REPORT OF

MEETING ON SAVANNA DEVELOPMENT

Khartoum, Sudan
25 October - 6 November 1966

UNITED NATIONS DEVELOPMENT PROGRAM
and
FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS
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INTRODUCTION

Since the beginning of its activities, the United Nations Development Program (formerly the United Nations Special Fund) has given constant attention to the development of the African continent and, in particular, to the stretch of country lying between the latitudes 10° and 18° north from the Atlantic Ocean to the Red Sea.

This area is generally known as the Savanna Belt. Owing to its vast extent and ecological complexity, the Savanna Belt has not yet been uniformly defined. However, for the purpose of the meeting it was agreed that the limits of the Savanna Belt would coincide with the area surveyed by the FAO-Unesco Agroclimatology project. The Savanna Belt offers an immense scope for activities in the field of agriculture, which is the chief industry of the population. The Food and Agriculture Organization of the United Nations was, therefore, the Executing Agency for many projects approved by the UNDP Governing body.

With the passing of time and the accumulation of experience and knowledge, the need arose for a joint review of past activities and future requirements, with a view to formulating a policy for future development in the Savanna Belt and providing a guideline for further UNDP/FAO assistance to the region.

This was the reason for the meeting which assembled in Khartoum. At the agreement of its Government, the Sudan acted as the host country.

The Faculty of Agriculture of the University of Khartoum provided all facilities for the meeting.

The meeting was attended by two representatives of the UNDP Special Fund, namely Messrs. L. Allbaugh and D. Francis. Mr. Paul Marc Henry, Assistant Administrator and Deputy Director of the UNDP Special Fund and Mr. G. Drouhin, Senior Consultant, participated in the final discussions and the elaboration of the recommendations of the meeting. At the end of the meeting, Mr. Paul Marc Henry made a statement stressing the urgency of agricultural development and the potentialities for food production of the Savanna Belt.

The United Nations Educational, Scientific and Cultural Organization, the World Health Organization, the Economic Commission for Africa and the African Development Bank and the U.S. AID were also represented at the Meeting.

The Project Managers and Co-Managers of UNDP/SF projects in countries of the Savanna Belt, other FAO field experts of the area and FAO officers from Headquarters, Rome, participated in the meeting. A list of participants is attached in Annex I.

ACKNOWLEDGMENT

Grateful thanks are expressed to the Sudan Government for their readiness to act as host country, for the excellent arrangements made and the hospitality shown to the participants during the entire duration of the meeting.

Special thanks are expressed to the Minister of Animal Resources who kindly agreed to open the meeting; to the Representatives of the Ministry of Agriculture and Forests and other Ministries who took an active participation in the discussions; to the Dean of the Agricultural College, University of Khartoum, and to his deputy, for the hospitality and facilities extended to the meeting; thanks are also expressed to the Governors and senior officials of the Kordofan and Darfur provinces for their hospitality during the field trips, and to other Government officials who contributed to the success of the meeting.

We also wish to thank the UN agencies, Unesco, WHO, ECA, the African Bank, and the USAID office in Sudan for their valuable contribution to the meeting.

A. Introductory Statement

The Meeting was opened on Tuesday, 25 October, at 17 hours by Mr. Andrew de Vajda, Deputy Director, Land and Water Division of FAO and Director of the Meeting. After greeting the participants and the representatives of other United Nations Agencies and welcoming the Officials of the Sudan Government, he requested His Excellency Sayed Mohammed el Helu Moussa, Minister of Animal Resources and Water Development, to deliver the opening address on behalf of the Government of the Republic of the Sudan.

The Meeting then heard the statements of the Representatives of the United Nations Development Program - Mr. Hans W. Kamberg, Resident Representative of the United Nations Development Program in the Sudan; and Mr. de Vajda, who, on behalf of the Food and Agriculture Organization, spoke on the objectives of the Meeting and its value for the Savanna Belt.

Further statements were made by:

Sayed Wadie Habashi, Representative of the Economic Commission for Africa,
Mr. J. Smid, Representative of the United Nations Educational, Scientific and Cultural Organization,
Mr. M. Le Bousquet, Representative of the World Food Organization, and
Mr. Leonard Matovu, Representative of the African Development Bank.

These statements were not intended for discussion.

B. Presentation of UNDP/FAO Projects operating in the Savanna Belt

On Wednesday, 26 October, descriptive statements by the various Project Managers who took part in the Meeting were presented and discussed. A summary of their statements is given in Annex II.

The discussions emphasized the need for comprehensive preliminary studies for pre-investment projects. It was agreed that the studies should cover:

(a) An evaluation of the area's food requirements and the expected increase in quality.
(b) The possibilities of developing export crops in order to increase the country's revenue in foreign currency.
(c) A search for crops which could be substituted for those now imported, thus reducing expenditure in foreign currency.

It was also agreed that the studies should indicate the project targets for production, and particularly for the more specialized crops.

The Director of the Meeting gave brief descriptions of the following completed projects which are linked with the development of the Savanna Belt:

1. Land and Water Resources Survey of two river basins in Somalia.
2. Survey of the water and soil resources in the Upper and Northern Regions of Ghana.
3. Survey of the Lower Volta River in Ghana.

C. Discussion on Development Factors

Each main factor in the development of the Savanna Belt was outlined in a separate paper. These introductory papers are given in Annex II. The present section summarizes their salient points and includes the recommendations made and adopted at the Meeting.

1. Soils

During the past two decades there has been a substantial advance in the knowledge of the soils throughout the world. Dr. Robinson's statement (Paper No. 1) showed that the soils of the Savanna Belt are not unknown. They are relatively diversified and include at least seven of the ten main soil orders recognized in the soil classification scheme (7th. approximation) of the United States Department of Agriculture.

A first attempt at a general soil map of Africa was published by CCTA. It gave a very general outline (1 : 5,000,000 scale) of the distribution of the broad soil units in the Savanna Belt.

In most of its countries soil surveys have been carried out during the past 20 years. They were made, however, on the basis of varying classification systems and methods. As a result, there is a large amount of heterogeneous information on Savanna soils, their distribution, agricultural properties and management. A detailed inventory of this information would enable full use to be made of previous work.

The varying classification systems which originated from different research organizations are now being steadily unified. The methods and techniques of soil surveys are also becoming standardized. This will greatly facilitate not only the use of former soil surveys and research, but also the planning of future programs.

A complete standardization of survey methods will be increasingly needed. So also will a close adaptation of soil survey programs to the particular requirements of individual development schemes. Even though the interpretative systems of land capability classification are now more uniform, a fuller standardization is still needed.

From the recommended studies it is possible to make a rough estimate of the soil resources of the Savanna Belt. None the less, the present knowledge of their distribution and agricultural properties is insufficiently detailed for any specific program of agricultural development.

The Meeting recommended:

Recommendation No. 1

Further efforts should be made to:

(a) compile and correlate existing information on soil distribution and agricultural capability;
(b) unify the various systems of soil and land capability classification and standardization of methods and techniques of soil survey.

Recommendation No. 2

The final objective of a soil survey is to provide reliable information on soils in view of agricultural development. The following are the main steps of a work program on soils which will be applicable to most agricultural development projects:

1. Quick reconnaissance survey of an area, including the general zone of the project. It should be based on the interpretation of aerial photography and the distribution of the main plant associations.

2. Suitable area(s) for agricultural development should be selected and delineated for a semidetailed soil survey (scale, 1 : 20,000 to 1 : 100,000). The mapped areas would often be larger than the areas selected for development so as to cover, whenever possible, a natural area, such as a watershed, and to allow a later overall planning of the total area. The modern techniques should include colour or infra-red aerial photography, helicopters and portable equipment for quick soil tests.

3. Detailed surveys should be carried out when needed on limited areas, such as experimental, station and pilot areas for intensive development.

4. Land capability maps should be compiled from the basic soil map, taking into account the objective of the development (irrigation or rainfed agriculture) the intensity of agriculture and the main crops.

5. Whenever possible or advisable, maps of the natural vegetation and present land use should also be compiled. The eventual correlation between soil distribution, vegetation and land use should be studied.

Recommendation No. 3

Representative soils should be described. Detailed studies should be made in the field and in the laboratory. Standardized methods are essential for an easy transfer of knowledge from country to country. The final objective should be to characterize accurately the agricultural potential of the main soils in the Savanna Belt.

The main research subjects would be:

(a) studies on soil permeability and water retention;
(b) cation exchange capacity and base saturation; percentage of different cations;
(c) depth of water table and salt content of groundwater;
(d) modification of soil properties under irrigation; salinity and other hazards' need for a drainage system;
(e) organic matter and microbiology;
(f) soil management (rotation, water and humus conservation, mulching, manures, etc.);

(g) Mechanization would be studied with due consideration of soil characteristics and mainly the stability of surface structure. There should be trials on the main representative soils in the experimental station and, whenever possible, in the farmers' actual fields.

(h) The use of fertilizers deserves particular attention. Trials should be carried out on a few representative soils and on main crops with irrigation. The economics of fertilizer use and the ways of improving distribution system and credit should be studied. The organization of revolving funds, successful in other developing countries, is also recommended.

Recommendation No. 4

Training of personnel should be actively pursued through fellowships, short courses and in-service training. Due regard should be paid to field surveys, techniques, laboratory methods and aerial photo-interpretation. Whenever needed, international specialists should be sent to organize intensive courses on a particular subject. The training would involve national technical personnel at both high and medium levels.

2. Water

The importance of drinking and irrigation water in the development of the Savanna Belt in three separate papers:

(a) Rainfall and climate: see Cochemé, Paper No. 2
(b) Surface water: see Bakker, Paper No. 3
(c) Groundwater: see Ambroggi, Paper No. 4.

(a) Rainfall and climate

The limits of the Savanna Belt in Africa north of the Equator largely coincide with those of a semiarid area south of the Sahara surveyed by the FAO/Unesco/WHO Agroclimatology Project.

The study accentuates the latitudinal alignment of the climatic zones and the meridional direction of the climatic gradients. Mean annual rainfall varies from up to 1,200 mm in the south to very small amounts in the north. The total amount for the whole area approximates to about 2,000 million m^3/year. In the south the rain falls during a summer season of about seven months. The remaining months of the year are practically dry. Northwards the rainy season is progressively reduced. Thus the northern limits of settled cultivation receive as little rain as 225 mm. This falls in a two-months' period and in very varying amounts.

The high net radiation which accelerates the transpiration and respiration of the plants increases the rainfall deficit.

The following values are typical of the daily potential evapotranspiration:

Sunny day before the rainy season	8 mm
Day during the rainy season	4-5 mm
Rainy day	2-3 mm

These values can be compared with the mean daily rainfall of 5.5 mm during the rainy season. The rainfall efficiency can be estimated at 4 mm.

A comparison of rainfall and potential evapotranspiration makes it possible to define quantitatively the short periods of the availability of water. To match the growth cycles of the main crops to these periods is to obtain a useful criterion for the choice of crops. The data collected by the World Weather Watch system can play an important part in increasing the region's food supplies.

(b) Surface water and groundwater

The best possible use should be made of water, whether it is in the form of rainfall or surface flow, or comes from underground.

Just as a cross section of the arc from north to south shows an increase in annual rainfall, so it also indicates an increasing possibility of rainfed agriculture. Thus, in the general pattern for water development from north to south, there is a decrease in the relative importance of groundwater development and a corresponding increase in the relative importance of the development of surface water.

Throughout the area there is a need to retain and control soil moisture. This can be best achieved by proper agricultural practices.

The types of Water Development in the Savanna Belt can be grouped under four headings. The following order of presentation, however, is not necessarily their order of priority. The four headings are:

1. Large scale irrigation development from major rivers
2. Medium sized irrigation development from local water resources
3. Small scale water supply supporting and supplementing rainfed agriculture
4. Water supply in the zone of primarily nomadic grazing.

Large scale irrigation systems are developed from the major rivers, which have their water sources outside the Savanna Belt. Their total annual water resources are about 130 billion m^3/year. The ceiling for the actual area to be put under perennial irrigation from the major rivers is probably 5 million hectares. Most of these development possibilities received early attention. A vast amount of experience is available in the Nile schemes (Sudan) and in the "Office du Niger".

Medium sized irrigation schemes depend for their water resources mainly on the non-perennial river systems and groundwater bodies in the arc of rainfed agriculture.

Systematic knowledge of these water resources is very scarce, but a large amount of experience has been gained from schemes, designed or also constructed, in Northern Ghana, Upper Volta, Niger and Sudan. Pilot examples are available in the UNDP projects of Jebel Marra and Kordofan in the Sudan. Examples of the spreading of flood water exist in North Africa, Saudi Arabia, Mauritania and Sudan (Tokar and Gash).

The total potential of this type of development is not yet known.

Small scale water development at household and village level is primarily to supply water for stock and domestic use, but it should also include small scale irrigation, thereby supporting various developments of rainfed agriculture. The scope of the small scale irrigation can range from the household garden to the garden of a large mechanized farm. It could also include a whole village.

There are various techniques for exploiting surface water and groundwater for these purposes. Continued attention, however, should be given to the special techniques for supplying water for households and gardens.

The quantities needed for domestic consumption are small. If planned from the start as sanitary supplies, the water can usually be made suitable for drinking, and at little extra cost.

Nomadic grazing: Development of water supply in the northern part of the Savanna Belt is the main problem of nomadic grazing. The sources of water will be mostly from underground. In special circumstances, however, they can also be from the surface storage of rain or flood waters.

Fundamentally, enough is known for the planning of groundwater development to be started on a sound basis. For nomadic grazing, the problem of groundwater is not its quantity, but its actual location.

The livestock and groundwater project in Eastern Niger forms a general pilot project for this type of development. Advantage should be taken of the experience gained from it.

The Meeting recommended:

Recommendation No. 1

More detailed data on local climatic conditions are needed. The World Weather Watch system will be very helpful in the Savanna Belt, where the varying climatic conditions are a major limiting factor in agricultural production.

Recommendation No. 2

In all agricultural development schemes and projects in the Savanna Belt, where climatic conditions need to be more closely scrutinized, the greatest care should be taken to co-ordinate the instrumentation of the agroclimatological and hydroclimatological stations and to bring the national network into line with WHO practices and plans.

Recommendation No. 3

Reference stations in which evapotranspiration and radiation can be directly measured need to be established in the Savanna Belt. By studying the correlation between the two factors it would be possible to estimate the water requirements of large irrigated perimeters. Reference stations played a useful part in the UNDP (SF) projects for developing the Senegal river and Lake Chad.

Recommendation No. 4

Since the water resources from the major rivers need to be developed according to integrated plans, the surveys should be undertaken on a long-term basis and involve the firm commitments of both the UNDP and the Governments over at least a ten-year period.

Recommendation No. 5

The establishment of Pilot development schemes should receive early attention, since it is the most suitable step towards solving the problems of ultimate development, including their technical, economic, social and financing aspects.

Recommendation No. 6

Further assistance should be given, if necessary, to improve the utilization of irrigation systems which already exist.

Recommendation No. 7

Projects should be established where medium sized irrigation development is integrated with rainfed agriculture and animal husbandry in order to gain more experience, including the social and economic aspects of the development, at district level.

Recommendation No. 8

Attention should be paid to the opening up of new areas for rainfed agriculture through their water supply.

Recommendation No. 9

An overall plan of groundwater development closely related to the available grazing resources and the periodic migrations should be prepared and advantage taken of the general experience gained in the present pilot project of Eastern Niger.

