies are being used in connection with two projects, the Research and Development Project for Rangelands in Southern Central Tunisia and the Desert Biome Project. Approximately 200,000 ha are being prepared as pilot areas for grazing land improvement on the basis of studies carried out by the first of these two projects.

INRAT, INRF, INAT and the Directorate for Forests are in charge of these projects on the Tunisian side, assisted by WFP, FAO, Unesco and the French National Centre for Scientific Research (CNRS).

The following lessons learned from these programmes.

(1) There is little point in trying to improve grazing lands unless attention is also given to other aspects of agricultural production and indeed to socio-economic activities as a whole.

(2) The local communities cannot be asked to change certain agricultural practices unless feasible alternatives are offered to them.

(3) The food requirements of the herds cannot be satisfactorily met by the natural grazing lands alone. Feed supplements must be provided for.

(4) The prevention of desert encroachment is an absolute imperative.

(5) Disadvantaged areas must be given assistance suited to their needs.

(6) Use must be made of all available resources.

The Secretary of State drew attention to the present world food crisis and the sensitization of world opinion to the problem of arid zones. Tunisia follows with interest the various international and intergovernmental programmes dealing with this problem and gives them its support; the Secretary of State referred in particular to the MAB and EMASAR programmes and to the programme of UNEP.

He then wished all success to the meeting, whose task was to use experience already acquired in this field as a basis for proposals for a co-operative, perhaps regional, programme for research and training geared to the objectives of the development of the zones in question.

2. Summary of the address by Mr. di Castri, Secretary of the International Co-ordinating Council of the Man and the Biosphere Programme, Unesco representative

After offering his sincere and heartfelt thanks to the Tunisian Government for the kind invitation which had made it possible to hold the meeting, for the very warm welcome and for the faultless organization, Mr. di Castri offered all the participants his best wishes for success in the work which lay before them.

The Unesco representative then referred to the participation and support of other United Nations agencies, and in particular to FAO's EMASAR programme for the ecological management of rangelands in Africa and the Middle East, and to UNEP.

The very organization of the meeting reflected the integration of efforts by the various North African States. It would, in fact, be appropriate to place the meeting itself under the sign of "integration", which is one of the features of the MAB programme.

A principal guideline of the Man and the Biosphere Programme, in both its conceptual and operational aspects is integration, making it possible to illustrate the ever-present interrelationships between human activities and their effects on natural resources, the biosphere and natural ecosystems.

The integration of basic and applied sciences is also necessary; hence the inevitable symbiosis between the MAB Programme of Unesco and the EMASAR Programme of FAO should facilitate the application of research results to training and development. This is turn calls for the integration of the different academic disciplines, such as the human sciences, sociology, human biology, economics, natural sciences, agriculture, forestry, animal husbandry, etc. Attention should also be drawn to integration among the five countries in the region and neighbouring countries such as the Sudan, Jordan and Lebanon which face similar ecological and social problems. Countries such as France, the United States, the United Kingdom and Sweden, whose economic and sociological situation is very different from that of this group of countries, could nevertheless co-operate with them on the basis of priorities established by the countries in the region.

This meeting on arid zone pasturelands was in fact one of a series of activities which had been the object of other MAB meetings in Montpellier, Niamey and Dakar, of UNEP meetings in Mendoza and Tehran and of an EMASAR meeting in Rome. Mention should also be made of the CASTARAB interministerial meeting of Arab countries on the application of science and technology in the countries of the region, which is to be held next year, and of the United Nations Conference on Desertization scheduled for 1977.

One of the most important of the meeting's objectives was to plan a regional network of integrated projects, taking into account the national priorities of the countries in the region and existing structures for research, training and development. The requirements for trained research-workers and management technicians should also be determined and concrete measures proposed to meet these requirements, as this would be one way of applying knowledge obtained from research and training measures to development.

3. Summary of the address of Mr. H. N. Le Houérou, representative of FAO

The FAO representative first outlined the work undertaken by his organization in connection with grazing lands and went on to describe the respective rôles of FAO and Unesco in this field, and finally gave an account of the reasons underlying the regional meeting at Sfax.

The FAO has almost thirty years experience of international co-operation for research, training and development relating to grazing lands. It operates two distinct programmes in this sphere: a "regular" programme which is concerned with co-operation and the flow of information (publications, seminars, consultations, formulation of programmes or projects, etc.) and is financed by the FAO's own budget; and a "field" programme which consists of specific projects drawn up at the request of governments and financed by extra-budgetary resources (UNDP, SIDA, the countries themselves, etc.).

The FAO is not in theory a body which deals with basic research which is more the concern of Unesco. However, FAO can become involved in research when it is applied to development in the short or medium term.

With the establishment of the MAB Programme and of MAB Project 3 on grazing lands in particular (1972) it became clear that FAO/Unesco co-operation in this sphere was essential in view of the similarity of the programmes, the experience accumulated by FAO and the complementarity of the fields covered. MAB Project 3 is concerned with integrated interdisciplinary research and training in general, while FAO's main objective is development and vocational training and, to a lesser extent, applied research. A joint FAO/Unesco secretariat in Rome is responsible for co-ordinating the activities of this project.

The FAO itself, with financial assistance from UNEP, has drawn up a general programme parallel to the MAB project which is known as EMASAR (Ecological Management of Arid and Semi-Arid Rangelands in Africa and the Near and Middle East). The conclusions and recommendations of the EMASAR conference which were referred to by the representative of FAO, are given in Annex 3.

Referring to the purpose of the meeting at Sfax, the speaker reminded participants of the meeting on ecology and nature conservation in the northern Sahara, organized by the IBP (International Biological Programme) at Hammamet in 1968, which led to the establishment of the Research and Development Project for Rangelands in southern Central Tunisia, which now involves FAO, Unesco, the CNRS (Montpellier CEPE), the French Office of Overseas Technological and Scientific Research (ORSTOM) and on the Tunisian side INRAT and the regional centres for agricultural development (CRDA), and in particular the Gabes centre. This project, which corresponds exactly to the objectives of both MAB Project 3 and EMASAR, although it was formulated long before either of them came into existence, has been in operation for five years now and despite its very limited resources it has achieved a great deal. It was therefore sensible to use the southern Central Tunisian project to demonstrate the possibilities of developing more or less similar programmes in countries in the same ecological zone and to try to set up a programme for co-operation in this domain in North Africa.

4. Summary of the address of Mr. Baumer, Director, Division of Ecosystems and Natural Resources, representative of UNEP

Mr. Baumer defined the rôle of the United Nations Environment Programme (UNEP), which is not an executive agency but is responsible for encouraging co-operation between agencies and also with bodies outside the United Nations system.

Its Division of Ecosystems and Natural Resources has, for example, encouraged FAO, Unesco and WMO to assess soil degradation on a world scale. The case of water is another example. Almost all the agencies had a programme for water, but few of them had considered the question of water quality and distribution (a town's supply of drinking water is in fact used for all kinds of purposes and there are quite simple methods of saving it). Another field in which the division acted as initiator and co-ordinator was that of genetic resources (fodder plants and plant cover), including the genetics of micro-organisms (fertilizers, recycling of waste materials). The problem of the transfer of technologies was also being investigated. Old and tried techniques should be rediscovered (aeolian energy) or new technical solutions found (solar energy). The division is also interested in forests and wooded areas in the tropics, in other types of ecosystems (mountains, islands, etc.), in species threatened with extinction, in national parks and reserves and in integrated pest control.

Mr. Baumer then placed the Sfax meeting against the background of others which have been held on the subject of arid zones and pastureland management in North Africa. This meeting, an extremely well-qualified one, must formulate programmes for co-operative action in the field, and not recommendations.

Mr. Baumer explained that UNEP whished to encourage the establishment of co-operative networks for research, training and application in the field and would look favourably upon requests for aid designed to produce more highly integrated projects.

Mr. Baumer then thanked the Tunisian Government for its welcome and for the opportunity to view the work done in the field.

ANNEX 3

RECOMMENDATIONS OF PREVIOUS EXPERTS MEETINGS ON MAB PROJECT 3

AND ON THE CONFERENCE ON EMASAR PROGRAMME

1. MAB Project 3 meeting in Montpellier, 2-7 October, 1972*

Objectives and programme of research. The general objectives of the research activities would be to improve and rationalise grazing management and development practices in zones where agriculture is marginal - either because of climatic constraints or edaphic limitations - and to avoid the irreversible degradation of "fragile" zones which constitute an important part of the available lands in this region.

The programme of research might valuably concentrate on the study of the relations between pasture management and the life styles of human populations, including consideration of socio-economic factors, and the study of the effects of modern technology (mechanization, etc.) on the evolution and utilization of grazing lands. The execution of this programme obviously requires that indispensible basic studies are effected, including studies of an ecological, agronomic, animal husbandry, economic and sociological nature.

Aspects which might merit special attention in this programme of study are: periods of food shortage for animals; adaptation of the cycles of production and reproduction of animals to the production patterns of different vegetation types; sustained increase in the production, and maintenance of the potential production, of grazing lands (through fertilization, periodic use of lands for grazing, better utilization of water, etc.); comparison of pastoral production compared to that resulting from multiple use of these lands; evaluation of the ecological imbalances caused by short-term, abusive exploitation of zones marginal for agriculture.

Action proposals. The panel, recognizing that there already exists in the Mediterranean region a number of projects responding to the above objectives, felt that the development of pilot projects, which would be sufficiently representative to facilitate the generalisation of results, should be encouraged and supported.

The panel, in confirming the insufficient exchange and diffusion of experimental results, suggested that a co-ordinated multinational network of experimental facilities and designs should be developed. This network should enable the study, in situations whose representativity could be verified, of the scientific and technical problems posed by the interfaces between man, animals and plants, in relation to the conditions of improvement or degradation of the natural environment.

Noting the needs for information exchange and for training of specialized personnel, the panel felt that all actions which would lead rapidly to the development of an information and training centre at the regional level should be encouraged and supported.

This centre would have a multi-disciplinary and international vocation and would have the following main objectives:

- to collect - within a standardised system - ecological, agro-economic and sociological information, and thus to build-up a form of "data bank" which would be available to research and development bodies in adhering or contracting countries;

- to process the information thus accumulated, in order to resolve both fundamental problems (analysis of the spatial and temporal structure of ecosystems, their functioning, their dynamics) and problems of an applied nature (land management and development models, integrated development projects);

- to participate in different ways, through bilateral, multilateral or other contractual arrangements, in pilot-project studies in the Mediterranean region;

- to contribute efficiently to the training of the scientific and technical personnel required, particularly in view of ensuring the transfer and diffusion of all types of information related to the objectives of MAB Project 3 and those of other relevant projects.

The panel suggested that a centre be developed in the Mediterranean Basin which would benefit from existing national and international bodies and which would co-operate with other centres in other parts of the world. The possible location of such a grazing lands information and training centre for the Mediterranean region was considered. It was suggested that this might valuably be sited at Montpellier, where there already exists substantial logistic facilities and where there is a tradition of co-operative work on grazing land problems with other institutes in the region. This suggestion received strong and explicit support from many participants, particularly those from Mediterranean climate countries.

The panel realized of course that the Mediterranean region had in principle no greater priority than other grazing areas of the world. It seemed likely, however, that there is a practical possibility to start with this suggested centre in the relatively near future. A number of countries in the region have already expressed willingness to co-operate in its work. Many developing countries would benefit immediately from the establishment of the centre, which would provide both a stimulus and a case example for the development of similar centres in other grazing land regions.

Some members of the panel thought that the centre should preferably deal with all lands in the isoclimatic Mediterranean region. Other members felt that this centre, at least initially, should concentrate on the countries of the Mediterranean Basin, though it might valuably expand its activities to the isoclimatic region at a later stage in its existence. There is clearly need for

* *Extract from MAB Report Series No. 6, page 40.*

further consideration of this matter, taking into due account on the one hand the scientific advantage of an isoclimatic approach and, on the other hand, the operational advantages and the practical value of an approach giving special attention to geographical and historical commonalities.

There is evidently need for further elaboration and definition of the structure and functions of such a centre and of the programme of work it should serve. In noting the need for developing regional centres in all the major grazing land areas, the panel felt that the formulation of concrete suggestions and proposals - identifying locations and securing financial support - should be of high priority in the process of implementation of MAB Project 3.

2. MAB Project 3 meeting in Hurley, United Kingdom, 2-5 July, 1974*

Areas and problems. Two main ecological zones, and related problem themes, relevant to MAB Project 3 can be distinguished in the Mediterranean isoclimatic region. First, there is the arid pastoral zone (about 100 to 400 mm annual precipitation) in which cropping is at best marginal, and satisfaction of the immediate socio-economic needs of the human populations depends upon rational use of water, of land and of vegetation. In this zone, a major problem is that of controlling the processes of desertization. Second, there is the pastoral area with moderate rainfall (annual rainfall greater than c. 400 mm) where cropping is marginal and where there is also a recent trend toward reduction of lands devoted to grazing use. The satisfaction of the socio-economic needs of the local peoples, and of transients (tourists, holiday-makers), is dependent on the restoration of soil fertility, the creation of diverse plant communities and the avoidance of fire risks.

Basic research aimed at the rational management of lands threatened by steppization and, more especially, by desertization. This research theme (termed "ARIDMED", for convenience) is relevant to the northern Sahara and the Near and Middle East. Proposals for field projects were presented to the working group by representatives of Egypt, Israel and Tunisia. France proposed to continue her involvement in activities already undertaken with Tunisia in a bilateral project. In addition, Algeria, Iran, Libya and Syria, among others, are likely to be interested in this co-operative research theme, as well as Australia, Chile and USA (California).

The essential objective of the proposed research is to understand the components of natural and human environments, and their interactions, in order to indicate those measures which might be undertaken to permit the long-term rational exploitation of natural resources. Research should particularly be designed to: (a) develop methods of management of land, water and biological resources which are based on ecological principles, and which aim to reduce the processes of steppization and desertization and to repair the damage these processes have caused; and (b) to establish measures for the improvement of the quality of life of local populations by limiting and buffering the effects of climatic irregularities on production.

The plan of work to be undertaken should include (a) assessment of the present situation, (b) examination of the possibilities for innovation and improvement and (c) assessment of alternative development options.

Thus, the first stage of assessment of the current situation might include:

- study of spatial and temporal variation in the composition of the ecosystems under examination, as related to environment factors;
- assessment of actual and potential plant and animal performance;
- study of the economic value of the products of the ecosystems examined;
- study of the dynamics of the relationships between plant communities, animal populations, abiotic factors and man;
- analysis of the processes leading to desertization as related to water availability and flow, to the effect of man and to fluctuations and long-term changes in climate;
- study of mineral cycling in the ecosystems examined and the effect of deficiencies and excesses of minerals on the health of human populations;
- study of land tenure problems as they affect the planning and implementation of development projects in grazing land areas.

Given this initial assessment of the present situation, a second stage in the work plan would focus on the possibilities for innovation and improvement, including:

- examination of different combinations of land use in complex systems, including grazing lands and croplands (either non-irrigated or irrigated), as well as woodlands, recreation areas and other forms of land use;
- assessment of the performance of local breeds of domestic grazing animals;
- study of the effects of formal schooling and other educational means (e.g. mass media) on the evolution of rural societies;
- examination of application of remote sensing techniques such as those provided by satellites (ERTS), in order to develop a monitoring system for desertization processes (e.g. Project ARZOTU, a project proposed to NASA for southern Tunisia).

A third stage in the work programme would comprise assessment of alternative development options and strategies as a basis for policy determination. This might entail, among other actions, the examination of various socio-economic strategies as affected by input-output energy budgets and the introduction of low-cost technologies.

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* *Extract from MAB Report Series No. 25, page 18.*

Work within this problem area should initially be based on existing national, bilateral, multi-national or international projects in the region, such as those already underway in Tunisia (central and southern regions), Israel (Migda, Wadi Meshash), Egypt (the coastal part of the North West desert), Algeria (Saïda steppes), etc. High priority should be accorded to fields of research which are not adequately covered in these projects, in particular the socio-economic aspects. A second step would be to encourage the early implementation of analogous projects in countries having similar environmental conditions. This could be done by:

- comparison of data and results obtained by different methods, with a view to facilitating their extrapolation;
- establishment of comparable methods for the measurement of the main parameters of representative ecosystems in the zone under consideration;
- examination of methods of generalization at several levels, by the use of the techniques of systems analysis and modelling;
- "in-service" training of specialists and technicians at all levels of skill, function and responsibility;
- awarding of fellowships for relevant studies at universities and institutes in the region;
- establishing a regional information centre to assemble, arrange and distribute information (see proposition on information centres under Section 3.6).

The working group further recommended that co-ordinated research should be undertaken on ecosystems dominated by *Artemisia herba-alba* and on saline lands which are widespread in the region in question.

Priority should be given to co-ordinated research on promising ecotypes which might be used for forage (shrubs, legumes, etc.). In this respect, the UNEP representative noted that his organization is planning to sponsor a programme of genetic research on fodder plants.

Collection, preservation and testing of genotypes of valuable, or potentially valuable, plants. Some collecting and selecting of potentially valuable plants for grazing is currently underway in the Mediterranean region. Work on MAB Project 3 in the Mediterranean region might give a new impetus to the work. The objective of activities under this theme ("GENMED", in short) is to co-ordinate work already being done, to encourage the exchange of genetic plant material between the countries concerned, to collect genotypes in localities which are rich in promising forms of important species, and to introduce promising species into natural or managed grazing lands.

Work of this kind was attempted in the period 1955/1957 by FAO within its programme on "Uniform Mediterranean Nurseries". Much of the work on development of grazing lands in the past 15 years in North Africa is derived from this activity.

Activities within this theme should:

- encourage institutes where genetic plant material is conserved to produce catalogues of their collections;
- encourage the exchange of seeds and other plant material between institutes;
- establish a centre where the collected plants will be grown and maintained in nurseries and/or seed stores;
- establish experimental plots in representative habitats where the performance of plant species can be tested;
- encourage research and education in the taxonomy, biology and adaptation of economic plants.

The primary responsibility for the execution of this activity should be entrusted to FAO, with due co-ordination being ensured with MAB Projects 3 and 8.

Monitoring of biotic changes in grazing lands throughout the Mediterranean region through establishment of biosphere reserves. The aim of this theme is to establish a network of biosphere reserves (see MAB Report Series No. 22) to serve as controls in studying the dynamics of grazing land and wildlife areas, as well as for *in situ* conservation of genetic material. Such protected areas for research, education and gene pool conservation are largely lacking in the region. The programme of work on biosphere reserves and other protected natural areas should include:

- establishment of a network of biosphere reserves and smaller exclosures in the most important and representative ecosystems throughout the Mediterranean region;
- development of ground and remote sensing methods for monitoring changes within and outside of the reserves;
- long-term comparative recording of the condition and state of the ecosystems under investigation.

Problems of information exchange in the Mediterranean region. The working group gave special attention to the problems of information exchange in the region. In particular, proposals for the "Ecothèque Méditerranéenne" ("ECOMED") were examined. This is a centre of ecological information for the Mediterranean region created by the Centre National de la Recherche Scientifique (CNRS) of France following the recommendations of the panel of experts on MAB Project 3 (see MAB Report Series No. 6). This centre, located at Montpellier, is open to all forms of co-operation with groups of research workers and institutions of the region on the basis of "research projects". The French delegation presented a document, indicating the features of this centre, to the Hurley meeting.

The working group recommended that this proposal be accepted by the International Co-ordinating Council, and suggested that Unesco accords all appropriate recognition and possible assistance to this centre in its work of regional co-ordination.

The immediate work programme of the centre includes:

- study of the compatibility of the nomenclature for about 2000 dominant species of the mediterranean flora;

- collection of climatic data from as many stations as possible, and its use in interpretative models which depict the dimensions of agro-climatological variation in space and time frameworks;

- collection, analysis and evaluation of the information available from thematic mapping in the countries of the region;

- organization of seminars on modelling methodology;

- dissemination of information to contributing projects.

3. International Conference on the EMASAR Programme, held in Rome, 3-8 February, 1975*

Conclusions. The Conference concluded:

(1) The rangeland problem is serious and acute, requiring immediate action.

(2) Arid and semi-arid rangelands and rangelands associated with them are important and deserve higher priority and emphasis in national, regional and international development and management programmes.

(3) Most nations have the technicians to conceive range management and development programmes, but the number of national technicians is inadequate for implementation, thus emphasising the need for immediate action relative to training and education programmes and centres.

(4) Considerable financial assistance will be needed for the range sector and, if more funds are to be made available for range development, more attention will need to be given to defining comprehensive strategies, developing appropriate structures and requesting assistance for project formulation and implementation.

(5) More attention needs to be given to establishing a basis for development, involving suitably trained manpower, data on land and human resources, improved technology and suitable organizational framework.

(6) Active participation by the pastoralists concerned will be essential to the implementation of a successful range development and management programme. This will require knowledge of socio-economic factors involved, defined appropriate management units, and motivation and training of the pastoralists.

(7) Special attention needs to be given to overcoming the effects of drought and seasonal forage availability, overexploitation, feed shortage, etc.

(8) The focus of attention should be at the national level, but there is an international gap that could be filled by regional programmes, making regional and sub-regional activities essential.

(9) A multi-disciplinary approach is required involving such disciplines as range management, animal health, animal husbandry and improvement, sociology, economics, forestry, soils, wildlife, watershed management, marketing and water development. Also, the multi-disciplinary approach requires co-ordination at national, regional and international levels.

(10) An international rangelands programme such as EMASAR is required and is in demand.

Endorsements. The Conference noted the report of Expert Consultation on the Ecological Management of Arid and Semi-Arid Rangelands in Africa and the Near East, and considered that the document provided guidelines for the EMASAR programme.

It stressed, however, that considerable variations exist among the needs of member countries and that these should be fully taken into account in the development of the EMASAR Programme.

The Conference endorsed the proposal to form an EMASAR International Programme for Africa and the Near and Middle East with the objectives of embracing the full range of interested parties including both funding organisations and nations and the countries in need. The Conference considered that such a Programme would give range management the identity and emphasis that is required to achieve immediate and widescale progress in Africa and the Near and Middle East. It felt that progress in the past was not commensurate to the urgency of the problem because range management has not been given proper status in the various programmes and projects at the national, regional and international levels.

The Conference also noted the technical and financial assistance that has been extended to the African and Near and Middle Eastern countries in the field of range management and hoped such assistance will be continued and expanded.

Recommendations. The Conference showed particular concern about the rangeland situation in Africa and the Near and Middle East and made the following recommendations:

(1) That emphasis should be placed upon national development including the development of national expertise to formulate and implement projects and programmes.

(2) That FAO in collaboration with other interested parties take steps to form an international rangelands programme (EMASAR) as soon as possible. An outline for the organization of the programme, with terms of reference and recommendations relative to the functions, structures, activities and co-operative links are presented as a separate action of this Report.

* *Extract from the Conference report.*

(3) That sub-regional, regional and international projects be developed to fill existing gaps and bring about better co-ordination.

(4) That emphasis be placed upon the immediate, practical application of already existing knowledge. The programme should include arrangements for the transfer of such knowledge. Research should be encouraged and its results made available to the countries concerned.

(5) That education and training at all levels on national and regional bases be given top priority in EMASAR activities.

(6) That EMASAR give emphasis to assisting the nations in formulating projects and programmes and in securing funds and implementing them.

(7) That the donor organizations and nations co-operate with the EMASAR International Programme and its objectives and assist it in every possible way.

(8) That EMASAR assist governments upon request in arranging appropriate surveys essential for the elaboration of development plans and schemes and, subject to the consent of the country concerned, assist in collecting and disseminating required data and information.

(9) That all interested organizations, institutions, foundations and nations that are currently assisting the African and Near and Middle Eastern countries continue and expand their endeavours in the field of range management.

(10) That EMASAR should consider all existing related activities and institutions in their endeavours and should co-operate with and/or include them when possible and avoid unnecessary duplication.

ANNEX 4

RESEARCH, TRAINING AND DEVELOPMENT PROGRAMME FOR ARID RANGELANDS

SUBMITTED BY THE FIVE NORTH AFRICAN STATES

1. Algeria

1.1 Integrated project on the "potential of rangelands in the Wilaya of Saida"

1.1.1 Description of area

The Wilaya of Saida covers an area of 9,000,000 ha. It extends to the Moroccan border in the west and in the north is bounded by the Saida mountains and the Northern edge of the Chott Chergui. In the east it takes in the Southern part of the Saharan Atlas as far as the Djebel Amour, and in the south its boundary is formed by the Northern foothills of the Grand Erg Occidental.