3. Range Management and Livestock Production

The variability of the factors indicated in the preceding paragraphs involves a parallel diversity in the plant life which covers the Savanna Belt. This vegetation and its development imply, in their turn, a diversity in the animal life which depends on it, whether this is natural (wildlife) or domestic or due to such human exploitations as stock-breeding, forestry development and other forms of agriculture. The meeting is not concerned with defining the types of vegetation found in the region, but with considering its exploitation by animals (the theme of this section, see Papers 5 to 10 in Annex II) and the exploitation of its forestry resources by man (the theme of the following section). For reasons of convenience, the discussions are reported in the concluding section. Some repetition is unavoidable.

The region is considered to have great possibilities for the exploitation of its natural vegetation by animals. Their number is unknown, and the few estimates already made are insufficient. At a rough guess, the northern part of the Belt contains about 30 million head of cattle, 20 million sheep, seven million goats and six million dromedaries. Donkeys are more numerous than horses. It is hazardous to say how much foraging cover is needed for their nourishment. With extreme reserve, it can be said that it would be possible to have some 47 million head of cattle in the area. A large portion of the necessary forage could be produced on land near the river courses when it is properly developed. The rest would be dependent on the local agriculture which needs to be shown how to build fodder supplies.

There was an exchange of views on the vital problem of watering herds in arid and semiarid zones.

Their feeding should be studied within the farmework of a long-term program. This cannot succeed without the full approval and active support of the pastoral people. In efforts to improve the forage on grazing lands, preference should be given to the study and selection of the best types of local species already naturally adapted to adverse climatic conditions rather than to types which are introduced.

As far as grazing lands are concerned, the emphasis should be on the control of fires, a better use of pasture in the rainy season, and an extended period for using green forage. All this involves important genetic and agronomic work. A particular effort should be made to set up national or regional forage stocks. Forage banks such as the one projected in North Africa should be created in the Savanna Belt with the aid of the World Food Program.

The choice of preferential animal categories - cattle versus sheep - for a particular climatic zone is a major programing decision. Even as a governmental responsibility the choice must have a firm technical and economic basis. The particular qualities of the different kinds of animals was not a subject for discussion, but it was emphasized that sheep-breeding provided one of the most rapid ways of securing proteins. A lively discussion on goat-breeding showed that, while it was very useful elsewhere to allow free wandering, the animal should be tethered in the Savanna Belt. Its breeding should be put on sound lines and under strict control. In animal selection, as in plant selection, there should be chiefly a search for quality from the local stocks best adapted to the natural conditions.

In the economic exploitation of animals and their products, some stock breeders have clearly responded to economic encouragement. There should be a definite improvement in the quality of products when the experience gained in various parts of the Savanna Belt is extended and more is paid for young animals of good quality than for those which are old or mediocre. These experiences, however, come within the category of a general price policy, which is a responsibility of the Government.

A better knowledge of the sociological background of the stock breeders should pave the way to more effective methods of teaching and training. They will then have better relations with the more sedentary people and become integrated into a modern economy.

A large fund of technical and scientific knowledge has been already acquired, alike in the Savanna Belt and in other African regions. None the less the exchange of information between experts and the governmental services calls for immediate attention. This should be considered from the viewpoint of collecting, co-ordinating and then imparting the information. Here the international organizations can, and should, play a vital part.

Whatever may be the future policies for solving the complex problem of improving simultaneously the breeding and grazing lands of the Savanna Belt, nothing will last without the wholehearted approval of the people whom they affect and a corresponding, but sustained, commitment by the governmental services to pursue them. This is the price to be paid for a harmonious development of stock breeding in the Savanna Belt.

The agricultural development of the Savanna Belt must be supported by the pre-eminence of nomadic stock breeding in the north. The stock breeders are not bound to be integrated into the more sedentary forms of agriculture, but the gain on which they could rely from their contact with people in the centre and south of the Savanna Belt should be shown to them. Among the essential technical elements in a policy aimed at improving conditions for the nomads are the development of natural grazing lands; the control of fires; the tapping of new water resources, and particularly their rational use within the context of a general plan; the opening of migration routes suitably supplied with water; and the establishment of slaughter-houses at strategic points.

The Meeting recommended:

Recommendation No. 1

There is an urgent need to prepare an inventory of the vegetation and to make particular use of the most modern methods of photo-interpretation. A parallel inventory should include the numerical data on the human and animal populations according to their sociological and ecological groupings.

Recommendation No. 2

The analysis of past and present research and studies will make it possible to determine the field in which new investigations are not needed.

The compilation of former studies could be entrusted to the universities or organizations already existing in the region (Sudan, Senegal) with the eventual aid of such international organizations as FAO or Unesco.

This synthesis would later enable the research program to be co-ordinated to the region's advantage.

Recommendation No. 3

The training of specialists should not be neglected. It is desirable to consider the possibilities of advanced specialized instruction in the ecology and management of pasture lands.

Though the training of specialized workers does not present serious difficulties, there is at the intermediate level a distinct lack of personnel who are specialized in the management of pasture lands and in stock breeding. Their training should be sufficiently general to enable the pupils, when their studies are ended, to be used for some other agricultural activities without any difficulties of re-adjustment.

It is very desirable that training should be uniform.

A system comparable to the one established by FAO and the member countries of the Mediterranean Commission of Grasslands could be created for the Savanna Belt.

Recommendation No. 4

Except in some sparsely populated regions, most people in the region live and feed on their own cattle. To persuade them to change to economic production and, in particular, to sell their cattle advantageously and to feed themselves in a different way, an important service of popularized information is essential.

The popularized information should be directed towards

(a) developing family-size operations
(b) handling food products and, in particular, milk.

Recommendation No. 5

The utilization of the available animal resources is imperfect. The multiplicity of recognized administrations and other factors are partly to blame. It is recommended that in each country a single organization should be created, or strengthened, to deal with all matters which concern the proper use of available animal resources, including grazing and pasture lands.

Recommendation No. 6

There is an urgent need to strengthen the veterinary and zoological services, and especially to provide them with technicians at the intermediate level. The integration of specialists in wild life is recommended.

Recommendation No. 7

It is recommended:

(a) to open new water points needed for a better use of grazing lands;
(b) to close water points before the pasturage deteriorates;
(c) to improve pumping chiefly through windmill pumps;
(d) to improve the approaches to the water points so as to reduce losses: drinking troughs, inclined cemented surfaces, wind screens, cleared spaces for waiting and resting, girdle of trees to protect the forage, etc.

Recommendation No. 8

As a general rule, domestic herds are not suitably selected for food production. They include too many female adults. Improved types are no less necessary. It is recommended that male animals of good quality should be selected for the governmental establishments instead of worthless animals from local herds, which would be destroyed. Milk production should be organized in the irrigated zones.

Recommendation No. 9

In some countries there should be programs for the systematic control of animal diseases; for example, protection against the bovine pest or the pleuropneumonic contagion of cattle. These programs need to be co-ordinated at the regional level if any return of the disease is to be avoided.

Recommendation No. 10

The preservation and management of the wildlife resources are an integral part of the economy of the Savanna Belt. They should be on an equal footing with the protection of the natural vegetation.

It is recommended that there should be studies on their best possible use, and chiefly in certain parts of the arid zone where wild game is, perhaps, the best source of proteins.

Recommendation No. 11

There should be a study of markets and an economic approach to the problem. To encourage economic exploitation it is in every instance necessary:

(a) to build access roads to the slaughter-houses equipped with water points, forage reserves and quarantine stations;
(b) to develop facilities for clearance, preparation of products, stockpiling and transport;
(c) to adhere firmly to the current prices according to the age and quality of the animals.

4. Forestry and Forest Products and Wildlife Management

Willan, in Paper No. 11, covered various aspects of forestry in the Savanna Belt. Trends in wood consumption show that fuelwood is by far the most important item; it is followed by building poles. For a long time to come, fuelwood will almost certainly remain the main feature in extensive Savanna forestry. Certain species of the natural Savanna, however, produce a better quality of timber used for railway sleepers and construction timbers. Others provide important secondary forest products: for example, gum arabic from Acacia Senegal.

Apart from its productivity, the extensive natural Savanna forest protects the soil and its crops from the dessicating winds.

Intensive Savanna forestry can be practised only when the siting is favorable. It faces competition from other land uses. The aim should be a balanced agricultural development.

Intensive forestry relies heavily on the use of exotic species. The choice of species depends on the results of trials. These are necessary before large-scale plantations can be considered.

Mence, in Paper No. 12, stressed the need in Wildlife Management for (a) conservation; (b) cropping for protein supplies; and (c) research and training, especially at the intermediate level.

The Meeting considered Savanna in the broadest sense. This included the three vegetation types of Open Woodland, Savanna and Steppe, as defined by the CCTA/CSA at a specialist meeting on phytogeography held at Yangambi in 1956. Its recommendations are, therefore, presented under three headings: Extensive Forestry, Intensive Forestry and Wildlife.

Recommendations on Extensive Forestry

Recommendation No. 1

In view of its valuable protective function, especially in the arid zones, more attention should be paid to the need for conserving adequate areas of the Savanna eco-system; for example, by leaving broad belts between areas cleared for development.

Recommendation No. 2

Because of the very large demand for fuelwood and poles throughout the Savanna Belt, substantial zones should be set aside for this purpose for a long time to come.

Recommendation No. 3

Immediate attention should be given to the possibilities of increasing industrial uses of some hitherto unused species; for example, for railway sleepers, constructional timber and particle boards, etc. At the same time, there should be further research on the utilization of the lesser-known secondary timbers of the Savanna Belt.

Recommendation No. 4

In view of the local value of certain non-woody products - for example, medicinal products, beeswax, gum arabic, tannin - more research should be devoted to them. The possibilities of UNDP projects in this field should be specially considered.

Recommendations on Intensive Forestry

Recommendation No. 5

In view of certain substantial advantages of plantations, especially for producing utility timbers, there should be more emphasis on research in plantation forestry throughout the Savanna Belt. Careful species trials and a thorough soil survey should invariably precede the large-scale planting of species exotic to the region. Countries in the Savanna Belt should plan to start research at an early stage in their development of plantation forestry.

Recommendation No. 6

In view of the need for shelter and for forest products in irrigation schemes, a proportion of all irrigated areas should be devoted to forest plantations.

Recommendation No. 7

Wherever wind is a serious danger, the possibilities of artificial shelterbelts to reinforce the natural woodland should be further investigated. More quantitative research is needed into the effect of shelterbelts on microclimate and agricultural production in the Savanna Belt.

Recommendation No. 8

In view of the advantages of small concentrated plantations in reducing the distances and time involved in collecting fuelwood and poles, the possibilities of establishing village woodlots of eucalyptus or other species on suitable sites should always be considered in planning village development.

Recommendations on Wildlife

Recommendation No. 9

Because wildlife is a natural component of the Savanna eco-system, appropriate measures for its conservation should be included in any scheme to maintain the protective function of the Savanna Belt.

Recommendation No. 10

Wildlife resources can be economically exploited through

(a) managed indigenous hunting, as source of protein and animal products, in regions where domestic stock cannot be kept;
(b) management within suitable regions to maintain a wildlife population for recreational purposes, and particularly for tourism;
(c) management within appropriate regions to obtain a high production of meat and animal products through game cropping or ranching wild animal species.

In planning any form of land use, therefore, due consideration should be given to the potential utilization of the wildlife resources.

Recommendation No. 11

Because an intensive development of Savanna regions implies a contraction of the habitat of wild animals, development plans should take into account the possible necessity for the intensified management and control of wildlife.

Recommendation No. 12

In view of the need for trained staff in the proper management of wildlife, it is recommended that institutions similar to the College of African Wildlife Management at Mweka, Tanzania, should be established wherever necessary.

5. Agriculture

Although agriculture was not included in the agenda as a separate subject, the Meeting requested the Technical Secretary to make a statement. It then recommended:

Recommendation No. 1

There is a need for pilot areas and surveys of natural resources and of present agricultural patterns with a view to elaborating a co-ordinated development plan in which all agricultural activities - including forestry, livestock and wildlife management, and range management - would be combined.

A general agronomist with long experience of the particular area for development should be attached to the survey project team at an early date. He would be responsible for outlining the land use pattern and, in the light of the local ecological factors, for combining such other possible activities as forestry, fisheries, range management and livestock. He would also be responsible for indicating the additional field work needed for a sound economic evaluation of crop production.

Recommendation No. 2

The demand of the fast growing population of the countries in the Savanna Belt for food and for foreign currency to further their development and economic growth should be met mainly through (a) increasing the productivity of currently producing units, and (b) exploiting the undeveloped resources.

Though all possible efforts to increase the productivity of currently producing subsistence and commercial units should continue, the substantial development of hitherto undeveloped resources depends essentially on the successful establishment of maximum crop areas. This should be done as soon as possible at the outset of the rains in the dry farming areas of the region.

Owing to the limited amount of human labour and animal draft generally available, the possibilities of mechanized crop production should be investigated as soon as possible, especially in the fly-infested areas of reliable rainfall. The aim should be to ascertain its technical and economic feasibilities in different situations and with due regard to maintaining the fertility of the soil. Through the co-ordination of the agronomist, agricultural engineer, plant breeder and economist, it should be possible to determine the suitability of various kinds of machines in different climatic and soil situations. The agronomic practices appropriate to the maximum utilization of the machine, the choice of crops for mechanized agriculture and the actual economics of mechanization should also be investigated.

Before any scheme for mechanized crop production is introduced, there should be investigations into the training at all levels of the operators of the scheme, the farm managers and the mechanics.

6. Human and Social Factors, Training and Research

Human and Social Aspects

Lunan (Paper No. 13) stressed the insufficient attention hitherto given to extremely important human and sociological factors in drawing up and implementing development schemes. The tendency is now passing. There is an increasing awareness that these factors, far from being opposed to the technical factors, are supplementary. They develop alongside them. They are not added as an afterthought.

No attempt was made to estimate the total population living in the Savanna Belt. According to a first approximation, the total would be about 50 million. Its geographical distribution depends on the availability of water; first for drinking, and then for the various needs of agriculture. Thus the density of population is very low in the northern part of the Savanna Belt and relatively much higher in the south.

The birth rate is high and approximates to the "natural" birth rate. In certain zones there is a high and compensatory mortality rate. The expectation of life is short. A large percentage of the population belongs to the lower age groups.

One human aspect is frequently avoided because it is so delicate and difficult, but it should be considered as it affects seriously the success of projects and of development as a whole; that is the Government organization associated with the project.

The view was expressed that the deciding factors in determining the Government agencies to be associated with projects should be their preparedness to co-ordinate and the number of counterparts they are able to provide. In certain instances, the first phase of a project may emphasize, for instance, land and water survey and the second phase agronomy and land use, so involving the possibility of change in the Government agency.

Every effort should be made to ensure effective co-ordination within the Government organization whenever several departments are concerned with the objectives of a project. This is reportedly done on Government initiative in some instances through Project Steering Committees or interdepartmental committees. The essential criterion is that the Government continues action in the recommended direction after the project assistance ends.

Linked with this necessary co-ordination of a project with Government cooperating agencies is its co-ordination with other assistance programs in the same subject matter field.

Farmer training and extension

The discussion revealed a general agreement on the need to train the farmers and to explain innovations through an effective extension service, if development schemes were to have lasting success. Several aspects were mentioned:

(a) The value of demonstrations, particularly in farmers' fields;
(b) The effectiveness of reaching the farmers through the natural and traditional leaders of the community;
(c) The need for further work among the women in a community;
(d) The need for the close association of an extension service with research and training;

(e) The need to set up extension training in a project at the earliest possible moment after the preliminary land and water surveys have been completed;
(f) The value of finding out what farmers really want, if they are to be persuaded to increase production;
(g) The value of pilot schemes to test out research results in the economic, labour, marketing and other conditions of local farming before starting large-scale schemes;
(h) The need to synchronize fact-finding on social and human conditions with fact-finding on land and water conditions.