It is therefore a very extensive area whose boundaries are almost all natural, and it can be considered to be a crossroads from the floristic and bioclimatic point of view. A feature of its continental climate is the general inadequacy of rainfall which is unevenly distributed both in space and time. Minimum temperatures are often below 0°C and frosts occur frequently. In the Ain Sefra and El Biod areas the influence of the Sahara is felt, whereas the north of the wilaya comes under the influence of sub-humid and semi-arid bioclimates.

The area as a whole falls mainly within the arid bio-climatic zone and examples of all the different sub-divisions and variants of this bioclimate are to be found within it. Examples of the semi-arid bioclimate occur in the main in the cold sub-zone on the peaks of the highest massifs of the Saharan Atlas, about whose ecological and floristic characteristics very little is as yet known.

Relief. This steppeland consists mainly of a series of glacis and regs interspersed with depressions and shallower surface layers of sand. It is traversed from southwest to north-east by the Atlas mountains which rise in a solid mass, sometimes to a height of almost 2,100 metres. The sharp outlines of the mainly sedimentary terrain are revealed in Jurassic and Cretaceous outcrops.

Hydrology. The hydrological system is extremely irregular, owing to the broken and abrupt nature of the relief. A wide variation in flow and methods of alimentation can be observed along the full length of the wadis. Underground water reserves are considerable.

Vegetation. The zone is covered by a wide variety of steppeland vegetation, including alfalfa, lygeum, wormwood, psammophytes and halophytes whose present or potential interactions, distribution, composition and biomass are as yet uncertain.

Population. Two hundred fifty thousand people are directly supported by sheep-raising. The number of sheep in the area is estimated to be 3,000,000, mainly of the hamra breed.

1.1.2 Objectives of the Programme

The objectives of the programme are the following :

(1) at regional level, an ecological inventory of the vegetation of the various milieux (1:500,000 map of the main types of vegetation) ;

(2) detailed inventory in the test areas ;

(3) medium scale mapping of the following major factors : land use, settlement, phyto-ecology, bioclimatology, edaphic factors and pastoral production in the test areas, and map of grazing patterns after four years.

Assistance would be required in the following specialized fields : phyto-ecology, animal breeding, fodder, socio-economics, and management models.

It should be noted that the Research Centre for Biological Land Resources (CRBT) which is co-ordinating this programme has already set up three field stations which are now staffed by ten research workers.

The request for staff concerns the following :

(1) one specialist in management and pastoral improvement (four years) with experience of grazing and animal breeding problems (sheep) ;

(2) two interpreters of photographs (three years) with experience of mapping and phyto-ecology ;

(3) two consultants (six months each) one specializing in the measurement of the various components of an ecosystem, and the other to collaborate in formulating a methodological approach to the study of socio-economic structures and who should therefore have a background in sociology and economics;

(4) one phyto-ecologist (two years) to work on the thematic mapping (scale : 1:500,000) of vegetation and the most important environmental factors, particularly those connected with the degradation of soil and grazing land, with a view to the rational use of 20 million hectares of rangeland.

It should be pointed out that the financial and material resources required for the programme as a whole are available. The Research Centre for Biological Land Resources (CRBT) will provide hosting facilities.

1.2 Training

At regional level, and in accordance with the recommendations adopted by the Sfax meeting's

committee on training, Algeria repeats its offer to take in five students from each of the countries concerned to attend courses in ecology and to prepare the DES diploma of higher studies (Diplôme d'Etudes Supérieures), specializing in the management of arid and semi-arid rangelands. Financial support is requested, however, to cover the travelling expenses of these students and the remuneration of two teachers.

2. Egypt

2.1 The Desert Institute (El Mataria, Cairo)

The Desert Institute was founded in 1949. Its present director is Prof. Dr. M.A. El-Mahdi.

The objectives of the Institute are the following :

(1) study of soil, biological, climatological, zoological and botanical aspects of the desert environment ;

(2) study of potentialities of the desert and semi-desert areas for developmental purposes ;

(3) study of methods and means of development based on the conditions of the region ;

(4) study of water resources, nature and capacity of the underground reservoir ;

(5) control of sand dune movements on agricultural land ;

(6) adaptation of methods against soil erosion by wind and water ;

(7) study of extension areas particularly those developped under permanent irrigation including fertility.

Research activities consist of integrated surveys dealing essentially with water resources, soil resources, plant and animals, over some selected areas in the Egyptian desert as well as in a number of Arab and African countries. In Egypt these areas include : the Mediterranean coastal zone (sub-arid) ; the New Valley in the Western Desert (extremely arid region) ; the Nile Delta marginal areas (arid) ; the Northeast and Central Sinai (arid) ; and the Lake Nasser area (extremely arid).

The work is carried out on both local and regional levels. Local activities include :

(1) study of the coastal area from Alexandria on the east to El-Sallum on the west ;

(2) study of the coastal area of Alexandria towards Port-Said ;

(3) study of the extension areas east and west of the Nile Delta ;

(4) study of Lake Nasser area ;

(5) study of the Oases depressions and their extension to the Sudan borders ; and

(6) development of the Sinai Peninsula.

Regional activities include :

(1) study of hydrogeological and pedological aspects in the North Yemen Republic ;

(2) study of a water reservoir in part of the Sudan Republic ;

(3) collaboration with the Arab Center for Development of Arid Regions.

2.2 The SAMDENE Project : "Systems analysis of Mediterranean desert ecosystems of Northern Egypt"*

There has been an increasing interest in the development of scientific bases for the rational use and conservation of the resources of natural and semi-natural areas. In many parts of the world, these areas are in serious danger of being completely or partially destroyed due to perturbations by human or other manipulation. This is particularly obvious in arid and semi-arid regions where ill-advised land-use methods have led to profound and often irreversible changes.

The western Mediterranean coastal land of Egypt provides a clear example of such changes. This region which extends for about 550 km between Alexandria and Salloum is characterized by the most favourable moisture regime, and consequently has the best biological potentiality of all Egyptian deserts. It is claimed that the region enjoyed prosperity during the Greco-Roman times and that continued uncontrolled cutting, grazing and farming which dominated the whole steppe region bordering the northern Sahara since the eleventh century have induced a process of degradation comprising reduction of perennial plant cover, impoverishment of flora, soil erosion, dust storms, formation of mobile sand dunes, and establishment of desert pavement.

In order to avoid devastating changes such as these and to restore, if possible, degraded areas, it is necessary to have a means of predicting the effects of manipulation on arid-land ecosystems. This is now made possible through the integrative approach of computer modeling with the objective of predicting changes in any part of an ecosystem due to either natural or man-made manipulation. The operational goal for attaining this objective is the development and testing of computer models which simulate the functioning of the system.

A five-year project is now being carried out in Egypt to study the ecology of the Mediterranean desert ecosystems of northern Egypt. The information obtained would not only add to the ecological knowledge of the area, but would also provide a sound base for land-use decisions which may be applicable to desert habitats within the same bioclimatic zone. The main long-range goal of this project is to construct predictive models simulating the major ecosystems on the western Mediterranean coastal land of Egypt in terms of energy and material flow, and of spatial and temporal changes in plants and animals and in soil features in relation to environmental variations.

* *The project is carried out by the University of Alexandria with support from the Environmental Protection Agency (EPA) of the United States of America.*

This area is characterized by prominent topographic configurations, which are a series of parallel ridges alternating with depressions. Accordingly, two sets of habitats may be distinguished, one on ridges and the other in depressions. Ridge habitats may be further differentiated into the habitat of the coastal ridge which is overlain by dunes of snow-white calcareous sand grains, and that of inland less calcareous ridges. Habitats of depressions are differentiated, according to the relative proximity of water table to the soil surface and the level of salinity, into saline and marshy depressions and non-saline depressions.

These four major types of habitat are physiographically and vegetationally distinct and it would be desirable to study them all. However, we are beginning with only two hoping to include the other two if, in the future, the support base for the project is broadened. The habitats of sand dunes and non-saline depressions have been selected for initial study. The sand dune habitat is dominated by *Ammophila arenaria, Ononis vaginalis, Echinops spinosissimus* and *Cruciancllu maritima*, and the non-saline depression habitat by *Thymelaea hirsuta, Asphodelus microcarpus, Noaea mucronata,* and *Gymnocarpos decandrum.*

The work to be carried out in this project may be categorized as follows.

Process studies. These consist of co-ordinated projects by individual investigators. They are addressed to the important population, and energy- and material-moving processes in the major plant and animal species, and in abiotic and micro-organism components of the ecosystem. These processes are measured as rates, and are expressed as functions of the biotic and abiotic environmental factors that affect them. The total projects needed are decided in the course of planning the entire programme, and the individual investigators are given considerable freedom in carrying out the research as long as they meet the objectives agreed upon at the outset and produced data that can be incorporated into the model. The major plant, animal, micro-organism and abiotic (soil and climate) components are :

Plants : net photosynthesis
vegetative growth
flowering and fruiting
nutrient uptake
water uptake
transpiration
germination
death (part or all)

Animals : food uptake
excretion
assimilation
metabolism
respiration
growth
reproduction
mortality
dispersion

Abiotic : soil-salt movement
water runoff
evaporation
infiltration
soil-water movement
radiation and heat flux

Micro-organisms : proteolysis
nitrification
nitrogen fixation
denitrification
phosphatization
decomposition

Data provided by these studies will be used to construct simulation models.

Modelling. This phase consists of integrating the many functional equations and relationships produced by process studies into a single computer model which simulates the functioning of the desert ecosystem. This effort is being carried out within the Biome Central Program at Utah State University, and at the American University in Cairo, Egypt.

Validation studies. These studies are conducted on representative desert areas and provide checks on the predictions of the model. An initial inventory of the state of the system - in terms of the amount and nature of energy and materials, and spatial, age and size distribution of the organisms - provides the original input to the model. The model will, given the inputs into and outputs from the system, simulate the changes over time of the ecosystem on the site. Periodic standing-crop measures of the site, which constitute the validation studies, provide checks on the accuracy with which the model simulates the real world, and feedback with which the model can be refined. These studies are conducted by groups of investigators close to the validation sites. They consist of :

(1) initial and periodic measurements of standing-crop inventory of the components of the site (these are defined as plants, animals and micro-organisms ; litter ;nitrogen and carbon compounds in the soil ; water ; energy) ;

(2) continuous records of climatic elements (these are above- and below-ground temperatures, relative humidity, dewfall, rainfall, soil moisture, runoff, input and output of solar energy).

3. Libya

The Agricultural Research Centre of Libya (Tripoli)

The Agricultural Research Centre of Libya (Tripoli) was established in 1971. Dr. Mohammed S. Zehni is the Chairman of the Board of Directors and Dr. Abdel Majeed Ben Saad is the Director-General of the Centre. The duties of this centre are the following :

(1) working out a short and long term plan for scientific research for the purpose of agricultural development, and arranging for priorities of research in co-operation and co-ordination with other existing bodies of scientific research ;

(2) collecting, classifying and evaluating technical, economical and social

research studies on agriculture in the country ;

(3) carrying out the following studies and research : development and maintenance of natural resources such as soil, water, crops and pastures ; problems of agriculture in oases, valleys, rainfed lands and arid zones ; climatological conditions relating to agriculture ; economical studies and research pertaining to agriculture and its development ; means of improving plant and animal production ; any other studies or research topics in the field of agricultural development which might be considered appropriate by the Minister of Agriculture and Agrarian Reform ;

(4) publication of results of studies carried out by the centre ;

(5) co-operation with agricultural extension (and advisory) services in investigating agricultural problems and finding adequate solutions for them, and implementing the findings of research studies ;

(6) holding scientific conferences, symposiums and seminars, and maintaining contacts with international bodies ; attending meetings connected with the functions of the centre ; exchange of research workers with other bodies, inside and outside the country, particularly with Arab countries.

Studies are in progress in the following fields of research : variety trials on cereals ; plant pathology ; entomology ; soils, water and fertilizer application ; fodder crops ; use of petrolium materials in conservation of moisture for crops ; cultivation of vegetables under cover (glass, polythene) ; some aspects on animal production.

The centre publishes a scientific periodical entitled "Journal of Agricultural Research" in Arabic, with an English summary.

4. Morocco

The following projects are at present connected with the themes of MAB Project 3 and the EMASAR programme.

4.1 FAO Forest Rangelands Project (Director Mr. Poupon).

This project is just being established at the moment. It will involve six test areas in which the problems of woodland pasture management will be studied. Particular attention is to be devoted to the Arganeraie in the Souss.

4.2 Management of a pastoral improvement area in the arid zone.

Three management projects, which are the responsibility of the Directorate for stock-raising, are at present in the preliminary study stage. These projects would be carried out in the following locations : Ain Beni Mathar (20,000 ha) in Eastern Morocco, El Borouj (14,000 ha) in West Morocco, and Bou Mia (25,000 ha) in the upper reaches of the Moulouya river. In 1972 the ERES Research Bureau (Société d'études) made some concrete proposals regarding the first area and the third is the subject of a thesis being written by students now completing their course in pastoral studies in the Hassan II Institute of Agriculture in Rabat. In none of the three areas has any substantial progress been made within the present legislative and socio-economic context.

4.3 Management of rangelands in the presaharan zone

This project was launched in 1975 by the Saharan Agriculture Station. It is to be sited in the North of the Plain of Tamlet, between Talsinnt and Bouârfa in an area already mapped and studied by the ERES Research Bureau in 1972. Its aim is to improve the management and use of rangelands and the conditions of animal production in areas normally used by the local stockraisers.

A number of research topics have an indirect link with MAB Project 3 and with the EMASAR programme, through the contribution which they make to our knowledge of the physical and human environment of the zones concerned :

(1) FAO project "Prevention of erosion in the Wadi Nekor basin" (arid and semi-arid zone in North-East Morocco) ;

(2) geobotanical and cartographical survey of the Souss area (Mr. Pelletier, Institut Scientifique Chérifien) ;

(3) floristic and ecological survey of the Eastern and North Eastern ranges of the Middle Atlas (Mr. Peyre, Institut Scientifique Chérifien) ;

(4) management of the Tessaout basin (surveys now being made by the SOMET Research Bureau).

5. Tunisia

5.1 The grazing land project in South-central Tunisia (TUN/69/001)

In 1970 the Tunisian authorities, aware of the need to improve the rangelands in the steppe areas in the south of the country, launched a limited project, at that time entitled "Integrated research and development project for Rangelands in pre-Saharan regions of Tunisia" but now known as the "Research and Development Project for Rangelands in Southern central Tunisia", whose main objectives, in accordance with the principles set out above, are as follows :

(1) the preparation of surveys and the establishment of pastoral improvement areas in public and co-operative sectors chosen by the Tunisian authorities; on the basis of the results obtained, the elaboration of a method of management and rational exploitation of rangelands involving, depending on the area, fodder reserves from dry-land or irrigated crop-farming ;

(2) the elaboration of a method of land use which might help to limit the encroachment of the desert ;

(3) scientific and technical training for work in grazing land improvement and the prevention of desertization. These measures should provide land users with the knowledge which will enable them to make more rational use of the ranges and to improve the management and use of the natural environment (bearing in mind the needs of the local communities).

The more important of the measures taken to achieve these objectives are :

(1) preparation of surveys and the drawing up of phyto-ecological maps and maps of grazing land resources with an indication of the above-ground bio-mass which can be consumed by the animals (expressed in kg of dry matter and converted into FU/ha/year) ;

(2) measurement of above-ground plant bio-mass with variations in space and in time as a function of the water factor ; construction of models showing DM/water/time ;

(3) investigation of consumption and of secondary production on the rangelands ;

(4) study of the process of desertization and modelling ;

(5) elaboration of a methodology for pastoral improvement ;

(6) preparation of plans for the management and rational exploitation of several areas of pastoral improvement in the Centre and South of Tunisia ; establishment of these areas for demonstration and development purposes.

The project comes under the aegis of the Tunisian National Institute for Agronomic Research (INRAT) and receives aid from the United Nations Development Programme (UNDP), Project TUN/69/001. Under the terms of an agreement between the French National Centre for Scientific Research (CNRS) and the Tunisian Ministry of Agriculture, the L. Emberger Centre for Phyto-sociological and Ecological Studies (CEPE) has assumed responsibility for scientific investigation and the execution of phyto-ecological measures. The Office for Scientific and Technical Research Overseas (ORSTOM) is also collaborating, with the agreement of the Directorate for Water and Land Resources (DRES) of Tunisia and INRAT, in respect of certain climatological, hydrological (catchment areas) and pedological (hydric balances and descriptions) aspects of the programme. The project is at present staffed by an FAO expert on grazing problems, who is the co-ordinator of the project, a Unesco expert on phyto-ecology responsible for measurement of bio-mass, a phyto-ecologist and photo interpreter from the CNRS, two chief technicians from INRAT who are experts on the problems of animal breeding and various executive staff from INRAT and the Gabès Regional Centre for Agricultural Development (CRDA).

As the pastoral improvement measures have progressed, close collaboration has developed with the Regional Centres for Agricultural Development of Gabès, Sfax, etc, with the Directorate for Forests, the Office des Terres Domaniales (OTD) and with other UNDP projects, WFP 482, TUN/71/525, TUN/72/004, TUN/5-13 (SWE), TUN/71/540. The project is financed by INRAT, the CNRS and UNDP. Although scheduled to continue until autumn 1976, the project has already some encouraging results to show. For the base inventory of the natural environment of grazing lands, the phyto-ecology and grazing resources of more than 300,000 ha have been mapped on a scale of 1:100,000, approximately 60,000 ha at 1:20,000 and fifteen thousand or so at 1:10,000. Sample measurements of bio-mass have been taken at over one hundred different stations and detailed measurements of seven reference units are regularly taken for the purpose of studying the relationships between plant production and mesological variables (temperature, precipitation, water available in soil, etc.). This data, supplemented by the measurement of secondary production in one station, is to be taken over a period of five years. The same is true of the process of desertization, which has been studied systematically since the beginning of the project.

In the context of regional planning it also proved necessary to study ways of evaluating the sensitivity of vegetation and the natural environment to various factors such as cultivation, the eradication of perennial species and overgrazing. A transition matrix model has also been constructed in order to study the effect of these factors on the evolution in time of 22 ecosystems in a test area of 20,000 ha.

As regards study of the operation and the achievements of the project, this was not originally intended to begin until basic data on rangelands had been accumulated over several years. But as the programme of research proceeded the project came under an obligation to answer various requests for immediate application studies and in this way it gradually evolved a pastoral methodology (see Annex 7) for the preparation and establishment of pastoral improvement areas.

5.2 Progress made in the management and development of arid zone pasture lands

5.2.1 General framework

The Southern central region of Tunisia accounts for more than 12,000,000 ha of the country's total area (15,500,000 ha), and can be divided into 5,500,000 ha in the arid zone (annual rainfall between 100 and 350 mm) and the remaining 6,500,000 ha in the desert zone (annual rainfall below 100 mm).

As in all Mediterranean countries, these steppe zones were in the past used mainly for grazing. For some decades now these areas which were formerly inhabited mainly by nomads have been subjected to severe pressure from an increasing population, which has begun to show a tendency to settle. In order to meet its

normal food requirements this population, estimated at approximately 2,800,000 including 2,200,000 rural population (population of the country as a whole is 5,200,000) has brought more and more land under rather unproductive cultivation at the expense of the best grazing lands. More than 2,700,000 ha of grazing land were taken over in this way from 1890 to 1973, leaving a total at present of 7,000,000 ha of grazing land (not counting the desert zones proper).

Herds consist of approximately 800,000 fat-tailed ewes of a barbary breed, 450,000 goats, approximately 30,000 bovine animals, 10,000 horses, 17,000 mules, 110,000 donkeys and 120,000 camels. Of these animals the sheep, goats and camels are able to make the best use of the vegetation of arid and desert rangelands and account for more than 80 per cent of the herds grazing on these lands. In an average year the total fodder production of the Southern-central area is estimated at 750,000 FU, of which more than 90 per cent is rough fodder, the remainder consisting of crops and fodder reserves and various types of by-product (bran, barley, feeding cakes and concentrates).

The herdsmen of South-central Tunisia, who were in ancient times fully nomadic, have gradually changed their system of land use until today they form almost settled communities. This is an irreversible process which now makes it necessary to find on the spot all the food supplies required to ensure subsistence. The herds themselves have a high proportion of unproductive animals, the fertility rate is variable and hygiene and health are generally poor. They are at the mercy of climatic variations, and in particular of variations in rainfall, which frequently varies by as much as 400 and even 700 per cent. In order to insure themselves against the risks of a high death rate in years of severe drought (when pastoral production may drop by 90 per cent), the herdsmen tend to increase herd numbers to the maximum, with the result that herds are almost permanently in the process of reconstitution.

In such circumstances it is not difficult to see why the rangelands in these areas are constantly over-grazed to a point where the animals suffer from chronic under-nutrition and where the process of desertization, which sets in as the vegetation is degraded, jeopardizes the national heritage. While these regressive trends are accelerated by customary methods of grazing it has in fact been shown that an animal can improve the quality of the land it grazes if a standardized approach and the appropriate rational techniques are used. This is the reasoning which led to the concept of an area of pastoral and animal health improvement, on which a herd should be able to graze permanently and increase its productivity.

To sum up, it would appear essential to :

(1) safeguard and improve the quality of the remaining rangelands by the use of rationalized techniques ;

(2) plant as much fodder as possible in order to tide over difficult periods and keep the herds alive in years of drought ;

(3) ensure regular and adequate feeding of the herds ;

(4) determine the appropriate stocking rate, bearing in mind both grazing and fodder resources ;

(5) stabilize herd numbers on the basis of this stocking rate ;

(6) protect the herds from disease by systematic prophylactic measures :

(7) ensure optimum productivity by rational herd management, in which selection and performance control are decisive factors ;

(8) keep stock-raisers and administrators who are in direct contact with them informed of these new techniques.

The methodology used to prepare and establish these areas for the improvement of pastureland, fodder and animal breeding simultaneously as part of an overall plan is described in Annex 7. Not only is their extension justified, but also essential for the future of stock-raising in the South-central region of Tunisia.

5.2.2 Action undertaken

A distinction should be drawn between the two aspects of the measures taken so far : study and research problems which are dealt with under the previous heading and in Annex 7, and extension work to familiarize stock-raisers with the new techniques.

As regards study of the operation of the project and results achieved so far, it should be pointed out that nine improvement and test areas totalling about ten thousand hectares are already in operation (improvement areas at Sbeitla, Hadj Gacem, El Adala and Chahal), about one hundred thousand hectares have already been evaluated (Oglat Merteba I, Ouled Chraiet and Chenini) and more than 150,000 ha are now under study (Oglat Merteba II and Zoughrata).

Areas in operation or in the process of being established by the projects TUN/69/001 and TUN/71/525 were studied at the request of bodies such as the Office des Terres domaniales (OTD), the Centres for Agricultural Development (CRDA), the Directorate for Forests, etc. Implementation of the measures in each area is the responsibility of the director of the holding and is carried out in accordance with the instructions set out in the study programme. Technical assistance for the implementation and control of the various measures is provided under projects FAO/TUN/71-525, WFP/482, TUN/69/001 and INRAT.

Experts working on these projects and research workers assist and train those responsible in each of the improvement areas for carrying out as closely as possible the measures laid down in the stock-raising calendar. Under their instructions, these agents check that rotation of herds is being strictly adhered to ; prevent other herds from grazing the area ; weigh the animals every month or help the experts to do so ; supervise prevention measures and check the animals' state of health ;

keep an account of lambing, identifying and weighing the lambs at birth ;organize the supplementary feeding for which provision has been made ; take part in prophylactic operations; and organize fodder plantations and keep records of stock.

5.2.3 Results

Study of the operation of the various areas over three years has yielded very useful information regarding the methodology adopted and the effectiveness of the measures taken.

Rangelands. As regards methodology, the main comments were as follows. Considerable experience has been acquired in the evaluation of pastoral production (measurement, estimates). However, there is a need for a programme to investigate the effective consumption of grazing species by the animals at different grazing periods and in different types of years. The food requirements of the animals were assessed on the basis of existing documentation. It would, however, be desirable to prepare a programme on the food requirements of the different types of animals as a function of their production cycle.