Fellowships and training of counterpart technicians

For the foreseeable future, counterpart training at the highest level must continue to be in the European and North American countries. Greater use for training purposes, however, could be made of the more developed countries in the Savanna Belt; for instance, Sudan and Kenya.

Fellowship periods were generally insufficient. Wherever possible, fellows should be selected in the preliminary stages of a project. Then, after training, they could return to work as counterparts to the experts. Alternatively, counterparts could receive training abroad when the particular project has ended. It is important that counterparts should work with the experts.

There is a general lack of training at all levels. The lack of training for economic and development activities is particularly marked at the intermediate level. The great need for training at the sub-university and middle grade level might be met by starting projects for this purpose on a regional basis.

Training courses, however, become less attractive to candidates if they do not lead to degrees. There is danger of giving too much responsibility to people after their middle course training.

Research

Devred, in Paper No. 14, stressed the need for increasing and improving agricultural research in the region. It involves better co-ordination in the technical and financial assistance to research as well as the most effective use of the available, and very limited, skilled manpower, finance and equipment.

To enable them to assist each other in this field, FAO is now endeavouring to co-ordinate the research work of the individual countries in the Savanna Belt on an ecological zone basis. Thus each country concentrates on a few aspects of research, and the results are pooled. An unnecessary and costly duplication of work is avoided.

Large multi-purpose research centres should be developed at the national level. They make better use of available resources and can provide a better working environment than the small and single disciplinary experimental stations.

Measures were suggested for reducing the shortage of suitable men who come forward for research work.

During the discussion, mention was made of the lead taken by Sudan in requesting assistance from FAO in retrieving and indexing the available results of research.

Projects, especially of the pre-investment study type, should not launch experimental programs. Instead, they should concentrate on demonstrations which can encourage farmers to accept innovations and on fact-finding trials which show the economic advantage of a project recommendation. The demonstrations and trials should begin at the outset of field operations.

The Meeting made the following recommendations on (a) human and social factors; (b) training; and (c) research:

Recommendations on Human and Social Factors

Recommendation No. 1

More sociological studies, including a careful consideration of traditions and problems of land tenure, should be undertaken in projects, especially when they involve the movement of population, settlement and water use.

Recommendation No. 2

Development planning should not only include the physical and technical aspects, but also so aim at improving human relationships and attitudes that beneficial use can be made of the knowledge and amenities which the project provides.

Recommendation No. 3

In projects which involve the movement of population and settlement, it is necessary to give close attention to sanitation and to preventing communicable diseases. Assistance should be given by the governmental health organizations, which have a continuity of responsibility for health matters. In each of these projects, there should be financial provision to ensure that qualified staff and equipment are available to cope with the problems of sanitation and health. Where necessary, WHO assistance should be given.

Recommendation No. 4

When any project is under consideration, every effort should be made to fit it into national development plans and to give it a definite and enduring place in the government structure.

Project agreements should provide assured finance, staff and equipment for the successful continuation of the work begun by the project. Otherwise there is a grave danger that many projects will end up as reports in government archives.

Recommendations on Training

Recommendation No. 5

Efforts should be made to secure a balanced program of training at all levels, from the farmer to the graduate technologist. The training of farmers should be strictly practical and aimed at improving production and the living standards of the rural people. In certain areas, agricultural training at the primary and middle grade levels is the more urgent need. The training of women in home economics is very important, provided that it is adapted to the local conditions and to the available materials.

Recommendation No. 6

To develop and improve production, it is essential for the local people not only to accept innovations, but also actively to support them. There should be projects for training and supervising extension workers, who will transmit to farmers the result of research, teach new techniques of water use, make beneficial use of the amenities of settlement and adopt improved agricultural methods.

An extension service is essential if farmers are to accept their Government's agricultural policy and development plans.

Recommendation No. 7

To be effective in increasing production, a training program needs the support of such services as supervised credit and farm supplies as well as the organization of suitable markets.

Recommendations on Research

Recommendation No. 8

Practical applied agricultural research should be improved and increased in the Savanna Belt. The best use should be made of the limited staff and facilities by:

(a) Co-ordinating national research programs within an ecological zone;
(b) Encouraging multi-disciplinary research centres rather than small experimental stations which are limited to one or two disciplines;
(c) Providing more attractive terms of service for African research workers;
(d) Retrieving and indexing existing research data for the benefit of future work and for promoting an improved exchange of information between the African countries.

Recommendation No. 9

Regional studies should be actively developed to include such subjects as those aspects of agricultural and forestry research, health and ecology which affect the whole region.

Recommendation No. 10

There should be a closer and more effective collaboration among the international and bilateral agencies associated with the harmonious development of the Savanna region.

7. Economic Aspects

The basic economic principle in agricultural development for the Savanna Belt is to choose those areas where the scarce water resources, capital and skilled management can be applied to the greatest advantage (for example, those which add most to the living levels, starting with food, clothing, and shelter) of the rapidly increasing population (see Paper No. 15).

Certain criteria are recognized as the bases for priorities in selecting the areas to be studied. In addition to improving the diets of their farm families involved and of the workers throughout a country, those areas with the potential ability to earn foreign exchange and/or produce goods which would substitute for imports should receive first priority. Other criteria include the ability to carry out a project without excessive infrastructure costs, the potential to increase employment in productive enterprises, and the relationship and relative importance to the established development policies and plans of the particular Government.

There are two approaches to the carrying out of development projects. One first indicates what is technically feasible and then determines whether it is economically feasible. The other first determines what an area needs for accelerated development and then what are the required technical measures. To reduce the time taken for selecting workable projects, the two approaches should be combined, since the technical and economic phases complement and supplement each other.

Recommendation No. 1

The economic and technical studies should take place simultaneously throughout the life of the project, thus providing the necessary technical and economic data for periodic appraisals of the potential usefulness of the technical work in progress and for the final economic feasibility study of the proposed follow-up projects for investment.

Recommendation No. 2

Timing and content of economic studies in the UNDP-FAO Land and Water Use Projects for the Savanna Belt should be given greater emphasis in order to (a) set forth the economic and social contributions expected from the project; (b) determine the relative importance of the project in the overall economic, social and political development of the country; and (c) speed up the determination of the project's economic viability. To accomplish this, provision should be made in each project request for an international agricultural production economist as an early member of the project team, with one or more full-time counterparts.

Recommendation No. 3

To increase the effectiveness and usefulness of the economic appraisals (of investment projects) which are the basis for decisions by planning and financing bodies, project managers and economists should present the information clearly and systematically. Such a procedure is set forth in "Economic Aspects and Eligibility of Projects for International Financing", now available from FAO/IBRD. This, or a similar, procedure provides for an economic feasibility analysis of the projects which will show (a) the "benefit-cost" ration; (b) the "internal rate of return;" and (c) the "capital-gross value added" ration (total investment-incremental gross value of production). In addition to the financial statements, the "intangible" benefits should also be indicated, so as fully to explain the merit of executing the project.

This information will be useful for possible investment projects with the World Bank (IBRD), the International Development Association (IDA), the African Development Bank (ADB) or other possible sources of investment funds. These international sources of funds are available for large river irrigation schemes (including pilot development schemes), medium-sized irrigation schemes, and some small-scale projects for water supply, or a part of a sufficiently large agricultural development project. The funds are also available for nomadic livestock development projects which require water development in the nomadic zone. Funds for agricultural production and supplies are available from agricultural banks, farmer co-operative credit associations and individual savings. Much of the investment required for infrastructure will be financed by the Government from its budget.

Recommendation No. 4

Because of the dearth of information available in the Savanna Belt, special farm management studies should analyze (a) the economics of alternative enterprises (crops, livestock, nomadic livestock, and forestry); (b) alternative systems of farming (cash crops, livestock and mixed); and (c) alternative sources of farm power (human, animal, and mechanical), especially on the rainfed clay plains. The studies should be conducted on both the rainfed and irrigated lands.

To help farmers in making decisions to invest funds in adopting new practices and farming systems, small pilot experimental-exploratory plots on types of crops, varieties, fertilizers and cultural practices should be started at a very early stage in the project.

At the end of two crop years, the data should enable small pilot farm or farming systems demonstrations to be set up. Later, large pilot demonstration schemes (500 - 5,000 farmers) could be planned, if the preliminary economic feasibility analyses indicate project viability.

Special economic studies of nomadic livestock production, holding yards and fattening pens as well as small farmer forage crop production for nomadic livestock may be needed in certain areas.

Recommendation No. 5

Since water is a major problem in the Savanna Belt, special studies on its economics should be made. They should include the cost (and values at the point of consumption) of drinking water for humans and animals, as well as the cost of irrigation water for large, medium and small irrigation works. As a preparation for these studies, FAO and IBRD should provide the project manager and economist with appropriate water economics data obtained from current and established projects of a similar nature in the Savanna Belt and in adjacent areas.

Recommendation No. 6

In view of the long distances from local, national and world markets in most of the Savanna Belt and the lack of educational, health and government service facilities, there should be special studies on transport costs (air, rail and road), communications and infrastructure costs.

Recommendation No. 7

There should be marketing studies for (a) export and perishable products; (b) handling and storage charges; (c) processing possibilities to reduce bulkiness and to increase the area's gross revenues; (d) local and national consumer preferences; and (e) improvements in marketing and distributive organizations.

In large development projects, there should be provision for the practical training of personnel to work for (a) co-operatives; (b) marketing boards; and (c) other marketing enterprises and services. Demonstrations of effective marketing methods together with packing and processing plants, wholesale and retail markets, storage and other operational marketing facilities should also be planned.

There should also be demonstrations of the ways in which to implement the contractual arrangements whereby produce is grown, graded, and delivered, according to the specific requirements of known consumer and processing markets.

Recommendation No. 8

Since traditional prestige values and the subsistence non-cash economy part of the Savanna zone are hindrances to overall economic development, particularly in the efficiency and utilization of livestock resources, the ways and means of transforming the economy of the livestock enterprises into a cash economy should be investigated. Demonstrations which would stimulate interest to procure money for needs, hitherto unfelt, deserve special attention. An example to be studied is the experience gained in projecting the Zande Development Scheme in Equatoria Province in Sudan on the joint basis of production and trading divisions.

D. General Conclusions presented by the FAO Secretariat to the Meeting

The Meeting provided a fairly general survey of the human, climatic, soil, animal, agricultural and capital resources of the Savanna Belt. These resources are substantial and, if properly developed, could provide an increasing population with a much higher living standard. Nevertheless they are below those of most other ecological regions in the world, therefore assistance from other parts of the world will be an essential factor of Savanna development. The total amount of assistance from various sources is, however, limited.

Though assistance from the United Nations and its Specialized Agencies has not been negligible, it does not measure up to the needs of the Savanna Belt. The main problem is to make the assistance already offered or promised as effective as possible. A main purpose of the Meeting, therefore, was to decide how to co-ordinate the various efforts in the Savanna Belt.

In this respect, the Meeting unanimously recognized that the paramount condition of development is to achieve a complete co-ordination and collaboration of projects with the two fundamental factors in each country of the Savanna Belt: its Government and its people. The continuity of Government policy, defined by national plans and co-ordinated at all levels, is a prior obligation. The Meeting proposed specific recommendations in view of such co-ordination.

Successive adjustments will involve consultations with the Governments at top level. It is, however, important to maintain the principle of collaboration and to assure that each project has a permanent place in the governmental structure and programs.

On a number of occasions, the Meeting emphasized the important part which the local people must play in making projects successful, and particularly in following them up. It recommended that more attention should be given to economic, social and human factors in preparing pre-investment studies.

At the present time, the most limiting factors to development in the Savanna Belt are water use, communications and capital resources. They should be given prior consideration.

The natural conditions and resources of the Savanna Belt should be fully appraised before any planning for development is undertaken.

The Savanna Belt contains large areas of soils with a good potential. They need to be surveyed and delineated. For many years to come, in fact, soils are unlikely to be a limiting factor in the development of the region.

Water - whether rainfall, surface water or groundwater - is an important resource, but it is ill distributed and misused. Rain water, which amounts annually to some 2,000 million cubic meters for the whole region, is concentrated in a single season. This season diminishes from about seven months in the south to less than two months in the north, where rain falls irregularly and in short spells. Where the intensity of rainfall is often high, it can cause erosion.

In a greater part of the Savanna Belt, water resources are mainly in the forms of rainfall and runoff. In areas with a rainfall higher than 300 mm, emphasis should be mostly on a balanced integration of rainfed agriculture and forestry with animal production. Attention should be given to diversifying crops, improving agricultural techniques and, wherever advisable, making good use of mechanization. In northern areas with an annual rainfall of less than 300 mm, livestock production should be combined with range management and a careful use of the scanty water resources for drinking and supplementary irrigation.

The four main river valleys represent the chief surface water potential of the Savanna Belt. Their potentialities for agricultural development should be studied separately; first by a general reconnaissance, where required, and then by more detailed surveys, with a view to financing the establishment of large irrigation projects.

In all areas, priority should be given to demonstrations and to training projects. Studies of home and external markets can play a vital part in gradually leading the people from a subsistence to a market economy. These studies should also include methods of improving transport.

Wherever applicable, the economic criteria regarding eligibility for financing should be established for the various types of agricultural development and for the improvement of infrastructure. In this way, possible investors are provided with a wide range of conditions. These conditions, when subjected to a comparative evaluation, could assist Governments in selecting their economic priorities, particularly when a choice has to be made between irrigated and rainfed agriculture. Available external capital resources should be secured to the more promising conditions. For those less favorable, grants rather than loans should be used.

Here again a plea is made for the co-ordination of effort. Members of the United Nations family should frequently consult among themselves to ensure that this strategy, if adopted, is firmly carried out. The Governments, in their turn, should collaborate closely in co-ordinating the assistance which they receive from outside the United Nations family. According to plan, this assistance should be assigned to development projects not eligible for external financing, which would impose too great a load on public finances.

Finally, the progressive advance in knowledge and the assembling, study and distribution of the technical information gathered in this huge region should be the object of an overall plan which reflects simultaneously both the need for further agricultural research and the most appropriate means for pursuing it. Every effort towards co-ordination and standardization and towards an increased efficiency of demonstrations is a step in the right direction.

Proposed organization

As a result of the Meeting, the Secretariat proposed the following action to implement this strategy.

1. A permanent small panel should be established by FAO to co-ordinate action and ensure its continuity, to gather information and to redistribute it.
2. This permanent panel should draw as required on the services of a group of:
   (a) Specialists from Headquarters;
   (b) Experts from projects in the Savanna Belt, FAO Regional Offices and ECA;
   (c) Consultants to be recruited;
   (d) Representatives of other UN Agencies invited as required.

3. The function of this group will be:
   (a) to centralize and classify available documentation;
   (b) to identify projects, draft preliminary requests and suggest priorities in line with the approved strategy.
4. The Governments should be encouraged to set up an association of countries or an inter-State committee to provide liaison with the United Nations family for the necessary development of the Savanna Belt.
5. A panel of senior consultants should be nominated to meet at one-year intervals in order to select from identified projects those to be submitted for United Nations Development Program approval, and to suggest a schedule of operations for a long-term period for these projects, taking into account the financial terms.
6. The assistance of the UNDP should be sought to implement the above recommendations.