In order to ensure the smooth running of a system of rational exploitation, it is best to have a small number of plots, for example four or five and rotation periods of three weeks to one month. If a period of one month is chosen, a permanent programme of exploitation can be drawn up. The rotational plots must be of a reasonable size, in order to make the system more easily acceptable to the shepherds. For the boundaries of the rotational plots and of the blocks and areas themselves, use must be made of natural or existing artificial boundaries, in order to reduce investment costs.

The success of pastoral improvement measures is largely dependent on supplementary fodder. This may be produced on the spot (dry-land or irrigated cultivation) or brought in from outside and stocked. Annual requirements for supplementary feed are at present calculated as a function of four or five different possible types of grazing deficit. This, however, is only a temporary solution as what is really needed is a research programme on the relationship between grazing land production and the water factor (which varies according to the type of year) in South-central Tunisia.

The smooth running of an improvement area is dependent on efficient staffing ; area supervisor, shepherds and herdsmen ensuring that pastoral improvement measures are carried out and the stock-raising calendar strictly adhered to. Frequent inspection of the area by specialized technicians who can advise the staff on problems is essential for the first few years.

Of course wider application of the methodology, the completion of phyto-ecological and pastoral research into the total above-ground phytomass and the amount consumed, the application of techniques for management, rational exploitation and the observance of the stock-raising calendar will gradually make it possible to obtain a clearer picture of the various ways of bringing about a general improvement in grazing and fodder resources and in animal breeding and in this way to establish the guiding principles for the pastoral development of the Tunisian steppe. But as these are complex problems the solutions cannot be chosen until all their different aspects have been investigated, whether they concern scientific and technical methodology or the human, social, economic and legal problems.

As regards improvement of plant cover and grazing species as a result of rotation on pastureland whose carrying capacity has been taken into account, it is as yet too early to hope to reach conclusions. Meaningful results can only be obtained in the medium and better still, the long term. Thus despite a subjective judgement that the density of grazing species in the areas at El Adala and Hadj Gacem has improved, it must be frankly admitted that no figures can be quoted to support such a judgement. This is understandable as these areas were only brought into effective operation a year ago. On the agricultural combine at Sbeitla which was launched three years ago, on the other hand, the improvement in the productivity of the rangeland is quite clear. It has been estimated to be 15 per cent higher than in Spring 1972. This is a particularly encouraging result as the surface area has been reduced from 530 to 436 ha in the meantime while the number of animals has remained the same.

If the herd remains constant at 200 sheep units, it is thus possible, despite the intrusion of some animals from outside the area, to raise one sheep unit to two hectares throughout the year, which would have seemed a very optimistic forecast *a priori*, in this environment.

However that may be, and in spite of two poor years when the autumn rains were insufficient, there has been a definite improvement in the feeding potential of the Sbeitla rangelands already. Stock-raisers in the region have been able to see this improvement for themselves in the course of information visits which will be described later.

Other improvement areas which have been sited in less promising environments have a much lower carrying capacity, which was determined in the preliminary studies.

Fodder plantations. The surface area to be planted with fodder crops intended to make good the shortfall of grazing resources is calculated for each improvement area on the basis of existing and available resources. In a locality in which olive-growing is important (Chaal, for example), there will be large amounts of clippings, the leaves of which can be eaten by the animals either fresh from the tree or dried. In the same way a holding which has an oil press will be able to feed olive cakes to the herd throughout the olive pressing season, which extends roughly from the end of November to April.

All that needs to be done in order to determine the need for further supplementary feed is to calculate the number of FU per feeding period which can be obtained from the by-products of olive cultivation.

Bearing in mind natural conditions and on the recommendation of the authorities, the crops planted for fodder are spineless cactus on light soils and *Acacia ligulata* or *cyanophylla* and *Atriplex* in heavy or saline soils (*numularia* and *halimus*). These shrubs, which are essential to bridge the usual periods of shortage or drought and also to provide extra feed for the lambing and suckling period, have been planted

over areas large enough to offset the risks of a severe drought.

It should, however, be pointed out that the additional fodder provided by these shrubs, and by the cactus in particular, does not cover the food requirements of pregnant or suckling ewes completely, as their content of digestible nitrogenous substances is low and the mineral components are not well balanced : a lack of phosphorous is accentuated by an excess of calcium. It is therefore necessary to supplement this fodder with *ad hoc* feed concentrates which are essential at those times of year when the animals' food requirements are greatest.

In addition to the plantations of fodder crops, four groups of *Acacia cyanophylla* were planted at intervals on the Sbeitla grazing land this winter to provide shade from the sun during the summer months in the heat of the day, when the herd is not grazing and is seeking a shady spot to ruminate. Each of these groves is approximately 300 m^2 in area.

Herds. The success of a programme of pastoral and animal breeding improvement must be judged in the first place by the productivity of the flock. This is quite easy to determine, even in the short term. If a record of the improvement in productivity is kept season by season it will be possible to assess the value of the programme itself and keep a check on the thoroughness with which it is being implemented.

Improvement in the grazing species and the productivity of the pastureland can only be accurately measured in the long term. Our aim is to achieve an optimum rate of 100 per cent or more as soon as possible. The herd on the Sbeitla grazing area gave us 97 per cent in 1973 and 114 per cent at the 1974 lambing. In addition to an increase of 80 per cent in number as compared with other herds, the lambs of the Sbeitla herd are more mature, heavier, in better condition and sell consistently at 3 or 4 dinars more per head.

Thus both the individual stock-raiser and the State stand to gain : the additional amounts of meat on the market represent a saving for the State. If we take as an example a herd of 200 ewes we find that the traditional herd will produce 110 lambs weighing 22 kg which are sold for 14 dinars, making a total of 2,420 kg and 1,540 dinars. Our herd produces 200 lambs weighing 25 kg which are sold for 17 dinars, making a total of 5,000 kg and 3,400 dinars. This 200 per cent increase in productivity speaks for itself.

The quality of the staffing is also an important aspect of the arrangements and one which is reflected in results achieved. Experts must give careful thought to the question of training.

Apart from problems of this nature the operations provided for in the programme were implemented without too much difficulty. Some problems were involved in rotation in the beginning as the shepherds were not willing to be restricted to grazing in the chosen plot. However they were soon won over and are now the most enthusiastic proponents of rotation and balanced stocking rates. At present grazing on organized rangelands takes place normally and the grazing is meeting the needs of the herds as planned. As far as health is concerned prophylactic measures have made it possible to prevent any kind of epizootic or contagious disease. Indeed rotation itself is a factor in the prevention of internal parasites, and of lungworm in particular, as it breaks the cycle.

Attempted economic evaluation at Sbeitla. It is always very difficult to keep accurate accounts for an agricultural holding and almost impossible for an area of pastureland which forms part of a larger holding, particularly during the first year, when all the equipment has to be installed. Figures for the 1973-1974 season are only available for the agricultural combine at Sbeitla.

In this rough balance sheet, account has been taken of expenditure for the herd, labour, supplementary fodder, veterinary expenses, the rent of the rangeland, etc. ; receipts come from the sale of lambs, wool and culling.

This method of calculation shows a net income of 9 dinars per year per ewe, or of 7 dinars if expenditure on staffing is included, that provided by a competent stocksman.

Demonstration and extension work. Extension work can only be undertaken if results can be clearly demonstrated. This is why the improvement area at Sbeitla was chosen this year as the first centre for extension work.

The expert responsible for relations with the local communities organized these information days which were held in January 1975 on the site at Sbeitla. Twelve days were devoted to these activities which were attended by 200 persons : chairmen of cooperatives, engineers and technicians of all levels, the pupils of a CFPA (Agricultural Training Centre) with their director, local and regional directors of WFP-482, regional project experts, etc.

If the interest shown by those who attended the information days is any criterion, they were a great success. The discussion of problems connected with grazing and animal raising give the clear impression that in general the stock-raisers themselves, whether owners or shepherds, were most interested in our explanations regarding the practical and financial aspects of the operation. The officials were more interested in technical aspects (time of year, supplementary rations) and in the arrangements made for herd management, rotation, the prevention of clandestine grazing, etc. All in all this first venture was a success. It commits us to organize further information visits to Sbeitla and, later, to other improvement areas. The Sbeitla site has thus become our first extension work centre.

5.2.4 General conclusions

The improvement of stock-raising in arid zones raises rather complex problems, as it calls for the synchronization of a variety of technical, economic, legal and institutional measures.

At a technical level solutions can be found quite easily. The following factors must be borne in mind :

(1) the primary production of the rangelands and their variations ;

(2) adjustment of the rate of stocking in terms of the plant production

potential ;

(3) the establishment of fodder reserves in the form of standing crops (fencing, fodder plantations) ;

(4) the possibility of obtaining feed supplements (concentrates, cultivated fodder crops) to help out in difficult periods.

As regards the economic aspect, it should be made clear that until recent years the maintenance of prices at a relatively low level did not encourage any departure from the free-range grazing system. For below a certain price level no investment is likely to appear very profitable. The improvement of prices, together with extension work, has led the more alert of the stock-raisers at least to agree to make certain investments in order to improve the health and food supplies of their flock. The stock-raiser should eventually be willing to recognize the force of economic arguments.

The main objective of the legal and institutional measures is to make it possible to apply the most appropriate technical solution, bearing in mind existing socio-economic structures. These measures relate to ways and means of implementing the programme in general and to the staffing structure in particular. The measures taken in these spheres are of crucial importance, as they will affect all the rest.

5.3 Research site of US/IBP Desert Biome Tunisian Presaharan Project

Objectives of the project. The general objective of the Desert Biome Tunisian Presaharan Project is to acquire a body of research information on which land-use patterns can be recommended which would preserve, and if possible increase, the productivity and economic gain from the land for the people. Due to intensive use, the present productivity of the land may be less than it is capable of producing. And the present productivity may be decreasing due to degradation of the land and, ultimately, desertization.

Potentially, there are different ways by which the productivity and economic gain can be improved. One is to change the structure and productivity of the natural vegetation by altering the grazing practices. Another is to determine whether the economic gain from a given parcel of land is greater by continued cultivation of crops over a long period of years, or by continued grazing, or by some rotation between grazing and cultivation.

In order to attain the objectives stated above, it is necessary to study the lives of the people for several reasons. First, it is necessary to determine the nutritional needs of the people in terms of energy required for daily living activity : cultivating the land, taking care of livestock, harvesting crops, cooking, housekeeping, etc.

Second, it is necessary to know the economic value of the various products derived from the land such as crops, animal production and vegetation used for fuel and building material. The proportion of those which are produced *in situ* and which must be purchased or earned outside the community must also be determined.

Third, it is necessary to know the ways in which the pattern of life in the culture is structured around means of gaining a livelihood so that we could understand how any recommended change in land-use would affect the people's lives. Some changes might be readily acceptable because their influence on the way of life could not be tolerated. It is for these reasons that a thorough understanding of the people and their culture is necessary.

The system is complex. There are many ways in which the land-use activities interact with different components of the ecosystem. Insects and rodents compete with livestock for forage. Livestock change vegetation structure, with sheep and goats each producing a different effect. Changes in vegetation structure affect soil physics, chemistry, and biology, and these soil changes in turn have feedback effects on the vegetation. Changes in vegetation structure affect micrometeorology which in turn affects vegetation and animals.

Because of these many interactions, it is necessary to study the entire ecosystem in order to understand and predict the effects of any specified or recommended land-use change. And because of this complexity, the many interactions cannot be calculated mentally or by traditional, manual data-processing methods. Hence, a major goal of the project is to develop computer simulation models which will simulate the ecosystem and predict the effects of different land-use patterns. In this way, it should be possible to simulate the effects of different land-use patterns and select the one which will provide the maximum economic gain for the local people on a long-term sustained-yield basis.

Description of intensive research site. The intensive research site actually consists of two tracts of land near the village of Chaabania : the 50 ha Dar ez Zaoui tract and the 35 ha Heuchir es Siane tract. These tracts are located on sandy soil and in the *Rhanterium suaveolens* vegetation type of the coastal Djeffara region, and are situated between the cities of Medenine and Ben Gardane. Measurements are made each year of precipitation, temperature, humidity, wind, soils, natural vegetation, and wild animals, both vertebrate and invertebrate. The processes by which these components interact are also being measured regularly : plant and animal growth, reproduction, kinds and amounts of foods consumed by the animals, bioenergetics of the animals, and their distribution and activity patterns.

Methods. Three flocks of livestock are being grazed on portions of the two sites, and the range management studies subdivided into two main lines of emphasis. The first is the bioenergetics of the livestock. The goals are to study vegetation preferences by sheep and goats, how much of their preferred plant species they consume on a daily and seasonal basis, what proportion of this consumed food they digest, and how fast they grow and reproduce. By understanding these processes, it should be possible to know how the vegetation structure could be changed to improve growth and reproductive rates of sheep or goats, or both.

A second line of emphasis is to analyze the impact that different numbers and kinds of sheep and goats have on the vegetation. To this end, the two research sites have been subdivided

into four areas with different grazing treatments : (1) grazed by mixed flocks of sheep and goats in spring, (2) grazed by goats alone in spring, (3) grazed by sheep alone in spring, (4) and ungrazed. In addition, the land adjacent to the sites is grazed by mixed flocks during much or most of the year by local people, and measurements of vegetation in these adjoining areas provide information on a fifth treatment.

In these five teatements, measurements are being made annually of the vegetation bio-mass and productivity by plant species, and as totals for the entire vegetation. As time passes, any changes in the vegetation associated with these five treatments will be measured. In the grazed areas, the proportions of the different plant species utilized by livestock are being measured to relate animal use to observed vegetative changes. In addition, gauges will be established in 1975 to measure the degree of soil movement due to aeolian erosion in each of the five treatments.

As mentioned above, the human biology and sociology studies are proceeding along three main lines : (1) bioenergetics, (2) economics, and (3) cultural characteristics. In the bioenergetics studies the people have been kind enough to allow measurement of oxygen consumption through respirometry while carrying on their normal, daily activities. Daily food consumption and diets are also measured.

The economic studies involve measuring the yields of land products : small grain, olives, meat, wool and hair, etc. These are measured over a series of years to determine how the yields vary in years with different rainfall patterns. At the same time, the people are asked to report the kinds and amounts of products which they purchase from outside the community.

The cultural studies include an analysis of family structure, and the role each person in the family plays in the different farming and pastoral activities : planting, harvesting, herding, shearing, etc. Information is also compiled on the extent to which some family members go outside the community for employment to supplement the income.

In 1974, the first steps were taken toward developing models of the system. A flow chart of a general ecosystem model was constructed. And a more detailed chart of the human subsystem was designed. Emphasis in 1975 and subsequent years will be placed on conducting research projects which provide data needed to complete the model.

Extensive research site. A rectangular area of about 150 km^2 around the intensive site was selected in 1974 as a larger prototype of the Djeffara region. This area will be subjected to low-altitude aerial photography in 1975. The total area of cropland and natural vegetation will be measured, and the total numbers of domestic animals and people will be determined.

A still larger area, with its corners approximately bounded by the towns of Medenine, Zarzis, Ben Gardane, and Sidi Toui, has been delineated to provide information on long-distance livestock movements. Agronomic products, human populations, and grazing patterns in this large area will be characterized in a general way.

Crop production will be measured in sample fields in the 150 km^2 rectangular area. Growth and reproduction of the livestock will be determined in samples of domestic animals in this same area. Productivity of the vegetation on the two Chaabania tracts, which are in about the center of the rectangle, supplemented by spot measurements in the remainder of the rectangle, will be applied to the vegetation of the rectangle as a whole.

This rectangular area will constitute the ecosystem for which the models are developed. The economic inputs and outputs will be measured and modelled, and predictions made for improved land-use patterns in the area. Those predictions should be applicable to a larger area of the Djeffara region.

ANNEX 5

SYSTEMS ANALYSIS IN ECOLOGY AND NATURAL RESOURCES MANAGEMENT*

1. Definitions

A system is commonly defined as "an assemblage of objects united by some form of regular interaction or interdependence". The implication is usually present that the alteration of any part of a system will eventually lead to change in the other parts, and in the system as a whole.

An ecosystem is the assemblage of living organisms - plants, animals, micro-organisms - in a specified area along with such non-living objects as soil organic and inorganic constituents, gases and particulate matter in the atmosphere, and solar energy. All act upon, and are acted upon, each other.

Systems analysis concerns itself with the identification, description, and measurements of the objects in the system; and the identification, description, and measurements of the interactions of the objects. Descriptions of a system may be termed "models" which are broadly defined as "miniature representations of things". Models are of different forms. A verbal description of a system is one form of model. Graphic representation and mathematical equations are also forms of models.

In recent years there has been growing emphasis in ecology and natural resources management on the development of computer simulation models to represent ecosystems. These systems - with their hundreds of species and millions of individuals all interacting in a network of relationships too complex for contemplation by the unaided human intellect - are among the most complex known to science. Analysis of ecological systems proceeds by describing in mathematical form one or a few relationships at a time. It continues until the important ones responsible for the functioning of the system, relative to a specified objective, have been described. These mathematical statements are then coded into a computer programme which is entered into the machine. The machine can then calculate the changes which occur in the system, and thus simulate the functioning of an ecosystem. Such a computer programme is a simulation model of an ecosystem.

2. Values of systems analysis

One of the most important values of systems analysis and simulation modelling in ecology and resource management is that it provides the resource manager with a means for making predictions about the effects of different land-use patterns on the ecosystem. Given a simulation model of an ecosystem, a land-manager can interrogate a model about the effects of different grazing patterns, vegetation alteration, fertilization, and weather modification on the different parts of the system. The computer will calculate and display the effects of these different schemes on the different parts of the ecosystem. In this way the land-manager can identify an improved land-use pattern for an area and recommend that it be adopted as policy.

A second value of systems analysis is that, in the course of constructing a model, the research scientist very quickly learns where data are lacking and where additional research is needed. In addition, through sensitivity analysis of a model, the scientist can determine which areas of the system are most sensitive - i.e. which areas are most responsible for variation in the functioning of the whole system - and which are relatively insensitive or influence the functioning of the system least. Research resources can then be concentrated on the more sensitive areas. Hence, modelling can play an important rôle in research planning.

A third value of systems analysis is that it aids the research scientist and resource manager in sharpening his concepts and in making more explicit his hypotheses and theories about the character of an ecosystem. Where one must reduce the growth pattern of a plant or the population fluctuations of an animal species to an equation, there is little room for ambiguity in the statement.

3. Major resource management areas where systems analysis has been used

Systems analysis has been used extensively in several areas of resource management for a number of years. One of these is watershed management where models have been developed to predict the water yield of different watersheds, given measured values for rainfall, physiographic characteristics of the watershed, meteorological conditions, soils and geology, and vegetative cover.

Another area utilizing the values of predictive models has been commercial fisheries, particularly marine fisheries. Models have been under development since the turn of the century to predict the yield of fish from a resource, given the size of the fish stock, the fishing pressure, and the growth, reproductive and natural mortality rates of the fish in the stock.

More recently, models have been under development to predict optimum control strategies for insect-pest populations, optimum grazing patterns for rangelands, effects on aquatic ecosystems of pollution, and effects on the biogeochemical cycles of forested areas from cutting and removing a timber crop.

4. Conceptualization of an ecosystem in a form in which it can be modelled

Three entities of an ecosystem. In order to develop a mathematical ecosystem model, it must be conceptualized in a form which can be measured and incorporated in mathematical statements. Any ecosystem can be characterized in three abstract entities for this purpose.

(1) Components. The objects or constituents of an ecosystem are the living organisms; dead plant and animal material; inorganic solids, liquids and gases; and energy. These are commonly called the "components" of an ecosystem, and are

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* *Background paper presented by Frederic H. Wagner and George S. Innis, Utah State University, Logan, Utah, U.S.A.*

into four areas with different grazing treatments : (1) grazed by mixed flocks of sheep and goats in spring, (2) grazed by goats alone in spring, (3) grazed by sheep alone in spring, (4) and ungrazed. In addition, the land adjacent to the sites is grazed by mixed flocks during much or most of the year by local people, and measurements of vegetation in these adjoining areas provide information on a fifth treatment.

In these five teatements, measurements are being made annually of the vegetation bio-mass and productivity by plant species, and as totals for the entire vegetation. As time passes, any changes in the vegetation associated with these five treatments will be measured. In the grazed areas, the proportions of the different plant species utilized by livestock are being measured to relate animal use to observed vegetative changes. In addition, gauges will be established in 1975 to measure the degree of soil movement due to aeolian erosion in each of the five treatments.

As mentioned above, the human biology and sociology studies are proceeding along three ma'n lines : (1) bioenergetics, (2) economics, and (3) cultural characteristics. In the bioenergetics studies the people have been kind enough to allow measurement of oxygen consumption through respirometry while carrying on their normal, daily activities. Daily food consumption and diets are also measured.

The economic studies involve measuring the yields of land products : small grain, olives, meat, wool and hair, etc. These are measured over a series of years to determine how the yields vary in years with different rainfall patterns. At the same time, the people are asked to report the kinds and amounts of products which they purchase from outside the community.

The cultural studies include an analysis of family structure, and the role each person in the family plays in the different farming and pastoral activities : planting, harvesting, herding, shearing, etc. Information is also compiled on the extent to which some family members go outside the community for employment to supplement the income.

In 1974, the first steps were taken toward developing models of the system. A flow chart of a general ecosystem model was constructed. And a more detailed chart of the human subsystem was designed. Emphasis in 1975 and subsequent years will be placed on conducting research projects which provide data needed to complete the model.

Extensive research site. A rectangular area of about 150 km^2 around the intensive site was selected in 1974 as a larger prototype of the Djeffara region. This area will be subjected to low-altitude aerial photography in 1975. The total area of cropland and natural vegetation will be measured, and the total numbers of domestic animals and people will be determined.

A still larger area, with its corners approximately bounded by the towns of Medenine, Zarzis, Ben Gardane, and Sidi Toui, has been delineated to provide information on long-distance livestock movements. Agronomic products, human populations, and grazing patterns in this large area will be characterized in a general way.

Crop production will be measured in sample fields in the 150 km^2 rectangular area. Growth and reproduction of the livestock will be determined in samples of domestic animals in this same area. Productivity of the vegetation on the two Chaabania tracts, which are in about the center of the rectangle, supplemented by spot measurements in the remainder of the rectangle, will be applied to the vegetation of the rectangle as a whole.

This rectangular area will constitute the ecosystem for which the models are developed. The economic inputs and outputs will be measured and modelled, and predictions made for improved land-use patterns in the area. Those predictions should be applicable to a larger area of the Djeffara region.

measurable in terms of numbers or density (plants per unit area, number of animals in a population, etc.): in terms of mass (weight or biomass of plant or animal material, or weight of carbon, nitrogen, phosphorus, and other elements per unit area); and in terms of energy (kilocalories of incident solar radiation, or of plant and animal material obtained through burning in a calorimeter).

(2) Processes. The components change in time under the influence of various processes. Plants take on energy and carbon through photosynthesis, lose some of that same energy and carbon through respiration, and store some of it through growth. Other plant processes include reproduction and death (of whole plants or parts, e.g. leaves), water and nutrient uptake, transpiration, and others.
Animal processes include food uptake, excretion, assimilation, respiration, growth, reproduction, and mortality.
Soil biotic processes include decomposition, humidification, nitrogen fixation, nitrification, denitrification, and others. Soil chemical and physical processes include water infiltration, evaporation, nutrient leaching, heat flow, various chemical transformation, and soil movement due to aeolian and water erosion.
All of these processes can be expressed as rates, and all are indirectly measurable. Photosynthesis can be measured and expressed in terms of gm of carbon fixed per unit area, per unit of time. Plant respiration and growth can be expressed in these same terms. Animal population dynamics can be expressed in terms of birth rates, death rates, and rates of population change. And their bioenergetics can be measured in terms of food consumption rates, assimilation efficiencies, respiration rates, and secondary production.

(3) Factors or controls. The rates at which the processes go on are affected by various controls or factors in the ecosystem. Plant photosynthetic rates are controlled by temperature, moisture and soil nutrients. Insect reproductive and growth rates are controlled by temperature and possibly by moisture.
The rates of all the processes are controlled by such factors, and hence the dynamics of the entire ecosystem are controlled by them. If the rates for the processes are measured over a period of time, and the factors affecting them are measured simultaneously, it is then possible to discern and describe the functional relationships between the process rates and the factors affecting them. These functional relationships are the fundamental basis for a predictive capability. If one has an equation for the functional relationships linking plant growth rate to moisture, or insect population growth rate to temperature, plant growth or insect populations in any one year can be predicted, given the moisture or temperature pattern for the relevant period of the year. Ecosystem models are constructed from such functional relationships.