ANNEX I

List of Participants

1. Representatives of the Government of the Republic of the Sudan invited to attend the Meeting

Minister of Animal Resources and Water Development
Minister of Agriculture and Forests
Minister of Industry and Mining
Minister of Irrigation
Representative of the Ministry of Health
The Acting Dean, Faculty of Agriculture
Sayed Abdall Abd el Rahman Nugud Alla
Permanent Under-Secretary, Ministry of Foreign Affairs
Permanent Under-Secretary, Ministry of Finance and Economics
Permanent Under-Secretary, Ministry of Local Government
Permanent Under-Secretary, Ministry of Irrigation and Hydro-Electricity Power
Director-General, Rural Water Development Authority
Acting Director, Department of Agriculture, Ministry of Agriculture and Forests
Director, Forests Department, Ministry of Agriculture and Forests
Director, Ministry of Animal Resources
Director, Geological Surveys, Ministry of Mining and Industry
Director, Surveys Department
Director, Land Use and Rural Water Development Department
Deputy Director, Land Use and Rural Water Development Department
Sayed Fadul M. Nurain, Economic Planning Division, Ministry of Finance and Economics
Sayed Abdel Aziz Bayoumi, Assistant Director of Research, Forests Department, Ministry of Agriculture and Forests
Sayed Abdall Hassan Ishag, Geological Survey Department, Ministry of Mining and Industry
Sayed Abdel Mageed, Assistant Under-Secretary, Ministry of Irrigation
University of Khartoum, Sudan Research Unit, Yussuf Fadl Hassan
One Member of the Lockheed Program Office, Ministry of Finance and Economics

2. Representatives of the United Nations Development Program

Mr. Paul-Marc Henry
Assistant Administrator and Associate Director
Bureau of Operations and Programing
United Nations Development Program, New York

Mr. Georges Drouhin
Senior Consultant to the Administrator
United Nations Development Program, New York

Mr. David Francis
Project Officer
United Nations Development Program, New York

Mr. Leland G. Allbaugh
Consultant for
United Nations Development Program, New York

Representatives of the United Nations Development Program (cont'd)

Mr. Hans W. Kamberg (Alternate: Mr. Juan Pascoe S.)
Resident Representative of the UNDP in Sudan
Khartoum

3. Representatives of other United Nations Specialised Agencies

Sayed Wadie Habashi
Chief, FAO/ECA Agriculture Division
Economic Commission for Africa
Addis Ababa, Ethiopia

Mr. J. Smid
Director
Middle East Science Co-ordination Office
Unesco, Paris, France

Mr. M. Baumer
Unesco Consultant

Mr. M. Le Bousquet
Consultant on Community Water Supply
World Health Organization
Geneva, Switzerland

Mr. D.V. Subrahmanyan
Eastern Mediterranean Region
World Health Organization
Khartoum, Sudan

Prof. J.M. Watson
WHO Consultant
Jebel Marra Project, Zalingei
Sudan

Mr. Leonard Matovu
Permanent Secretary
Ministry of Commerce and Industry
Kampala, Uganda
African Development Bank

Mr. L.A. Garnier
Director, Irrigation
FAO/IBRD Co-operative Program
Rome, Italy

Mr. D.R. Groenveld
FAO/IBRD Co-operative Program
Seconded to the Permanent Mission of the World Bank
Nairobi, Kenya

4. Project Managers

G.A. van't Leven — Survey of the Water Resources of the Chad Basin for Development Purposes (Cameroon, Chad, Niger, Nigeria), Chad.

Project Managers (cont'd.)

V. Bunderson	Range Management Division of the Ministry of Agriculture and Animal Husbandry, Kenya.
J.P. Bonett	Livestock Production and Associated Water Resources Development in Eastern Niger, Niger.
T.C. Petruc	Surveys for the Agricultural Development of the Dalloul-Maouri, Niger.
A.L. McComb	Savanna Forestry Research Station, Nigeria.
G.L. Saravanamuttu	Soil and Water Resources Survey of the Sokoto Valley, N. Nigeria.
J. Grolée	Hydro-Agricultural Survey of the Senegal River Basin, Senegal.
A.J. Bakker	Land and Water Resources Survey in the Jebel Marra Area, Sudan.
D.A. Lane	Forestry Research and Education Centre, Sudan.
Glenn H. Robinson	Strengthening the Soil Survey Division of the Ministry of Agriculture, Sudan.
G. Philippe-Auguste (Representing Mr. R. Agmon, Project Manager)	Animal Production Officer, Agricultural Training Centre, Bobo-Dioulasso, Upper Volta.
M.G. Ionides (ex-Project Manager)	Land and Water Use Survey of the Kordofan Province (Completed Project)

5. Project Co-Managers

Mr. David J. Pratt Head of Range Management Division, Kenya	Range Management Division of the Ministry of Agriculture and Animal Husbandry
Dr. Harouna Bembello Directeur, Service de l'Elevage, Ministère de l'Economie Rurale Niamey, Niger	Livestock Production and Associated Water Resources Development in Eastern Niger (Dr. Bembello was substituting for the Co-Manager, who was away on a Fellowship)
Mr. D.E. Iyambo Zaria, Nigeria Acting Principal Research Officer	Savanna Forestry Research Station
Mr. N. Popoola Deputy Hydrological Engineer of the Northern Ministry of Works Kaduna, Nigeria	Soil and Water Resources Survey of the Sokoto Valley

Project Co-Managers (cont'd)

Sayed Abdel Aziz Bayoumi Assistant Director, Research Khartoum, Sudan	Forestry Research and Education Centre
Sayed Omar Mohamed Ahmed Mukhtar Wad Medani, Sudan	Strengthening of the Soil Survey Division of the Ministry of Agriculture
Sayed Isam Mustafa Zalingei, Sudan	Land and Water Resources Survey in the Jebel Marra Area
Sayed Abbas Abdel Magid Department of Land Use and Rural Water Development El Obeid, Sudan	Land and Water Use Survey of the Kordofan Province (Completed Project)
Mr. Raphael Rapademnaba	Agricultural Training Centre, Bobo-Dioulasso, Upper Volta

6. Consultants

J.C. Abbott, Deputy Director, Economic Analysis Division, FAO Headquarters, Rome.
R. Ambroggi, Consulting Hydrogeologist, Land and Water Development Division, FAO Headquarters, Rome.
A.J. Bakker, Project Manager, Land and Water Resources Survey in the Jebel Marra Area, Zalingei, Sudan.
J.A.M. Cochemé, Meteorologist, Plant Production and Protection Division, FAO Headquarters, Rome.
P.E. Glover, Consultant, Plant Production and Protection Division, Nairobi, Kenya.
G.W. Ivens, Bush Control Expert, Nairobi, Kenya.
E.P. Lindley, Team Leader, UNDP/SF Project NEAHI, Khartoum, Sudan.
Murray Lunan, Agricultural Research Organization, Rural Institutions and Services Division, FAO Headquarters, Rome.
A.J. Mence, Principal, College of African Wildlife Management, Mweka, Tanzania.
Glenn H. Robinson, Project Manager, Strengthening the Soil Survey Division of the Ministry of Agriculture, Wad Medani, Sudan.
Y. Satyanarayan, EPTA Regional Ecologist, Addis Ababa, Ethiopia.
W.O. Shepherd, Range Management Expert (EPTA), Khartoum, Sudan.
R.L. Willan, Afforestation Section, Forestry and Forest Products Division, FAO Headquarters, Rome.
K. Hamad, Regional Forestry Officer, FAO Near East Regional Office, Cairo.

7. Observers

US AID - Sudan (Dr. L.S. Peek, Director, Rural Development Activities
(Mr. H.R. Yust, Deputy Director, Division of Agriculture
Sayed Mustafa Ba'asher, Head of Range Management Section, Ministry of Animal Resources, Khartoum, Sudan. (Counterpart to W.O. Shepherd).
Sir Hugh Boustead, London.
Mr. G.W. Hope, Project Manager, Food Processing and Research Centre, Khartoum.
Mr. G. Poulsen, Forestry Officer, Jebel Marra Project, Zalingei, Sudan.
Prof. Mitchell G. Vavich, Special Field Staff Member, The Rockefeller Foundation; Secretary, Arid Zone Research Unit, University of Khartoum.

8. Secretariat

A. de Vajda, Director of the Meeting and Deputy Director, Land and Water Development Division, FAO Headquarters, Rome.
A. Molle, Technical Secretary, FAO Headquarters, Rome.
A. Pecrot, Soils Specialist, FAO Headquarters, Rome.
Liliane Foncke, Secretary, FAO Headquarters, Rome.
Ursula Sherman, Secretary, FAO Headquarters, Rome.
Victor Salin, Administrative Officer, Land and Water Resources Survey in the Jebel Marra Area, Zalingei, Sudan.

9. Interpreters

Madame Estelle Hicks
Madame Isabelle Porcher
John Coleman
T. de Liffiac

10. Technician in charge of Simultaneous Interpretation Equipment

Pietro Zega, FAO Headquarters, Rome.

List of Papers Presented at Meeting

Statements by Project Managers

Statements by Project Managers (cont'd.)

Topics for Discussion (cont'd.)	Discussion Leader	Page
Plant Production and Potential, including Range and Pasture, Food, Fodder, Fuel, Trial Forest System (LA:SF/SD/66/5)	W.O. Shepherd Range Management Expert (EPTA), Khartoum, Sudan and M.W. Ba'asher Head of Range Management Section, Ministry of Animal Resources Khartoum	136
Bush Control in Savanna Development (LA:SF/SD/66/6)	G.W. Ivens Bush Control Expert Nairobi, Kenya	150
Animal Production and Savanna Areas (LA:SF/SD/66/7) (Paper presented by Dr. E.P. Lindley)	M.H. French Chief, Animal Production Branch, Animal Production and Health Division, FAO Headquarters, Rome	153
Animal Health and its Significance in the Development of Savanna Zones (LA:SF/SD/66/8)	E.P. Lindley Team Leader UNDP/SF Project NEAHI Khartoum, Sudan	157
Further Research needed for Conservation and Development of the Savanna Habitat (LA:SF/SD/66/9)	P.E. Glover Consultant, Plant Production and Protection Division, Nairobi, Kenya	160
Grassland Ecology in Relation to Conservation and Development of the Savanna Habitat (LA:SF/SD/66/10)	Y. Satyanarayan EPTA Regional Ecologist Addis Ababa, Ethiopia	169
The Role of Forestry in Savanna Development (LA:SF/SD/66/11)	R.L. Willan Afforestation Section Forestry and Forest Products Division, FAO Headquarters, Rome	178
The Role of Wildlife Management in Savanna Development (LA:SF/SD/66/12)	A.K.J. Mence Principal College of African Wildlife Management Mweka, Tanzania	185
Human and Institutional Factors: Sociological and Relative Problems of Shifting Cultivation, Nomads and Settlements (LA:SF/SD/66/13)	Murray Lunan Agricultural Research Organization Rural Institutions and Services Division FAO Headquarters, Rome	189

<u>Topics for Discussion</u> (cont'd.)	<u>Discussion Leader</u>	<u>Page</u>
Organization of Regional Agricultural Research Programs for Agricultural Development within the Framework of Ecological Zones (LA:SF/SD/66/14)	R.F.E. Devred Agricultural Services Branch, Rural Institutions and Services Division FAO Headquarters, Rome	192
Economic Aspects of Savanna Development Projects Including Eligibility of Projects for International Financing (LA:SF/SD/66/15)	J.C. Abbott Deputy Director Economic Analysis Division FAO Headquarters, Rome	197

ANNEX II

LA:SF/SD/66/INF/1

TRANSLATION OF THE OPENING ADDRESS OF HIS EXCELLENCY
THE MINISTER OF ANIMAL RESOURCES AND RURAL WATER
DEVELOPMENT

Ladies and Gentlemen,

It gives me great pleasure to welcome you, our honourable guests, men of science and learning, and our countrymen who participate in this important conference on development of the savanna belt in Africa.

We attach much importance to the objectives of this conference, not only because it has been initiated as an important issue by an important world organization, in the activities of which we are honored to participate, but also because the development of our savanna belt is our means for larger economic development and raising of our standards of living and prosperity.

Ladies and Gentlemen,

The savanna belt in the Sudan covers the widest and the most important areas. Its development in broad objectives means the development of the whole country with the exception of one third in the form of semi deserts and deserts of the North, the swamps of the Upper Nile and the tropical forest belt. The belt includes under dry farming our main production centres for crops and livestock and therefore it is the backbone of this country's economy and wealth. In it now live over 70% of the population who produce as much as 90% of the national income. The potentialities, however, for more accommodation of people and more production are very great.

We consider that the development of the economic possibilities which this belt offers is the hope and responsibility of every Sudanese, but this goal cannot be achieved without the use of proper scientific means and hence you are the people to whom we can look for help.

It is with much satisfaction and gratitude that we appreciate the Special Fund work in Kordofan and the Nuba Mountains and its work in the fields of Forestry Education and Soil Survey and the Survey of Jebel Marra. These Special Fund Projects have done much work in the field of agricultural research for better crops, forestry and pasture production, besides other activities on provision of domestic water supplies for man and his beast.

Ladies and Gentlemen,

Some of the efforts of the government of the Sudan in this belt can also be seen in the development of the irrigated areas in the Gezira, Gasim El Girba, and the pump schemes scattered on the banks of the two Niles, besides the new Rosieres dam built for the irrigation of projected Rahad and Kenana Schemes.

The achievement of the government in the field of animal production is also clearly indicated by the continuous rise in the number of animals as a result of very active veterinary care which checked serious epidemics and common diseases. This policy is adopted by the Government in the hope of making full use of the animal wealth of the country. It necessitates closer action in the improvement of range land, animal breeding and production and marketing.

Ladies and Gentlemen,

The conservation and development of the natural resources of the country as a whole also take much of the attention of the Government. It is realised that land, pasture, forestry and water form the backbone of our agricultural development now and in the future. We believe that keeping these natural resources in good condition and using them on proper scientific bases should guarantee continuous production without deterioration.

Since the end of the last world war the Government has achieved much in the field of good use of our natural resources, and much of this work was done with the help of Mr. de Vajda, the Director of this Conference who contributed much to those achievements in hard executive work as an official of the Sudan Government.

The Government is now launching a large project for making available domestic water supplies in this central belt of the Sudan to remove a barrier prohibiting a wider and proper land use.

Ladies and Gentlemen,

This long introduction is merely a register of some of the activities and achievements which may be part of the subjects you are going to discuss in this Conference, on which the eyes of many African states are focused. We have been very much honoured to have the conference held in Khartoum.

It pleases us very much that other African countries make use of our achievements as much as it pleases us to make use of some of their conditions.

It is very gratifying to note the many interesting subjects on the Agenda of the Conference dealing with the various research works in the various sister African states.

I should like to thank all who have been able to attend this Conference, and in particular our honourable guests of the Special Fund, the FAO and other International Organizations of the United Nations, not only for holding this Conference in the Sudan but also for the much appreciated joint work in Kordofan and Jebel Marra and other fields of agricultural and social work in the Sudan.

Last but not least, it gives me great pleasure to thank again Mr. de Vajda, the old friend of the Sudan, and express to him our deepest gratitude for his previous hard productive work in all parts of the Sudan and for the continuous advice and support he has maintained up to this day.

Thank you and God bless you all.

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STATEMENT BY HANS W. KAMBERG

Resident Representative of the United Nations Development Program in Sudan

Your Excellency, Honourable Guests, Ladies and Gentlemen,

It is a great honour for me and a very pleasant duty to welcome you in the name of the Administrator and the Co-Administrator of the United Nations Development Program to this most active city of Khartoum, and to this meeting on the Development of the Savanna Belt in Africa.

You have come to this capital of the country in Africa covering the largest area just a few days after the second anniversary of the October Revolution which re-established democracy in the Sudan. That it was possible to arrange this meeting such a short time after extensive festivities on the occasion of this anniversary is largely due to the untiring efforts of our Sudanese friends. I am sure you will allow me to be your mouthpiece in expressing our heartfelt thanks to the President and the Members of the Supreme Council for welcoming us to this highly interesting country and seeing to it that facilities are extended for the comfortable conduct of this meeting. Our appreciation certainly also goes to the Prime Minister and the Council of Ministers and to those high Government officials who have taken the necessary steps to make sure that the meeting and the field trips can be carried out successfully. This, in a very special way, includes Prof. Mohamed Abdalla Nur, the Dean of the Faculty of Agriculture of the University of Khartoum, who most kindly has extended to us the facilities which will be used for the various sessions of this meeting, and Dr. Bayoumi, the former Director of the Land Use and Water Development Department, who has a long-standing association with our United Nations Development Program, being for many years the promoter and supervisor of one of our major projects in the Savanna Belt, the Land and Water Use Survey Project in North Kordofan.

Before leaving the floor to Mr. Andrew de Vajda, Deputy Director of the Land and Water Development Division of the FAO, the guiding spirit of this important meeting, to talk about its more technical aspects, I would like to make a few brief remarks on what I would consider the overall significance of your forthcoming deliberations.

These lie in the following three aspects. One, in the area of social and economic development within one country; secondly, in the realm of African regional development and co-operation, and thirdly, in our constant task to refine the techniques and procedures in providing technical assistance.

Those of us who are involved in the promotion of development of countries in Africa, regard with concern the many obstacles with which planners are constantly faced: insufficient funds, insufficient statistics, insufficient trained personnel, insufficient communications, and, above all, insufficient knowledge of facts and figures about certain areas of the African continent which lie dormant with possibly unknown wealth and potential. Only too often the paramount interest within a developing country is directed to areas that seem at a particular time to be more promising. It is only a very natural reaction that developing efforts are directed again and again to places and areas where development has already started. It is these areas that appear to be most promising and easy to develop which constantly attract new attention and investment. But governments, fortunately, are becoming increasingly aware of the necessity to carry forward economic development on a broad front, to look into the possibilities of development also of those regions of the country which have so far been left behind. May I, therefore, express the hope which certainly has been on the mind of the planners of this meeting that your discussions based on your great variety of experience may produce new ideas and new challenges for national planners as well as international financial and technical assistance agencies for the rational development of those forgotten backward areas within the Savanna Belt of African countries.

Another significant area of interest and of potential impact of this meeting lies in the realm of regional development and co-operation. One very important dimension which international agencies have added in the last few years to the concepts and efforts towards development in the world is the concept of the potential development of regions which cut across national boundaries. What is happening right now in the Mekong River Basin, in the Paraguay River Basin, and what is hopefully going to happen within the regional project of the Lake Victoria Catchment Area, where the interest and resources of various countries are being pooled, are but three examples of promising developments now gaining in impetus in different areas of the world.

I would hope, therefore, that this conference will not only serve as a forum for the exchange of statistics, descriptions of existing projects, of research results on land use, agronomics, communications and market studies, but will also be the source of new ideas on regional relationships, division of labour and production and possibly regional project financing. I suggest, therefore, that with our feet planted firmly on the ground of available technical knowledge and experience, we allow our imagination to fly high reaching for the yet unattained goals of regional co-operation which would certainly bring the development of the African nations one considerable step forward.

The third area of significance which I see in the calling of this meeting is more directly related to the agencies which provide Technical Assistance. It has to do with the refining of the techniques we used in providing technical assistance and the consequences drawn from the experience gained in our work. Although this is not the first meeting of its nature, I should like to think that it will contribute to providing the international technical assistance agencies of the UN family with further useful knowledge and experience which might be applicable to other areas of technical assistance endeavours. While it is a well-known fact that it is increasingly difficult even within one country to keep track of reports and studies which have been produced a few years before, and to apply the valuable information contained in them, it becomes even more difficult and sometimes almost impossible to take advantage of useful pertinent and applicable findings from areas which may be similar in their character but which are separated by national boundaries. In recognizing these great difficulties in the exchange of experience and findings, the United Nations Development Program and the Food and Agriculture Organization have called this meeting to find ways and means of bridging the gap in the sharing of experience.

I am sure that the representatives of all the organizations of the UN family present here will look with the greatest interest at this aspect of your discussions with a view to facilitating exchange of technical knowledge and experience within their own fields of activity. As the representative of the United Nations Development Program in this country, I have always considered it one of my major tasks to help the experts of the various agencies working in this country to draw on each other's experience and each other's knowledge. Any gathering which would help to disseminate such information not only within one country but within several countries of the same region should certainly attract our greatest attention and support.

Moreover, I would like to draw your attention to the fact that the United Nations, the World Health Organization and Unesco have joined hands with FAO to share their views and findings in this Meeting. I consider this to be a further demonstration that we have now left behind the earlier days when technical assistance to development was all too often seen as the domain of one or another discipline. I may point out in this connection that in our Land and Water Resources Survey Project in Jebel Marra we have counted, among our experts, hydrologists, geologists, agronomists, horticulturists, economists, soil-survey specialists, engineers, as well as medical doctors, road experts, sociologists and anthropologists.

With this expansion in depth of development efforts in mind, the United Nations Development Program, without in any sense attempting to pre-empt the scientific and technical dominance and prerogatives of the Specialized Agencies, does play the role of catalyst, looking for ways of encouraging further inter-disciplinary approaches.

May this exercise in which you are engaged to share separately gained information, form a common body of knowledge about the African Savanna Belt, and may it also serve as a first stop to the continued exchange of ideas even if a meeting such as this is not repeated in the near future. The personal relationships you will have occasion to establish between yourselves will certainly make it possible for you to keep in close contact with each other in the future.

Having said this, I do not wish to keep you from your work any longer. I only wish to thank you for having come to this most interesting and challenging country. I hope you will bear in mind throughout your discussions the three significant broader aspects of this meeting. I wish you every success in your important deliberations.

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OBJECTIVES OF THE MEETING AND ITS VALUE FOR THE AFRICAN SAVANNA BELT

A. de Vajda
Deputy Director
Land and Water Development Division
FAO Headquarters, Rome.

This meeting is the first of its kind, bringing together Project Managers of a number of United Nations Development Program (Special Fund) Projects operated by FAO, working in the same climatic and ecological areas, having similar problems and, to a great extent, similar physical and even soil conditions.

The UNDP/FAO have selected the Savanna Belt for this first meeting because the Savanna Belt of Africa, and this applies also to the other Savanna areas, has a number of important common problems which are at present under study. Problems of water supplies, scarcity of grassland and low agricultural production have in the past made the life of the pastoral and of the settled population difficult. The majority, if not all, of the countries in the Savanna belt have become independent within the last fifteen years and this, together with the increase in population and social and economic development, has made these problems more acute.

We who have lived in and studied the Savanna area have always felt that in spite of the scarcity of water and soil moisture, living conditions in the Savanna could be made attractive and could compete with other areas of the African continent. The African Savanna, spreading from the Red Sea and the Indian Ocean to the Atlantic, has a healthy climate and often sufficient capability to maintain a substantial agricultural population as well as livestock.

It is certainly worthwhile studying the means and methods of increasing the potential of the Savanna for agriculture in its broadest sense, Exchanging information and making known to the whole Savanna belt the results of experience already gained certainly deserves attention. There must be a limit to the productive capacity of the Savanna and it is certain that the population, due to better health and other social measures, will increase, causing a surplus which will have to be employed elsewhere. A study of the best use of the surplus population should really form part of the study carried out in most of the Savanna projects.

It is, therefore, evident that in addition to purely hydraulic and agricultural aspects many other problems have to be studied. One of the main characteristics of the Savanna belt is the great distance from harbours as well as between inland consumers. The question of transport, therefore, needs specific consideration. A combined study of transportation and markets has to be included in any development planning. The same applies to industries based on the processing of agricultural products; this not only from the economical point of view, but also because these industries might provide additional jobs for a substantial percentage of the population. This additional employment under Savanna conditions is of very great importance. The creation of additional jobs will become more necessary with the growth of the population and in view of the relatively limited internal agricultural resources. With regard to industries, we are thinking in the first place of tanning industries, cotton mills, processing of vegetable oils. When planning regional development, these processing industries should be linked with the planning of agricultural production.

Nearly all the projects which are represented at this meeting deal with resource studies. Some of them deal with irrigation potential; to these belong some projects in Somalia, the project in Sokoto, Northern Nigeria, and projects in the Republic of Niger. The Northern Ghana project is also partly directed towards the utilisation of streams for irrigation purposes. But the majority of the projects represented here deal with the conservation of moisture, the provision of drinking water for man and livestock, improvement of animal health and quality of livestock, and grass cover and afforestation, including timber production and maintenance of the gum acacia.

We have selected the Sudan for this meeting, not only because of its central geographic position and because of the large number of projects in this country located in the Savanna belt - these are the Jebel Marra project, the completed Kordofan survey, the Forestry project and also the Soil Survey, part of whose activities are also located in the Savanna belt— but also because the Sudan is one of the most representative areas of the Savanna belt and because of the wide experience already gained in this country. Here in the Sudan projects exist under climatic conditions which vary considerably, dealing with almost desert conditions to the north of Bara and Mazrour and extending into areas of good rainfall in the south.

As I already mentioned, this meeting may be visualised as the first of a series of meetings which we hope will later develop into seminars dealing with the various specific aspects of the Savanna belt. What we hope from this first meeting is an exchange of experience gathered during project operations, as well as of problems still to be solved. Such experience, which we believe the Project Managers and their counterparts and the representatives of the various countries will be able to submit to the meeting, will help to formulate future projects in cases where it is felt that certain problems have not been studied by any of the existing projects. It will also help to allocate certain specific studies to individual projects where conditions are most suited for such investigations.

We also hope that at this first meeting contact can be established between the various countries with a view to close and continued co-operation in research activities and, where possible, in joint programs. Given the great similarity of physical conditions as well as of socio-economic objectives, such close co-operation and, where possible, joint programs in all aspects of Savanna research, will not only result in considerable economies by using results obtained in one beneficially in the other Savanna countries, but the availability of dependable and tested results may also facilitate decisions regarding specific programs and projects and help to avoid mistakes due to lack of practical experience. The benefit of close co-operation will be not only in the technical field but will also improve solutions of organizational and operational problems. We trust that contacts established during the envisaged future periodical Savanna meetings will help to initiate a number of regional projects similar to the UNDP projects for the Chad basin and the Senegal river.

Further, we hope that this meeting will point the way to a sufficiently intensive study of groundwater potential which, under the conditions existing in the Savanna, might be one of the solutions for increasing agricultural production and improving living conditions in large areas hitherto not utilised. This does not mean that the harnessing of the scarce surface water should be neglected, neither does it mean that bold solutions for the transportation of available river water or improved storage of surface run-off should be excluded. Even less should this mean that efforts to conserve soil moisture should not continue with the greatest possible intensity. However, we feel that the utilisation of groundwater has not been carried sufficiently far and it can contribute in the future to an important development of the land resources.

It is clear that the problems of the Savanna belt must be viewed against the geographical background of the region in its broadest sense where climate, soil and water as well as socio-economic conditions are the basic elements which will decide policies and programs.

We also hope that in the light of up-to-date results, this first meeting will help in the selection of pilot and actual development projects for implementation. Although we consider that at present most of the projects may not be ready to serve as a basis for actual requests for international financing, we hope that this meeting will help to clarify ideas as to the eligibility of projects for such financing.

Finally, I hope that the participants, including the consultants, will direct us towards new solutions and prepare the way for future joint work in the complex and difficult problems of the Savanna.

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STATEMENT BY THE REPRESENTATIVE OF THE ECONOMIC COMMISSION FOR AFRICA

W. Habashi, Chief, ECA/FAO, Joint Agricultural Division, Addis Ababa

On behalf of the Executive Secretary of the Economic Commission for Africa I wish to thank the United Nations Special Fund Development Program and FAO for making it possible for the ECA to be represented at this meeting.

The importance which the ECA attaches to this Seminar stems from the nature of the problems of economic and social development of this vast region of Africa which is estimated to occupy about 22% of the area of the Continent, and to be occupied by about 22% of all its population, and also from the hope we have that discussion of the work undertaken under the various projects, the subject of this Seminar, will lead to solution of the problems involved in the best economic and social interest of the people of the Savanna region in particular, and of the economic growth of the countries to which it belongs in general.

Some of us present here who have worked in Savanna areas or travelled through them will be acquainted with some of these problems and will probably have lived them.

The first and most important problem of the region is its limited water resources. Apart from a few river basin areas where irrigated agriculture sustains fairly dense population concentrations, human and animal life over the greater part depends on rainfall which also determines the flora and general ecology of the zone. Rainfall is not only seasonal covering three or four months of the year, but also variable as between seasons, in terms of both quantity and distribution. At its lower end, rainfall ranges between 100 and 250 mms. per year, and in this part of the region, no crops can be raised, but only short grasses and a scatter of bush scrub grow, on which livestock, mainly camels and sheep, can live. Proceeding south, rainfall improves, ranging at its higher limits between 500 and 750 mms. per year, and taller grasses and a thicker type of tree growth, mainly Acacias and Balanites species, constitute the main flora. Here, production of cereals as a staple food characterizes the agriculture of the region, and sizeable numbers of cattle and sheep thrive. Depending on the kind of soil and quantity of rainfall, a range of other crops like oil seeds and short staple cotton is produced, and forest products like gum and timber for fuel and local buildings are harvested. Where irrigation possibilities exist in parts of the region, perennial and seasonal crops like long staple cottons, fodder crops, cereals, and vegetable and fruit are raised, depending on volume of irrigation water, suitability of soil and seasonality of crops.

Since it is water supply, whether from rain or from rivers, which will ultimately shape the pattern and decide the extent of agricultural development of the Savanna region, thorough studies and inventories of water resources must receive top priority of attention in our studies, and in this respect our studies must seek to ascertain the most effective and economic means of conserving domestic water for humans and animals during the dry months in the dry parts of the region, and the limits of certainty, with the least hazard, of development and extension of dry farming. These are important considerations in as much as no agricultural development activity of crop production or livestock raising can be sustained if potable water is not available after the rains for humans to harvest the crops or for livestock to graze the pastures, and also in as much as limited capital resources demand that minimum risks of climatic hazards be taken.

Studies of water resources in terms of underground water, surface water in wells, rivers or natural or artificial catchment areas must essentially take care of investigations of land use capabilities of the soils round the water centres to be developed, as effective economic use of the water to be supplied in any area can be made only to the extent of stretch and crop producing or livestock carrying capacities of the soil round it. This will help in gearing development of water supply to optimum economic land use possibilities, and in avoiding situations of investment in water development works in areas where land use capabilities for crop or livestock production are meagre, and investment in capital installations in land beyond water supply limits. One could quote many examples of such situations. Such investigations will have to cover the agronomic and production economics aspects of producing various commodities, and will be valuable in determining the pattern and scale of feasible enterprises to be undertaken. The organizational, administrative and rural institutional aspects of control of numbers of farmers and/or numbers of stock to the limits of resources available as different situations may demand, and of the necessary agricultural services to the schemes to be developed should also not be neglected.