Common denominators of components. The processes by which the living organisms in an ecosystem involve the exchange of material and energy. Plants fix carbon, nitrogen, and energy in their tissues; pass these on to herbivorous animals through feeding interactions, or pass them on to soil micro-organisms when they die. Herbivores fix the carbon, nitrogen, and energy in their own tissues or in those of their offspring; pass them on to carnivorous animals through feeding interactions or to soil micro-organisms through death.

Hence, carbon, nitrogen, and energy are common denominators of all the organic components of the system, both living and dead. In a sense, the functioning of the system can be looked upon as the flow of energy, and cycling of materials, through time. If the vegetation composition changes over time due to grazing, it can be said that the heavily grazed plant species - expressed in carbon, nitrogen, and energy equivalents - have declined while the less palatable species expressed in those same equivalents have increased. If an animal population declines - e.g. if the range supports fewer grazing animals - that fact can be expressed in terms of smaller amounts of carbon, nitrogen or energy equivalents. It is in these ways that ecosystem models commonly express the pattern of energy flow, or of carbon and nitrogen exchange.

Dynamic view of the ecosystem. The components of an ecosystem change in time. They change seasonally with increase due to growth and reproduction during the active season, and decline due to death and removal during the dormant season. They change from year-to-year as the weather varies annually. And they change over longer periods of time due to long-term pressures such as grazing, climatic change, soil loss, pollution, etc.

An ecosystem model is designed to simulate these changes, given the values for the factors which effect these changes. The usefulness of such a model to the resource manager is that he can simulate the effects of different land-use patterns, and predict the changes in the ecosystem over time. Different grazing patterns, fertilization, vegetation manipulation, weather modification, and other treatments can all be simulated; and the treatment which will result in the greatest, long-term productivity for man determined and recommended as policy.

5. Approach to modelling

An early stage in the development of a model is the construction of a box-and-arrow diagram of the system with which they are concerned. By representing the system in this manner, the modeller systematically makes explicit the components and processes of the system, and insures that all are in mind and accounted for.

The next step is to develop equations for the functional relationships of the processes. A convenient first step in this procedure may be a graphical representation of the function. With these relationships represented pictorially in this fashion, a suitable equation can then be formulated to represent the relationship.

Once the equations are developed, the next step is to develop a computer programme. This programme instructs a computer to calculate the values for the processes, given the measured values for the factors; and it instructs it to calculate the exchanges (i.e. exchange processes) between the components, given the values for the components and, once again, the measured values for the factors controlling the rates at which the exchanges take place.

Execution of the model requires that an initial set of values for the components is coded into the programme. Then, the measured values for the factors over a specified time period are coded. Once these steps have been completed, the computer can be "run" to simulate the dynamics of the system during this same time period.

If the resource manager wishes to simulate (or "predict") what the effects of different land-use patterns would have been during this same time period, he can write into the programme these alternative land-use patterns. He can then "run" the model and see what the simulated effects are on the ecosystem from the different land-use programmes.

ANNEX 6

SOME HUMAN SCIENCES BACKGROUND AND METHODS

FOR THE STUDY OF NORTH AFRICAN ARID GRASSLANDS*

Human sciences methods may be useful in the study of many aspects of ecological problems and biotic productivity in arid grasslands. It should first be pointed out, however, that the human sciences cover a very great diversity of academic disciplines and within each discipline a number of objectives and theories prevail. One may expect, therefore, that only a very small percentage of the social and human biological scientists in any institution will be interested in or have a command of the methods desired for ecological or land development studies. Furthermore, these scientists are unlikely to find the study of man in arid land settings interesting for the same reasons as natural scientists working on the same topic. Finally, it should be noted that because the human sciences cover a wide variety of theories and methods, it is always necessary to be specific about the objectives of a research effort in order to develop the methods for studies involving man. Despite these difficulties, studies of ecological problems in arid grasslands which involve the co-operation of natural and human sciences have become increasing common in recent years, and some methods have evolved which have been of value not only in solving various problems in the natural and human sciences, but also in planning for regional development.

1. Universal needs

The socio-cultural and land use patterns of the arid regions in North Africa are today highly diverse. However, this diversity is of rather recent origin and can be traced to diverse government objectives and experiences during the past forty years. Prior to this time, a fairly uniform gradation from settled agricultural societies in the wetter parts into strictly pastoral societies in the drier parts prevailed. While certain language and cultural factors diverged across this broad belt of land, the basic land use patterns, health problems and even attitude toward the environment were fairly uniform. Since the divergence has been of fairly recent origin, one may assume that many of the cultural attitudes, practices and health problems, remain despite modified settlement patterns and often alter patterns of economic activity. It would therefore seem that a survey of the attitudes, behaviour and health of these groups retaining the original practices would be of value in explaining present conditions and predicting future directions of change. A comparison of the findings with the fairly extensive ethnographic literature available would improve the understanding of the previous degree of homogeneity and, if compared with present day attitudes, etc., in the various countries, would be particularly helpful in predicting future changes.

Although some information of predictive value could be obtained by reconstruction of the previous man/environment interaction in almost every other instance, the utility of human science studies will depend on the country involved and the objective of the study. It does appear that, in most instances, the studies will be pursued in order to predict or assess the effects of external intervention. It may therefore be useful to outline available methods which will provide the desirable information for any type of intervention.

Most attempts at intervention in the man/environment relationship without a thorough knowledge of the existing populations attitudes, practices and biological fitness, have either failed in their objectives or have produced considerable human suffering. Unfortunately, the diversity of problems is so great that it is at this time impossible to make generalized predictions. Considering the diversity of social and economic conditions prevailing today in the various North African countries, it will probably be necessary to carry out several studies in order to predict the consequence of intervention.

At the simplest level, decision-makers should have available the basic demographic, social and health information on the populations which would be affected. This information can often be at least partially compiled from existing sources such as the national census, public health records and ethnographic writings. The derived data may be compiled into map and tabular form for easy reference. In addition, records on the existing economics and production of the region are essential if one is to later assess the impact of change.

Although such compilation from existing data can be very useful in decision-making about intervention and can serve as an essential record from which the effect of intervention may be assessed, it often does not provide the depth of information required. For these purposes, an intensive study on a small but representative population sample is necessary.

To exemplify the latter points, let us assume that a planned action was initiated in southern Tunisia to modify the productivity of the land for certain villages. A recent study there shows that the people do not, indeed, depend on local land holdings to provide their livelihood. Instead, they have widespread holdings. The reasons for these diversified land holdings are partially historical, but the reasons for retaining them are very practical. The very erratic nature of rainfall in arid regions means that in a given year some areas will receive enough rainfall to promote plant growth while others will not. By the ownership of dispersed lands, the individual family is better assured that it will hold at least some useful land. It appears that this land-use strategy replaced the previous nomadism of the area and, while apparently successful, is dependent on modern transportation in order to permit the establishment of a permanent residence. In terms of its importance

* *Prepared by P. Baker, Unesco consultant in human ecology.*

to planning, it may be pointed out that the improved productivity of some land or the development of a productive capacity which was not dependent on annual rainfall would in this area affect a very broad sector of the population and might lead to rapid and unexpected migration to the productive area. Such a conclusion is tentative, since at present we do not know enough about attitudes or social organization values to predict how willing the people would be to change residence or break social organization units. Only an intensive study of one of these groups would provide the necessary predictive information.

In order to exemplify further the need for such in-depth study, we may look further at the complex land use relationship which now exists in the western sections of North Africa.

2. Characteristics of pastoral ecosystems

2.1 Human occupation of pastoral ecosystems

The main productive activity is stock-raising, which places the animal and vegetable kingdoms in a specific relationship with each other : the plant cover is exploited through the intermediary of nomadic herbivorous animals organized in herds. This having been established it is necessary to draw a distinction between : the use of the pastoral ecosystem almost exclusively for grazing and simultaneous use of the system for grazing and by socio-economic systems based on other types of productive activity, mainly irrigated or extensive agriculture but also mining, industry, etc.

These two types of land-use, which correspond roughly to arid and semi-arid conditions, are both found in North Africa. This is partly a reflection of ecological conditions as the specialized nature of arid pastoral ecosystems and the constraints imposed by their use certainly encourage a rather exclusive approach to grazing, except in marginal areas where man's management of water resources allows diversification of production.

However, the diversity of the forms of human occupation of pastoral ecosystems cannot be attributed simply to the variability of ecological conditions. Forms of human occupation are also determined by historical processes and in particular by the history of production. Thus the transition from land-use based on simultaneous use of the ecosystem for grazing and for other productive activities to land-use based almost exclusively on grazing is a consequence of differentiation in neolithic agro-pastoral economics and specialization in extensive grazing involving transhumance. This process was still taking place in the 19th century, when the Regueibat, who had previously divided their attention between sheep and crop-farming in southern Morocco, began to specialize in camel-breeding and spread out over the Saharan pasturelands. Transition from land-use based exclusively on grazing to land-use based on both grazing and other activities is even more common. This process is often observed on both the northern and southern edges of arid zones of the Sahara.

2.2 The organization of space in pastoral ecosystems

Ecosystems in which grazing is the dominant activity. Where pastoral production is the main activity, the spatial organization of social groups takes on a highly original aspect. When associated with transhumance of livestock and nomadism of human groups, it necessitates a radiative use of space which can be contracted with the concentric approach to space of sedentary communities.

Use of the rangelands for grazing, when seen in the context of the human communities' occupation of space, does indeed appear to be based on certain principles. The first principle is that of regular distribution of the livestock on a given plant cover. The areas most distant from the watering points will generally be grazed during periods of rain. Throughout the year the herds must be distributed over the pastureland in such a way as to permit their reproduction and maximum use of often very limited plant resources. Second, is the use of different ecological "niches" in the course of a year. For example, nomadic stock-raising in mountain areas is characterized by the pasturing of the animals at different altitudes, depending on the time of year.

Herds are divided among the families and constitute their main means of production (milk, meat, leather, etc.). The reproduction at the same time of the herds and of the families used to ensure the circulation and distribution of livestock within each family production unit (inheritance, marriage, etc.).

These ecological and technical constraints, together with the social rules in which they are neglected, determine the conditions which govern the distribution of social groups in space.

The territory which is occupied on a collective basis by the pastoral community appears as the spatial projection of relationships of residentiality, of co-operation in the use of resources and of exchange trade in livestock between the family units and as the projection of the rules governing their movement. Residential and territorial units are very often unstable. In extreme cases, with stock-raising groups which are often on the move, the notion of territory may have no legal meaning.

The originality of this form of organization of space is very noticeable in cases where pastoral communities graze their herds in different ecological niches of the same area (relations between cattle-raisers and camel-breeders in East Africa) or which use identical environments at different times of the year (successive transhumance of social groups on the same grazing lands to be observed in the Sahel or the Middle East).

Diversity of occupations. The insertion in pastoral ecosystems of human groups which follow different productive activities can also serve to identify the effect of the dominance of pastoral activities. Study of the spatial implications of this situation will reveal the importance of the network of relationships established between different human groups. Two examples are caravan transport by stock-raising societies forming a link between different production zones within the ecosystem ; and the complex relationships established between crop-farmers and stock-raisers for grazing of stubble, manuring of fields, etc.

The dominance of pastoral production will also determine the spatial implications of the

introduction of modern types of productive activity. One need only consider the examples of mining and exploitation of petroleum deposits to see that the introduction of such activities raises new problems of spacial organization, whether for prospection or transport. Even tourism, which is a recent development in this region, must be of an itinerant kind, requiring its own peculiar logistic structures. Here again it is difficult to distinguish environmental constraints from the results of human action on these ecosystems in the past.

3. Complementarities and antagonisms in pastoral ecosystems

These considerations make it clear that a major, if not a decisive, factor of any scheme for management and integrated development in these regions is that of the complementarities and antagonisms which emerge in the spatial relationships between the social groups occupying the area. It is particularly important to identify contradictions which may hinder overall development. The greater the diversity of human activity and the density of population, the more apparent these contradictions will be. We shall not attempt to make a complete list but rather to establish the typology of the problems which arise, using current situations as our basis.