Another problem of the Savanna region is the problem of distance and means of communications and transport, Cost of transport is an important element in the cost of production of the commodities to be produced, and the speed with which produce can be brought to the market in the right shape and condition is bound to influence its marketing opportunities. The Savanna region is land-locked and facilities of trunk road or rail services and of feeder crop extraction roads to bring its produce to main consumption centres or export points are necessary. The cost of opening roads or extending railways is bound to be influenced by the extent of the development to be served by such facilities, and the volume and value of produce to be carried from production centres and of the goods to be carried into them. The need for careful consideration of the economics of communication and transport facilities, and of the ancillary requirement of storage connected with them cannot be over-emphasized. Information available about the techniques and economics of road transport under different soil conditions in Africa is inadequate and is not standardised, and exchange of experiences in this field will help developing the right approach to each situation.

The relative economic merits of moving livestock on the hoof with all that is involved in this means of transport in the way of ensuring adequate pasture and water requirements en route, of moving it as meat from slaughter-houses strategically located by air or in refrigerated trucks or railway wagons, and the relative economic merits of moving produce such as oil seeds and cotton in whole, semi processed or fully processed forms demand investigation.

We have already noted that the population of the Savanna region is estimated at about 22% of the whole population of Africa. In absolute terms of number of people per square mile, the population is thin and scattered, but in relative terms of work opportunities available at the present state of development, there is a surplus of human hands which can be more effectively occupied within or outside the region. How much of the active productive part of this population can be utilised in development within the region will depend on the nature and size of the projects which evolve from the studies in hand and such other studies as may be undertaken in future. This will in turn decide the size of surplus labour which may be available for investment in high labour demanding enterprizes outside the region. It is a well-known fact that such operations like cotton picking in currently operating enterprises like the Gezira scheme in the Sudan, and cocoa, rubber and oil palm picking in plantations of countries of the West African Coast depend for their timely performances on mobile labour which migrates from the Savanna areas of these countries, and even from Savanna areas outside political boundaries for work on such schemes inbetween rainy seasons. The economic use of labour in development projects within the region will, therefore, have to be assessed in relation to the impact such use may have on the requirements of such running enterprises currently dependent on such labour.

These considerations will essentially pose examination of possibilities of mechanization of operations under different situations within and outside the Savanna region; studies of the economics of mechanization where technically feasible, of its requirements in the way of skilled mechanics and operators and of the way and means whereby such requirements can be met must also be made. The problem of skilled manpower at all levels as a scarce resource in Africa, will have to be studied in respect of the requirements for it within the region, in the context of the national requirements of all sectors in each country for this scarce resource.

And last, but not least, the problem of capital as a scarce resource in Africa must occupy a central place in our studies. Investigations must cover estimates of capital establishment and operating costs, in components of foreign and local currency, indications of possible sources of financing and cost of such financing in the short, medium and long term.

Integration of all these studies and research should enable us to determine the optimum utilization of scarce resources for the effective increase in productivity and production in the region and its contribution to the economic growth of its countries.

The Economic Commission for Africa, in line with its program of working to promote regional economic co-operation and intra-African trade, fixes great hopes on the outcome of these studies, and greatly commends this approach of bringing experiences from different parts of the Savanna region together for exchange of views and discussion of problems of common interest, and in it, it feels it has support for its strategy of working to promote sub-regional co-operation in the economic and social development of Africa.

We wish the Seminar every success and we hope that the studies in hand will yield results to enable the national planning of projects to be implemented for the economic benefit of Africa and the well-being of its people.

LA: SF/SD/66/INF/5

STATEMENT BY THE REPRESENTATIVE OF THE
AFRICAN DEVELOPMENT BANK

L. D. Matovu, Permanent Secretary, Ministry of Commerce and Industry,
Kampala, Uganda

Mr. Chairman and distinguished Delegates,

The President of the African Development Bank, Mr. Mamoun Beheiry, has asked me to convey his most sincere greetings to this Joint Meeting of the United Nations Development Program (Special Fund) and the Food and Agriculture Organization, and his best wishes for the success of this very important meeting. It is hoped that the discussions which will be held during the following days will be very fruitful and that appropriate ways and means can be found for the implementation of their results to the benefit of the people in the Savanna Belt.

The African Development Bank which I have the honour to represent at this meeting is a relatively young institution - it is only two years old. With a membership of twenty-nine independent African countries as shareholders, the Bank covers most of the African continent. Within a period of two years since its inception, the Bank has consolidated its position as regards staffing and increase in the number of member countries. As you may know, the Bank has started its operations since July of this year and it is now developing a general credit policy. Already the Bank has sent missions to several countries to examine specific projects for financing from its funds.

The African Development Bank attaches great importance to agricultural questions and particularly to those which by their very nature may be capable of giving greater impetus to the economic and social development of those areas or regions which in comparison with others in the same continent of Africa appear to be less favoured. I would like to assure all of you that matters concerning the agricultural sector are well to the fore in the mind of the President of the Bank. Our presence here is not merely symbolic: it demonstrates to all concerned the desire of the Bank to learn more about the agricultural problems of its member countries; the aim is also to investigate any concrete forms of financial assistance which may be granted in order to implement any programs which the experts may draw up in meetings such as this one.

Mr. Chairman, we in the African Development Bank realise that there are many organizations already operating in African countries in fields which we might well enter. The Bank is, however, not in existence to compete with any other organization. Its role will in certain respects be complementary and in others we hope of a leading and pioneering nature. I wish, therefore, to reiterate the Bank's desire to co-operate with all specialized agencies in various fields of activities, and in particular with the Food and Agriculture Organization in relation to agricultural development programs and policies. I emphasize the importance of co-operation among the various organizations operating in African countries in full realization of the fact that developmental problems are very many, varied and complex in our Continent. We therefore need as many organizations as possible, working together and attacking our problems from all sides in order to obtain quick and effective results. No doubt some of these problems are peculiar to individual members or to particular areas of a given country, but the experience gained by any member country or any area in the African Continent is certainly of great value to the work of the Bank as well as to other African Governments which may have to face similar problems.

The African Development Bank, as its name suggests, is a bank for development. Its resources and operations are directed to stimulating and promoting development in its member countries. Its policy emphasizes that priority should be given to multi-national projects, that is to say, projects which benefit several member countries. The multi-national approach of the Bank implies a collective effort by our member countries to achieve the harmonious development of their economies. The co-ordination of development efforts demands the most efficient and profitable utilization of the limited and scanty resources available. Within such a context the Bank is now seeking out problems which affect whole areas in Africa rather than concentrating on individual projects.

This Meeting has assembled to discuss the problem of the Savanna Belt. This is one of the major problems in many of our member countries. We would therefore welcome any suggestions which the experts in the field may make concerning the transformation, exploitation and conservation of the Savanna as well as specific activities and problems such as the improvement of soils, land tenure, husbandry, of forestation, etc. We are looking for solutions to these problems in order to help further the development of the Savanna Belt.

Mr. Chairman, lack of markets is one of the retarding factors in the development of the Savanna Belt. It is axiomatic to-day that trade is an indispensable factor for development and economic growth. Such development and economic growth have been adversely affected in this region because of a dearth of markets for some of the products which this area does or could produce. New methods and techniques may be applied to increase production. But future production, and therefore growth, will be discouraged or arrested if there is no market for what is produced. The national markets of all countries in the Savanna Belt are very small. This is because these countries have scanty populations and the income per caput is too low. Needless to say, therefore, the ability to pay for what is produced is very limited. There are a number of projects which it is technically possible to establish in some of these countries. However, because of the fact that their minimum economic scales require a market larger than that of one individual country, if they are to be viable, they cannot be e established on the basis of national markets. There must therefore be a strong drive for co-operation between the neighbouring countries to form a larger economic unit. And this is what the African Development Bank would view very favourably.

Mr. Chairman, we cannot participate in a technical debate at this particular stage, but we are very happy to listen and to play our humble part and also to make our facilities available to member countries for any financial request ensuing upon the deliberations of this meeting which may be submitted for consideration at a later stage.

LA: SF/SD/66/INF/6

STATEMENT BY THE REPRESENTATIVE OF UNESCO

J. Smid, Director, Bureau for Scientific Co-operation
for the Near East, Cairo

Mr. Chairman and Gentlemen,

It is an honour for me to bring you Unesco's best wishes for the success of this meeting on the development of the African Savanna.

Our Organization is keenly interested in this subject, which comes within the scope of our program for developing the natural resources of the Member States.

Without wishing to encroach on the great possibilities of the Savanna for stock-breeding, which is the field of FAO, our sister Organization, you will certainly consider during your discussions some problems which concern or can interest Unesco, particularly when they relate to the teaching of the basic sciences, the promotion of scientific research and the training of specialists.

Moreover, many of our problems are directly linked with the International Hydrological Decade, which was started by Unesco two years ago, or else with the development or arid, semi-arid and even humid regions; for they include certain savannas which have been preoccupying our Organization for a number of years.

In short, I should like merely to offer some suggestions which may be considered during your discussions and for which a solution may be found.

In the first place, it seems to me that it would be helpful to obtain a certain uniformity of the terms and symbols used in reports. If I understand correctly, a definition already adopted by the ecologists does not, perhaps, correspond exactly with the general idea which we each have of the Savanna.

On the other hand, it seems to me that this region suffers from the same difficulty that I used to encounter in Asia. Owing to past history in the African countries, specimens of plants, insects etc. were more easily exchanged between European countries with a common linguistic background than between countries of the same region. Thus, even the simple identification of a botanical or zoological species can differ from one country to another. Without wishing to suggest that these indispensable exchanges should be interrupted, it would be desirable to increase the regional relations between the countries of Africa, especially when they are in the same ecological zone or in ecologically similar or neighbouring zones.

Under the auspices of FAO, Unesco and the Special Fund, some inventories of natural resources and several studies have been completed with interesting results. None the less, it seems that not all this work has yet been sufficiently analyzed or integrated to permit concrete realizations. It would be appropriate, therefore, to make a methodological and systematic synthesis of the results of these studies and also to compare them with studies made by bilateral aid outside the framework of the United Nations.

At the request of some Member States, Unesco tried to bring about the establishment of institutes for research on natural resources. Unfortunately, these institutes are costly in funds and personnel.

The countries of the Sahelian zone are poor and too short of qualified manpower for each one of them to provide such an institute. It could thus be thought that here is the possibility for a sub-regional institute; but, while emphasizing its value, the difficulties and drawbacks of such an establishment should be recognized. It appears to be too soon to begin pressing for the creation of this sort of institution in the zone of the African Savanna.

Since the institute does not exist, would it be possible to launch forthwith a joint FAO-Unesco project, as was done for locust control and agroclimatology, to examine the possibilities of a regional centre for documentation on the Savanna and also of a regional herbarium in which comparative collections of useful plants are displayed, and notably medicinal and fodder plants? The first stage would be the formation of an itinerant working party, financially supported by UNDP and consisting of specialists qualified to make an inventory of what has been done. This working party should also study the possibilities of training specialists in the region itself and work out an appropriate distribution of research tasks between the countries, without forgetting the sociological study and the improvement in the situation of the stock-breeders, nomadic or not nomadic, and the peasants.

The problems of the conservation of nature and the creation of national parks and reserves should not be overlooked.

All this would make it easier to identify ecological systems and specific problems with the aim of giving ever more solid foundations to some more ambitious solutions in the future stages of development.

These are all only suggestions which I allow myself to submit for your consideration.

I should like to assure you, Gentlement, that Unesco participates with very great interest in your deliberations and that it is ready to co-operate as fully as possible within the limits of its powers.

In conclusion, I wish sincerely to thank the organizers of this meeting for the invitation to Unesco and for having allowed me to make this brief intervention.

LA: SF/SD/66/INF/7

STATEMENT BY THE REPRESENTATIVE OF WHO

M. Le Bousquet
Consultant on Community Water Supply
WHO, Geneva

In the next 25 years and in all countries, the problem of water needs and the water to meet these needs will become more and more serious with the expansion of population, industry, irrigation and the new technological demands for water. Efficient use and re-use must be planned for available natural water resources. Present indications are that desalted water from the sea will continue to be expensive in the extreme and practical for the highest priority use only.

The Food and Agriculture Organization (FAO), through its United Nations Development Program projects (UNDP), has increasingly, in the last few years, devoted its energies to the assessment of available water resources and needs and the development of water resources. While FAO's primary interest may be in irrigated agriculture, a broad spectrum of uses is recognized. It has also been recognized that irrigation is, in a sense, community development. The health and welfare of the people affected by the changes resulting from the project are important considerations. WHO is particularly interested in helping to safeguard the public health in connection with these projects, and especially the large-scale regional projects being assisted by UNDP. These are complex undertakings, such as the Chad Basin and the Senegal River. Several Governments can be involved, and several agencies and tens of millions of dollars.

FAO/UNDP activities are prerequisites to future investment and this type of work will naturally continue and expand for many years to come. About eighty land, water and irrigation schemes are now under consideration, and on at least half of these planning has proceeded to the point where specific projects have been outlined.

In the last year or two there has been increasing collaboration between FAO and the World Health Organization (WHO) in the consideration of public health aspects for water resources development. The participation of WHO has generally been in the furnishing of health specialists, either from the staff of WHO Regional Offices, or retained as consultants working under the WHO Regional Offices. These health consultants generally include a public health adviser with broad experience in preventive medicine and epidemiology, with special stress on water-related diseases. A second type of consultant is a sanitary engineer with special experience in community water supply, water quality control, and the control of insect vectors of diseases. In special instances other experts are utilized, such as entomologists and biologists.

The specific health aspects covered by WHO advisers include:

a. Supply of water to communities
b. Removal, treatment and disposal of waste waters
c. Prevention and control of water-related diseases
d. Health services during construction and resettlement in new water resource areas.

Besides these there are other aspects of interest to WHO which are only indirectly related to health. There is an interest in water quality prior to impoundment, as this in turn determines reservoir water quality, including its suitability for community water supply. There is an interest in the self purification capacity of the stream and the possible reduction of this capacity in converting a rapidly flowing stream into a reservoir. In this connection the thermal stratifications of a reservoir results in deterioration of water in deep areas from which water may be drawn by modern hydroelectric installations. Degraded water which can be void of oxygen may damage water use downstream and fish and aquatic life may be eliminated. Incidentally, these are some of the problems which will certainly be met with in the proposed Research Project for Lake Volta. There is interest and concern over flow reduction which reduces stream purification capacity, and in irrigation use which adds salt and total solids to return flows. All of these factors, of some interest to WHO, are considered in any broad program of water resource management.

Community Water Supply

It is generally recognized that the domestic water supply has a top priority in water resources development. WHO is active in this field through its Community Water Supply Unit, and is in a position to évaluate not only domestic supply needs but also current urban and industrial needs and predicted future requirements. This water use, necessary for human survival, cannot be over-stated; it is generally recognized by FAO and receives mention in the plans of operation of FAO/UNDP projects. Community Water Supply is not only essential for drinking and domestic purposes, but can also be a governing consideration in the establishment and location of industrial plants. Community water supply has been described as a springboard in an industrial development program. Experience has shown that properly designed, managed and operating community water supplies in all but the smallest municipalities can be run efficiently, with income to match not only operating costs but also to repay construction loans and normal replacements and expansions. The inclusion of community water supply in water resources development can add greatly to the benefits derived from the project, and play an important role in justifying the large expenditures normally involved.

Community water supply is a nonconsumptive use and the spent water can be used for other purposes, usually following treatment, such as for industrial use or for irrigation of crops not eaten raw. Maximum benefit from valuable water resources can result from such multiple use of water. With irrigation re-use in mind, a planning possibility worthy of consideration is the placing of irrigation projects below new urban developments rather than above.

Rural water supply has also received attention in WHO's collaboration with FAO. There will be a water supply problem for the population resettled in a newly irrigated area. If irrigation is from wells these can be constructed as sanitary wells suitable for drinking water supply at very little expense. Exploratory wells can be converted and used for the small quantities needed for rural water supply. Along this line, ECA has been interested in organizing a Training Centre on Small Scale Water Storage Works and Small Scale Dams. Special small scale treatment facilities are desirable if impounded irrigation water is used for drinking.

Removal, Treatment and Disposal of Waste Water

A waste water problem is invariably created by the provision of community water supply and the two systems should be planned together and constructed within a short time of one another. Many health benefits result from a sewerage and sewage disposal system. There is prevention of reduction of insect-borne diseases such as filhariasis (elephantiasis etc.), the vector of which breeds in sewage and stagnant pools of waste water. There is reduction of water-borne diseases such as cholera, typhoid and dysentery. The line of transmission between infected and healthy persons is broken, thus reducing infection in parasites, such as hookworm, which can be transmitted when excreta is disposed of in an insanitary manner.

The sewer system has not only a health benefit but also an aesthetic benefit in removing wastes from living areas and eliminating not only a health hazard but also an aesthetic nuisance. This in turn can have an economic impact, as many businesses including tourism are encouraged by sanitary surroundings. Other benefits result from the removal of industrial and other wastes from the community.

Following the provision of the sewer system there arises the need for domestic and industrial waste treatment facilities to maintain stream water in satisfactory quality as it flows downstream and becomes available for repeated re-use.

Prevention of Water-Related Diseases*

A number of diseases related to water can affect local populations in various ways, apart from being carried by drinking-water. Unless suitable precautions are taken these diseases may be encouraged or spread by such works as irrigation, flood control, hydropower and the like. These diseases include:

a. Malaria. Mosquitoes breeding in natural or artificially stored waters can infect populations residing within several kilometres of the source.
b. Bilharzia. A widespread and increasing disease affecting, it is estimated, a large portion of the world's population. It is transmitted by certain snails breeding in canals, irrigation ditches and similar works, and is contracted by physical contact with the water, not necessarily by drinking it. Irrigation workers, rice cultivators, fishermen, women washing clothes in a river, children swimming, are all particularly prone to infection.
c. Onchocerciasis (or river blindness). Spread by a fly which lives in clear running water, and which breeds particularly in concrete spillways or similar structures.
d. Filariasis. Transmitted by a mosquito which breeds mainly in stagnant and contaminated pools, causes elphantiasis and similar conditions.
e. Trypanosomiasis (sleeping sickness). Transmitted by tsetse flies breeding on the verges of irrigation channels, particularly in the shade of vegetation adjoining the water.

Suitable precautions can be taken at the design stage of any water regulation project to minimise the spread of these diseases, and constant vigilance is necessary during the construction and operation stages to prevent the benefits of a project from being outweighed by dissemination of sickness. WHO is co-operating with other agencies by supplying medical and engineering specialists to ensure that these precautions are built into projects of water development. FAO, United Nations and World Bank projects are receiving particular attention.

Health Services

A major population resettlement is to be expected as a result of a water resources development. Project success will require that health services be provided to the resettled population and an opportunity may be provided to establish an effective health service based on disease prevention. Certainly every effort should be made to prevent the introduction of diseases into areas where such diseases never

* From a recent WHO Staff Paper

existed before. Aspects to be considered may include the screening, training and health education of settlers and possibly a broad immunization program. A health organization suitable to local conditions and resources may be recommended for both the periods of construction and operation.

WHO is making public health advisers available to assist with the strengthening of local health services, resettlement problems and the co-ordination of health measures within the context of the UNDP project. In some instances, as for the Lake Nasser Research Project in U.A.R. and the Kenji Dam Project in Northern Nigeria, WHO sends a health adviser to assist in drawing up the Plan of Operations and planning, together with the Executing Agency, the exact type and timing of the consultants which WHO is to provide.

It is highly desirable that an item be included in the project for at least initial health service as an integral part of any construction project involving resettlement. Projects are ultimately to improve the well-being of man and building a project is of little purpose without a parallel building of man.

Procedure

Most important is the early and timely collaboration between the different sources of assistance and funds in the international field and at the national level in order to take care of the health components of FAO/UNDP and similar projects. Normally WHO, FAO and other agencies, including the World Bank, receive from the Administrator of the UNDP resumés of Government project requests for technical evaluation. On the basis of the comments received, the UNDP can negotiate the request further with the Government and, if necessary, organize a special mission to assess or even redefine the request. In this way the request and the assistance envisaged can be brought into line with the criteria of the UNDP established by the General Assembly in its fundamental resolution creating UNDP. Such preparatory assistance to the Government and the reformulating of requests is provided by the Administrator in close collaboration with the technical agencies involved. Account is also taken of complementary activities which may be under execution or under study by bilateral agencies. WHO has always been anxious to play the maximum part it can in assisting in the formulation of projects expressly to ensure that the health implications are given the fullest attention. Further, while WHO comments (and these emanate from all levels of the Organization) are transmitted to the UNDP for the guidance of the Executing Agency ultimately designated, the detailed evaluations of projects from other agencies are also taken into account by WHO in planning its own later participation.

WHO's material assistance can consist of short or medium term consultants - such as a public health administrator, epidemiologist and a sanitary engineer - working as a team or separately; visits by WHO Regional Office staff and WHO can also be requested to provide certain specialized drugs and medicines. Reports by these consultants and others, once cleared by WHO, are submitted directly to the Executing Agency - in this case to the FAO Headquarters in Rome. Naturally the WHO consultants will, in the course of their assignments, discuss their findings with the FAO Project Manager. This close collaboration between the WHO consultants and the Project Managers is essential. Equally important is a firm understanding between the respective Headquarters of the agencies. But perhaps of paramount significance is the role which the national Health Ministry must play with its sister Ministries or agencies directly responsible for the project.

Summary

While WHO will continue to seek for more effective methods of improving collaboration between other agencies and itself in the interests of health in projects under execution in the UNDP field, we believe that an encouraging start has been made in this complex field to safeguard the health needs of the people affected by these projects. The health authorities in a country have a continuing responsibility, and it is essential that these authorities be fully acquainted with future plans and be brought into the co-ordination picture at the first possible moment. Everything should be done to assist in developing co-operative working relations between the various Ministries, such that there is mutual reinforcement of each sector to form a national or even regional whole, and that maximum economic, social and health benefits may accrue from the project. WHO will do everything within its power to further the objective which it shares with FAO of improving the well-being of the people and ensuring that FAO/UNDP projects produce maximum health benefits and do not become the instruments of the propagation of disease.

LA: SF/SD/66/INF/8

STATEMENT OF MR. PAUL-MARC HENRY

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UNDP, New York

We have reached the first stage of the world food crisis. The manifestations of this crisis are everywhere to be seen. In every possible continent, with the exception of Western Europe, there are food problems.

The Savanna Belt is one area of a great development potential for food production of the world, due to the combination of space, land, water and sunshine. The Savanna Belt can contribute a great deal to ease the food problem in Africa.

FAO is engaged in a major work of collecting data for the Indicative World Plan. The document will show that in order to reach the required food production level, enormous investments are indispensable, the source of which has still to be found. At present the official figure of capital investments has remained stagnant at a little over $ 6,000 billion for the last six years (World Bank figures). This means, therefore, that the annual investment has gone down because of depreciation of money.

The main objectives of this meeting were discussed two years ago, and we had in mind two main issues:

1. An exchange of views between people engaged in the same type of work - Project Managers and Co-Managers - to share experiences and to point out the shortcomings, problems, difficulties, and make recommendations for future development. This was the first and very important objective.

2. A second, and more general issue, was to define the whole strategy of the UNSF - UNDP in relation to future project development. You are all aware of the fact that the FAO sponsored activities supported by UNDP are by far the largest in relation to all other agencies. $ 650 million next January; the figure for FAO will be the largest, $ 300 million (i.e. 42%), and this proportion is increasing.

The amount of Special Fund assistance granted to Africa has increased regularly since the beginning of the Special Fund operations in 1959/60. Some of the projects represented here date from that period. Other are more recent. But basically the philosophy of these projects dates back to the beginning of relations between the Special Fund and FAO. Most of these projects have common characteristics: they are relatively long-term with a built-in second phase of three to five years' duration and are aimed at assembling background information on physical and economical conditions of an area. Recommendations are made on future development and possible investments in specific fields. Such projects are pre-investment projects.

There are cases where investment has almost immediately followed up the pre-investment program. But this is exceptional, either because financial resources of the Government are scarce, or because the region has not received first priority in the development program, or because the data provided are insufficient to justify investment. Sometimes the findings of the projects do not lead to investment or no possibility of investment is offered. The pre-investment project is evaluated on the basis of the investments realised, and therefore the project should generally include feasibility studies similar to those conducted by the World Bank.

During the few years of a project, it is often difficult to make a satisfactory diagnosis of the general conditions of soils, water and climate of an area. Unless there is already a considerable amount of existing information available, the scanty information assembled during the project is not a sufficient basis for investment.

There is no short cut to collecting background information for investment, especially in agriculture. Field experimentation, climatic and hydrological studies must cover a sufficient number of seasons.

On the other hand, in view of the present world food situation, there is great urgency for making immediate use of the information available. This is a basic dilemma which has to be solved in each development project.

One alternative would be to evaluate all projects primarily on the basis of criteria of immediate pre-investment. Another possibility would be to consider the projects as a continuous contribution to better knowledge of natural resources and ecological conditions. But in that case, it is to be expected that member countries contributing voluntarily to the Special Fund would raise serious objections. The total of contributions has been increasing steadily since the establishment of the Special Fund. The total contribution of the first year amounted to US $ 29 million, and now reaches US $ 130 million. However, being voluntary, such contribution can be stopped almost immediately should the program be unsuccessful. In passing, it is worth mentioning that, even if all contributions were cut, funds would be available to finish the projects now in operation as the total budget of these projects (for a total amount of about US $ 200 million) is already earmarked.

Member countries are voluntarily contributing to our program because they feel that it is their duty vis-à-vis the developing countries; because also they hope and believe that somehow systematic pre-investment programs will lead to major investment, not only through bank loans but through mobilisation of international resources of all kinds: natural, human and financial resources.

If our program clearly contributes to a large scale mobilisation of such resources, it will be a success; if not, it will be a failure. Time is short and we have only a few years (may be as few as 5) ahead. Unless largescale investments for the development of agriculture are made, unless the Governments of the developing countries are assisted in the development of their resources, the world food situation will shortly become dramatic. Initiative in this field is clearly the responsibility of the FAO and the IBRD.

A part of the developing world is now relying on a few developed countries for help in their critical food situation. The United States and Canada are trying desperately to help in the world food problem. Large areas of the world are provided with the necessary natural resources for large scale food production. They are idle now. The Savanna Belt is a good example of such an area. It is our duty to help make them productive.

It is an objective of this meeting to make suggestions and recommendations in this respect, to propose a general stategy of development on a regional basis such as the Savanna Belt, to raise interest of UNDP and finally assist FAO in its approach to the problems of agricultural development.

LA:SF/SD/66/PM/1

SURVEY OF THE WATER RESOURCES IN THE CHAD BASIN FOR DEVELOPMENT PURPOSES

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Project Manager
Chad Basin Development Project

Preface

The project is not yet operational and cannot be expected to contribute much experience to this meeting.

However, the experience gained by the other UNDP/FAO project in the Savanna Belt can contribute towards the success of this joint attempt of FAO and Unesco in this regional Chad Basin project, covering parts of the territory of Cameroon, Chad, Niger and Nigeria in their struggle for development.

A critical appraisal, both technical and economic, of this project, described in the following pages, will be very useful in giving the project a good start, both in operations and follow-up.

Background of the Project

Hydrologists in the Chad Basin held a meeting in Fort-Lamy in March 1966, which concluded in concentrated action for the development of the water resources, not being influenced by artificial country boundaries, as they exist now.

The Inter-African Hydrological conference of the CCIA (Comité pour la Coopération Technique en Afrique) held in 1962, in Nairobi, made a recommendation concerning regional co-operation between the countries bordering the Lake Chad. It stated that a project for the reclamation of the whole Chad Basin had to be worked out by an inter-state organism represented by the four States, Cameroon, Chad, Niger and Nigeria.

Experts of the four countries attending a meeting at Fort-Lamy in October 1962 made suggestions for a conference of the Heads of States.

This meeting took place in December 1962, and it was decided to create an inter-state committee of experts to produce a detailed inventory of the knowledge acquired in the four States, particularly concerning the natural resources including agriculture, irrigation, animal husbandy and fisheries.

Circumstances did not permit fertile activities. Nevertheless on 21 May 1966, the Chad Basin Commission was officially set up at a meeting of the Heads of States bordering the Lake.

Difficulties in forming a staff for the Secretariat due to the scarcity of trained technicians led to submission of an application to the UNDP with the main purpose of obtaining technical staff for its secretariat.

Finally, Special Fund consultants proposed two complementary projects for which Unesco and FAO would be the executing agencies.

The Unesco project aims at the establishment of a synthesis of all hydrological studies already completed in the four countries resulting in a hydrological map, the construction of an electrical analogue model and a complete documentation of all studies. This synthesis is a very important basis for the more practical directed FAO project.

The FAO project has to assist the Chad Basin Commission in completing a survey of the water resources of the Basin as a basis for the comprehensive development of agriculture, animal husbandry, and fisheries, running into the preparation and evaluation of specific development projects.

Description of the FAO/UNDP Project

In particular the project will:

a) Complete the knowledge of the total water resources by ascertaining the proportions of surface and underground water available and by drawing up recommendations concerning a balanced exploitation of surface and underground water for domestic and agriculture use;

b) Through fellowships give training to African technicians in water exploitation and utilisation;

c) Assist the Chad Basin Commission in preparing and evaluating specific development projects relating to agriculture, animal husbandry and fisheries.

Activities and investigations included in the project to complete, as far as possible, knowledge of the total water resources in the project area, grouped under the following headings:

Meteorology

Installation of meteorological stations, recording rain-gauges, evapotranspiration measuring equipment, lysimeters, etc.

Interpretation of all meteorological data available to be measured during the study. The interpretation has to be done in the field of rainfall distribution and intensity, in relation to river discharges, soil moisture, qualities of soils and evapotranspiration of crops (formula of Blaney Criddle, Penman, Rytema, etc.) and water balance studies.

Hydrology

Installation of automatic water-level recorders, establishment of relationships between all water-level recorders (as already available), and discharge measuring stations, and establishment of basic hydrological equations for the area.

Determination of the hydrological regime of the Chari river, being the main contributor to the lake, together with Logone which already has been studied.

Preliminary estimates of effects of proposed water development schemes on the overall water-balance and on affected river discharges, and acquifer water-levels.

Hydrogeology

Any necessary geological studies required in addition to the general geological mapping already available. Close definition of the geological structure and aquifer boundaries in the basin by means of geophysical studies and deep trial bore-holes using core-drilling and electric logging. Definition of the boundaries of artisan ground-water in the two lower aquifers of the Chad formation by means of 12 core-drilling boreholes.