3.1 Competition for use of space

Competition among stock-raisers. When several different types of grazing activity take place on the same area, several contradictions may result. These contradictions are due to :

(1) limited nature of certain resources, such as water. This situation in the Sahel south of the Sahara has brought fulani and Tuareg stock-raisers into conflict on many occasions ;

(2) modification of the distribution of human groups and resources, when these groups exploit different ecological niches simultaneously or the same niches successively. Here again, examples can be drawn from the Sahel where conflicts have been exacerbated by the effects of the recent drought which have involved population movement. During the colonial period the system of free herd movement under administrative control, which superseded the traditional regulation of group distribution in space, led to many conflicts of this type ;

(3) introduction of new approaches to use of grazing lands. For example the "ranch" system may appear to compete for use of pasturage with extensive grazing systems operating previously ;

(4) increasing inequalities within a pastoral society as regards both access to livestock and access to grazing. Such inequalities were often aggravated during the colonial period when collective production structures declined and tendencies to acquire livestock on an individual basis were strengthened.

Contradictions between stock-raisers and crop-farmers. Competition for the occupation of space also occurs when agricultural and pastoral exploitation of the pastoral ecosystem exist side by side. A slight modification of methods of production can have a very disruptive effect on relations between animal and crop-raisers, particularly in the case of extensive dry-land farming. Two examples can be cited. First is the reduction of the annual period during which cultivated land may be grazed. The introduction of industrial crops such as cotton has this effect : fields which were once opened to animals for grazing after harvest will no longer be made available to them. Second is cultivation of marginal areas or of small areas in which access to water is easy deprives stock-raisers of the richest pasture-land, often held in reserve for the most difficult period, and creates serious problems for them.

Water supplies will obviously be a bone of contention if irrigated cropland is extended or if types of arboriculture are introduced which use up large amounts of this precious commodity.

Even the very limited development of this subject which is possible within the framework of typology of this kind makes it clear that in the examples quoted above the basic problem is that of exclusive or partial competition for resources and for occupation of space by human communities. Our task is therefore to reduce these antagonisms and re-establish complementary systems or if necessary, introduce new ones.

3.2 Specialized activities and their use of space

When pastoral activities co-exist with mining, industry, tourism, etc. (which at present occupy points in space rather than zones but which are nevertheless expanding), the basic problem is of a different order.

Where mining or industry are developed in areas formerly given over to grazing, competition for the use of pastureland and water resources is a problem of secondary importance, except in the case of pollution. Indeed the high productivity of these types of activity, a corollary of high levels of investment, may have a beneficial effect. Water supplies may improve as deeper wells are drilled and desalination techniques used. Such effects have been observed in mining areas (iron, copper) in Mauritania. However, rapid proletarization has also taken place in this region, and the most precarious pastoral communities have been completely destroyed (those in the north, the Mauritanian Adrar). The problem of the use of human resources is highlighted in regions of low population density (Mauritania, Libya) where there is no possibility of importing a large labour force from over-populated areas (as in Algeria).

The same situation arises when tourism is introduced into a pastureland area, although in this case there may be some competition for water and even for pasture (particularly when parks or reserves are created for tourists). The economic effects

(wage-earning and migration in the pastoral society) raise many more complex problems, to which are added those of the presentation of traditional activities and cultures as "folklore". Once it is considered to be a relic of the past the community loses all ability or desire to assume responsibility for its own future.

These examples show that the basic problem concerns the specialization of relations between social groups with different occupations, rather than the competition among these groups for the use of the same resources. This latter problem exists, but is of secondary importance. History shows that the introduction of urban and trading societies in pastoral ecosystems of North Africa and the Middle East were based on similar specialization (caravan transport and production of livestock and by-products of stock-raising for the urban market) which was one aspect of the activity of pastoral stock-raisers in earlier times.

Another aspect of integrated management and development projects for pastoral ecosystems is the re-establishment of old forms of specialization and the introduction of new ones. This is essential if some pastoral activity and human occupation are to be maintained. Unless this new type of specialization is introduced among human groups which at present are engaged in stock-raising, the contrast between their production and highly productive modern types of activity will inevitably lead to their dissolution. Such specialization should begin by transforming processing of grazing land products.

This analysis is necessarily brief and superficial. It raises the problems of effective planning which not only takes into account immediate economic cost but also integrates assessment of human cost with a view to integrated and comprehensive development. It also draws attention to the fact that the spatial distribution of the different productive activities within pastoral ecosystems involves the introduction of a characteristic complex of a relationship in terms of complementarity (in the use of resources) and of specialization. This complex of relationships calls for great care in the definition of intervention measures.

4. Intervention studies

As noted earlier, the methodological approach most appropriate for intervention studies is somewhat dependent on the purposes of intervention. If the intervention is to halt desertification, the methods used must be quite different from those that would be used in a programme where the sole purpose is the augmentation of economic development. While most studies will probably contain some mixture of objectives, these objectives must be rather carefully stated in order to provide the appropriate methodology. For example, if the purpose is to reduce desertification by changing land use practices, a number of changes might be envisaged. These might include the abandonment of agriculture in certain areas, a modification of the type of animals used for grazing or even the return of large strips of land to unused conditions. While definition of the mechanisms which help solve the problem remain ecological questions, the cause and probably success of such efforts would depend on appropriate social scientific knowledge. If, as one assumes, several alternative mechanisms would succeed in halting the rate of desertification, a proper analysis of the populations involved should be able to indicate the one most likely to succeed. Perhaps, it may even be more feasible and even less traumatic to the group to move them entirely out of the area than to modify their traditional land use patterns. Such a statement is, of course, only theoretical but indicates the need to make a careful analysis of population attitudes and beliefs before action is taken.

Efforts to increase economic output in an area modified by land use is a more familiar problem in the human sciences and a considerable body of literature exists on the subject. Nevertheless, a few precautions should be taken in considering the particular problems of development planning in arid zones. First, mechanisms used to successfully introduce a change of behaviour in one society do not necessarily work in another because of differences in attitudes, authority structures, kinship ties, health consequences, etc. Second, traditional economic analysis can be misleading in societies where subsistence behaviour accounts for a large percentage of the production. In these cases, an analysis based on a combination of economic and subsistence products is needed. Energy flow studies offer one method for more precise analysis of the effects of change. Finally, studies on the adoption of new practices for economic development have frequently been so narrowly concerned with the acceptance problem that they failed to predict numerous consequences detrimental to overall objectives. For example, the introduction of new productive techniques have often been accompanied by increases in population which frequently was faster than economic growth. It is, therefore, recommended that such plans include detailed and intensive studies which allow predictions to be made concerning not only acceptance but also possible social, demographic and health consequences.

ANNEX 7

RESEARCH AND TECHNIQUES APPLIED TO RANGELAND DEVELOPMENT AND MANAGEMENT*

Example : methodology used by the Research and Development Project for Rangelands in Southern Central Tunisia (UNDP Project TUN/69/001)

1. The general principle of grazing land improvement in the steppe

The basic purpose of measures to improve steppeland grazing areas is to increase the productivity of stock-raising in order to supply the protein requirements of the local communities more satisfactorily and at the same time to improve their standard of living. They form part of a large-scale operation designed to conserve the national heritage and introduce ecological management in the interlinking sectors of grazing, fodder cultivation and stock-raising.

The point of departure for these measures is obviously the need to provide selected and productive herds with regular supplies of their normal feedingstuffs throughout each stock-raising year. These cannot be fully supplied by steppeland grazing areas alone. But these areas do have obvious potential and the grazing resources which they provide can be increased. Hence the need for grazing land improvement, involving management and rational exploitation of the rangelands.

During the difficult times of year and in case of drought, it is essential to be able to continue to meet the animals' normal food requirements by making up the grazing deficit with cultivated forage plants or various agricultural by-products. Hence the need to grow fodder crops, either by dry-land or irrigated farming, and, of course, to keep them in stock. In addition to these two basic measures action must also be taken to improve animal breeding, in order to produce selected herds and ensure their maximum productivity.

2. General framework of the methodology

On the basis of the principle outlined above, the improvement of pastoral areas and steppeland stock-raising must be carried out on three fronts : grazing land, fodder supplies and animal breeding. It must take account of natural vegetation, cultivated forage plants, the animals and, of course, man (who is the subject of a sociological study given in the previous Annex). The problem with which we are faced is thus a complex one and cannot be solved without reference to the most refined technical and scientific framework. What is required is research on the natural environment, the species to be introduced and the animals using the grazing resources, and the elaboration of methods of improving these three basic elements. The method used in the management of rural areas and rational exploitation of the rangelands takes into consideration on the one hand the study of steppe ecosystems and on the other ways and means of improving the situation.

3. Study and cartography of ecosystems as a preliminary to regional management

There is no need to stress the fact that knowledge of the natural environment is essential to planners and managers if they wish to make the most of the area's resources. For they must select and localize the most suitable types of agricultural production and decide upon the appropriate level of intensity for each one. Poor management may irreparably disrupt the natural balances (disappearance of vegetation, soil erosion, desertization).

The following methodology will make it possible to localize the various types of production, to fix the proportion of surface area covered and the levels of intensity in the whole of a natural region :

Taking stock of the current situation. This will include a socio-economic survey of farming methods, population numbers, animal stocks, etc. It will also involve study of the natural environment, climate (probability of recurrence of typical pluviometric years), soil, vegetation (production of the various types of rangeland and of main crops as a function of typical pluviometric years), percentage of consumable primary production, evaluation of the animals' energy needs, available fodder supplies, water resources, etc. Most of this information will be plotted on maps.

Study of possible lines of development. The socio-economic survey makes it possible to select a number of farming systems which would be suitable for the region. Different methods can also be used to study the possible development of pastoral vegetation and therefore of its production under these different agricultural systems. Research is also undertaken to determine the potential of domestic animals.

Modelling. It is then possible to use computers to simulate the evolution in time of the surfaces and of the production of the different types of rangelands and by the same token of the stocks of the various types of animals as a function of the agricultural system used. This will enable the manager to choose the course of action which will draw the maximum benefit from natural resources without aggravating the process of desertization.

4. The technique of pastoral improvement

Analysis of all this information, including socio-economic data, enables the pastoralist to place, classify or divide the zones in question into sectors in which different

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farming methods may be used : areas for improvement of intensive use of grazingland and fodder and animal breeding ; areas of extensive seasonal grazing zones, including transhumance zones ; and forage suppliers.

For example, the technique which has made it possible to establish and bring into operation several areas designated for the improvement of grazing land, fodder and animal breeding takes into consideration the following two essential ingredients of grazing land improvement.

Management of grazing land and fodder resources. These include :

(1) inventory and cartography of grazing resources and phyto-ecology ; evaluation of consumable above-ground phytomass and determination of grazing periods for each pastoral type ;

(2) delimitation of the areas, blocks or other grazing zones (transhumance rangelands, grazing on fallow land, on stubble, etc.) ; determination and evaluation of grazing resources and needs for supplementation in an average year, study and selection of fodder crops for this purpose ; crops grown or reserves stocked on the spot, supplies brought in from outside, storage ;

(3) choice of animal types ; calculation of food requirements of animals as a function of type of animal (sheep, goat, etc.) ; determination of the number and size of herds in each area, block, zone, etc. ; evaluation of consumption on the rangeland and of the need for supplementation to make up the shortfall ;

(4) plan for rotation from one plot to another ;

(5) general management plan.

Rotational exploitation of rangelands. This includes :

(1) calculation of grazing potential per plot per season ;

(2) balance sheet for grazing and fodder ;

(3) calculation of feed supplement required ;

(4) elaboration of general programme ;

(5) definition of animal breeding and veterinary measures ;

(6) control measures ;

(7) determination of measures necessary for the smooth operation of the areas ;

(8) stock-raising calendar.

5. Conclusions

A study for pastoral improvement can be drawn up fairly rapidly on the basis of the methodology described above. Two to four months will be all that is needed for zones of 1,000 to 2,000 ha if the services of a phyto-ecologist and a specialist on arid land grazing are available. Once the study is finished the area can be brought into operation at any time of year as long as the necessary staff and equipment are available. Rational exploitation of the rangelands can begin, however, as soon as herds have been formed. It is sometimes possible to carry out such work as the delimitation of the plots in stages. Such situations have arisen for practically all the areas now in operation.