Determination of the potential yields of the sand/gravel surface aquifers above the Chad formation rocks and their dependence on the Lake storage by electric resistivity survey, trial borehole drilling and test pumping.

Inventory of all wells and boreholes, and chemical analysis of water from each, as well as investigation of the chemical properties of underground water.

Definition of the main recharge areas and estimation of the overall long-term availability of exploitable water.

Agriculture

The project will start with the collection of all information in the basin relating to past activities in traditional and modernized methods of agriculture. Amelioration of traditional agriculture by extension services can be an initial step towards the development of the country involved.

The establishment of three agricultural experimental stations for normal activities related to the development and improvement of cultivation techniques, and also to investigate problems concerned with improvement and use of saline soils and water, and with the control of the groundwater table in irrigated soils.

In connection with the work of the experimental stations, trial plots will be established to evolve suitable irrigation techniques.

Action programs and plans for extension services will be prepared to transmit the results of trial plots and experimental stations to the farmers and to convince them to change methods.

Assessment of existing pilot irrigation projects, their improvement, extension, and installation of new ones if considered necessary.

Animal Production

The livestock herds are still the main natural resources of the region, for the surrounding densely populated areas constitute a natural market. In animal production one of the main problems is getting water for cattle. A comparative study of the means of tapping and distributing water for cattle, and the material and economic problems involved will be made.

Another serious problem for the Government is the migration of the herds to other neighbouring countries where they are marketed, being an economic disadvantage for the country.

Programs of experimental work for the development of fodder crops and live-stock production inside the pilot irrigated areas will be established.

Fishery

Investigation of long-term effects on fishing due to hydro-agricultural developments resulting from the project, as there is a constant fall of the water level in the river and the lake, drying up of the river-bed, decrease of inundated area influencing the maintenance of the fish population.

Modernization of fishing methods, conservation of fish and its distribution. One of the indispensable items in the chain is a good network of roads, the lack of it being one of the bottle-necks in the development of all activities in the region.

Collection of statistics of fish yield with present fishing methods so as to estimate future yields with improved techniques and to draw up a system of control to ensure that reserves are not depleted.

Economic development

Collection of all economic and social information at present available, particularly with regard to those aspects related to water development.

The preparation of a perspective long-term economic development plan of the area.

Proposals for additional social and economic studies to be made in the future.

Public Health

The possible danger to public health by the introduction in the project area of irrigation and new agricultural and animal husbandry techniques will be reported on by consultants.

Comments

The project has to be a regional project because of the common interest of the countries in:

- the water discharged by boundary rivers and usable on both sides of the banks;
- the stock of water in Lake Chad to be used for irrigation purposes;
- exploitation of the groundwater reserves discovered in the Sahara and situated under the four countries;
- fishing on the boundary rivers and the Lake;
- flood protection on one side of the river causing more severe inundations on the other bank;
- building up their infrastructure together for that part of the country, especially for the two countries totally divided from direct connections with the sea.

In the regional project it will be more easy to transmit experience from other bilateral or multilateral aid projects to the other partner-countries. Communication between projects in different countries seems to be more or less poor.

The project will encourage many activities in co-operation and co-ordination with other projects and bilateral aid agencies.

In this project FAO and Unesco will co-operate closely, proving the unity of the big UN family, and will share the more practical and scientific part of the project.

The counterpart contribution in kind covers the common interests of the four countries in the research program. For special items added to the Special Fund allocation under equipment or experts, the interested country has to make available other funds. An example is the experimental polder in Bol which is only of importance for the Government of Chad. Special Fund allocated the pumps, but the Government of Chad has to pay its part for operation and maintenance. The dikes can be made, for example, with the aid of the World Food Program.

The backbone of the project will be the hydrological and hydrogeological studies demanding many years of hard work. Identification of projects for submission to international financing agencies will accompany the project as soon as possible, as it is of immediate importance for the development of the Chad Basin. The time between submission and approval can be used for completing the data before the project will be executed.

The first projects in this field are expected im fisheries, ranching, and flood protection in combination with irrigation projects.

LA: SF/SD/66/PM/2

RANGE MANAGEMENT DIVISION OF THE MINISTRY OF AGRICULTURE AND ANIMAL HUSBANDRY, KENYA

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of Agriculture and Animal Husbandry, Kenya

Introduction

The Kenya Range Management Project resulted from an application to the United Nations Special Fund by the then (1964) newly formed Range Management Division of the Ministry of Agriculture and Animal Husbandry. A basic agreement between the Special Fund and the Kenya Government was signed October 1, 1964, since when the Plan of Operations has been agreed upon and FAO designated as the Executing Agency. The Division of Range Management is the responsible Government Department.

The Project is for a period of five years and its stated purpose is to strengthen and expand the Range Management Division of the Ministry of Agriculture and Animal Husbandry to enable it :

a) to carry out land use surveys as a basis for detailed range development planning;

b) to provide training for range officers, field instructors and technicians as well as extension services for ranchers and pastoralists;

c) to intensify applied research on specific problems of range development and productivity. The immediate objective of this will be to promote the pastoral development of the Kenya rangelands in compliance with Government's 1966-70 Development Plan.

The team of internationally recruited experts will consist of the Project Manager who is also Senior Range Research Specialist and experts grouped as follows:

Research

Range Ecology/Management
Bush Control
Plant Physiology
Wildlife Biology
Animal Production/Livestock Improvement.

Land Use and Planning Survey

Range Ecology/Management Water Development Wildlife Biology Range Economics	From beginning of the Project
Range Ecology/Management Water Development	From mid 1967

The latter two men will also be supported by the Wildlife Biologist and Range Economist of the first survey team as required.

Range Education

2 Range Education

Most of the team members are now on the Project or their arrival is imminent.

The UN Development Program is providing a total of US $2,047,000 in personnel and equipment and the Kenya Government counterpart contribution in kind is US $1,704,000.

Background to the Project

The Kenya Government had started working on a 5 year development plan in 1964 and it was apparent that if the objectives of the rangeland development portion of the Plan were to be realized, outside assistance would be required. Thus the submission of the request to the UN Special Fund.

Kenya's rangelands make up 80 percent of the land surface of the country or that portion receiving less than 30" of rainfall (760 mm). With the exception of some areas in the upper range of precipitation where sisal does well (commercial prospects for this crop are deteriorating) and about 250,000 acres of potentially irrigable land, this enormous area is not suitable for cultivated crops. Livestock production, wildlife and tourism are the uses to which this very large proportion of Kenya should be devoted. However, production from most of this area is much below its potential, with deliveries of livestock products, excluding those from commercial ranches and national irrigation schemes (approx. 5 m out of 115 m acres), estimated at £1.5 million and of other commodities at £0.5 million. The remainder of the output is consumed for subsistence or bartered locally (valued at £10 million annually). It is estimated that the gross output per acre in strictly pastoral areas is Shs.2/- and in semi-pastoralist and subsistence cultivator areas just under Shs.4/-. This contrasts with an average of Shs.12/- per acre on commercial ranches (Kenya Development Plan 1966-70 para.23).

The Government, in their 1966-70 Development Plan anticipate raising the productivity of nearly 15 million acres in the 2-4 shilling output category to the point where the gross return per acre will be approaching that of the Shs.12/- realized by commercial ranches. This will be accomplished by establishing new Government/Private ranches to the extent of 600,000 acres on previously unoccupied lands in the Coast Province; Co-operative ranches of 1,356,000 acres in Eastern, Coast and Central Provinces; group and individual ranches of 5,361,000 acres in Rift Valley, Eastern and Coast Provinces; and grazing schemes of 7,570,000 acres in all provinces except Central. Improved production will be obtained by grazing rotations, increased water supplies, communal dips, and improved animal husbandry practises. The exploitation of the considerable wildlife resources of these areas from the standpoint of meat production, trophies, recreation and tourism will be integrated into the overall economic development.

General Ecology

Of the 80 percent of Kenya which is classified as rangelands, 20 percent receives an average of 12" or less rainfall per annum and 60 percent receives between this and 30". Most of the development envisaged above except for about 1.5 million acres in the Grazing Scheme category will be undertaken in the areas receiving 12" - 30" rainfall. Most of this area, or vegetative types with similar components, have been described by various ecologists as some sort of savanna. The East African Range Classification Committee have discarded the term "Savanna" for what we consider to be good and valid reasons but this is not the time to argue ecological classifications.

Most of the 12-30" rainfall zone in which the UNDP Range Management Project will be operating is classified as "Arid" (climatic indices - 40 to - 50) under the system of classification proposed by the East African Rangeland Classification Committee. For this system, climate has been defined according to Thorthwaite (1948), except that the estimate of evaporation used in the calculation of climatic follows Penman (1948).*. In physiognomic terms, the most important rangeland types with which we will be dealing will be; Bushland, Woodland, Grassland, Bushed Grassland, Wooded Grassland and Dwarf shrub Grassland, (mainly confined to the very arid zone, climatic indices -50 to -60). As in all East African, and probably most of the arid vegetative types of the world where woody components form an appreciable proportion of the climax vegetation, the same problems exist, i.e. to either find the means to make a fuller and more economic use of the existing species or to replace them with something more productive. In order to assist the Kenya Government in attaining the objectives of their 1966-70 Development Plan, the Range Management Project will be investigating both of the above approaches, but with differing emphasis according to the dominant vegetative type and its component species. In this project we will be stressing increased forage production for domestic livestock and/or game.

The physiognomic type which is the most troublesome of the rangeland types is Bushland. This type has been defined (Pratt et.al 1966) as an assemblage of woody plants, mostly of shrubby habit, having a shrub canopy of less than 6 m. in height, with occasional emergents, and a canopy cover of more than 20 per cent. Fires are usually infrequent.

In Kenya there are many types of bushland with the bush species and their degree of dominance determining whether or not they are a problem. Such types as Tarchonanthus-Dodonaca, Lannea-Commiphora, Euphorbia-Sansevieria and Acacia reficiens, can so dominate a site that few plants useful for grazing by domestic livestock or (to a lesser degree) game are able to survive. The reasons for and conditons under which we find an undesirable degree of bush dominance are as varied as the bush types. Probably the most important of these is the reduction in the intensity and frequency of fires. This has been affected largely by the degree and season of use, and the class of livestock or game species utilizing the grazing resource. As grazing pressure increases there is less combustible material available to carry a fire and ultimately, due to a combination of reduced competition from grasses, and fires of decreasing intensity, many sites become almost impenetrable thickets.

The team members of the UNDP Range Management Project have been selected with the view to obtaining and utilizing the best available skills in the various fields in order to make a scientific approach to the best use of the existing vegetation or to change it by the most economical and practical means to something more useful.

It has already been shown in Kenya that by bush control measures production of grass can be increased by 50 percent where the density of woody vegetation is moderate and up to 60 percent where thicket types were eradicated.

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* (An East African Rangeland Classification, D.J. Pratt, P.J. Greenway, M.D. Gwynne, to be published Journal of Applied Ecology, 3, 369-382)

The Range Management Project

Research

The Bush Control expert and Plant Physiologist will be investigating chemical, mechanical, and biological control of undesirable woody species. The Wildlife Biologists will study the degree of competition between the various game species and domestic livestock and assess the possibilities of utilising the very considerable populations of wild animals to the maximum extent in obtaining economic returns from the lands sub-marginal for ranching domestic livestock. They will also investigate the desirability of combining various wildlife species with domestic livestock in order to make more complete use of the grazing resource. Habitat manipulation to encourage the increase of the most useful game species will be attempted. The Range Ecologist will be studying grazing systems which will encourage greater production and the increase of desirable forage species. He will be investigating management as a tool in bush eradication or suppression and the effects of burning frequencies and intensities on both the undesirable and desirable species. The introduction of more useful forage species, especially legumes will also be investigated. The Animal Husbandry/Livestock Improvement Specialist will study and assess the requirements of the various breeds and crosses of domestic livestock and attempt to determine methods for improving their performance. The nutritional requirements and animal husbandry practises necessary to reduce the breeding cycle and increase calving percentages, and to reduce mortalities and increase weights for age, will be investigated.

Land Use Planning Surveys

In order to assist the Range Management Division to attain the goals of new ranching developments envisaged in the 1966-70 Plan the survey team will be evaluating the productivity of the areas where development can take place most rapidly and make the greatest contribution to the Development Plan. Overall appraisals will be made to get an appreciation of the ecological potential within the various sociological units and a determination made of areas within these entities where the production of domestic livestock, game, tourism, food crops or a combination of these should receive greatest emphasis. The Water Development Officers will investigate sources of supply and plan installation of watering facilities with the view to obtaining a distribution of supplies which will permit optimum use of the range resource compatible with the cost of installations. The Wildlife Biologist will assess the possibility of game as an alternate or complementary use of the developing areas. The Range Economist will be evaluating the development costs for all planned projects and making recommendations as to the most viable areas for development and the form which such enterprises should take.

Range Education

The Kenya rangelands consist of over 100 million acres which are presently being grazed by domestic livestock but only in rare instances is the full potential of the land and livestock being realized. The lack of knowledge of good range and livestock management is probably the greatest factor in the failure to realize this potential. The Range Education Team of two FAO experts, their Government counterparts and supporting staff will strengthen the Extension Services and assist them with the task of improving the range and livestock management practises of the Kenya Pastoralist. They will provide inservice training for range officers and instructors working with the pastoralist, and they will prepare and convey information in improved practises to the pastoralist through the use of mobile education units equipped with cinema, slide projectors and other visual aids.

Co-operating Organization in the 1966-70 Plan

In the overall Development Plan the shortage of capital required to meet the various costs of development remains a problem. However, the International Bank for Reconstruction and Development are considering an application from the Kenya Government for a very considerable loan for rangeland development and have stressed the importance the implementation of the UNDP Range Management Project would have in their consideration of the loan. The United States Agency for International Development are also making a substantial contribution to the Development Plan. If the application to IBRD is successful, there will be three separate organisations assisting the Range Management Division of the Ministry of Agriculture and Animal Husbandry in carrying to a successful conclusion their Development Plan. The RMD, however, intend that the three projects shall be complementary to each other and will be completely integrated under the RMD so that the Development Program can proceed without confusion or duplication of effort. If this succeeds it will be an interesting example to other countries as to how multi-lateral aid and their parent organizations can be welded together to better realize the objectives of their efforts.

The three Projects mentioned have drawn attention to Government's desire to fully develop the rangeland potential of Kenya and investors from the private sector are being attracted and can confidently be expected to make a considerable contribution to the Plan.

LA: SF/SD/66/PM/3

DEVELOPMENT OF ANIMAL PRODUCTION AND WATER RESOURCES IN THE EAST OF NIGER

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Development of Animal Production
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General

It is not easy to state exact figures for the revenue derived from Animal Production in the Republic of Niger. It can reasonably be stated that some 60% of the revenue has its source in livestock.

The size of the cattle population has been the object of a number of guesses until the campaign for the eradication of Rinderpest came recently to an end. The figures arrived at by the Animal Production Department on the conclusion of the anti-Rinderpest Campaign are reasonably accurate being based on the number of cattle inoculated. The number of cattle in the country is of the order of 4,000,000 and, of this number, it is estimated that about 800,000 are, at one time or another, in the zone which is covered by the Project, of about 50,000 sq. kms.

The country is, by law, divided into two main zones by an artificial boundary. To the South of this line agriculture has priority over animal production and this settled area is given over to the production of millet, ground-nuts, cow peas and some cotton. North of this line, the land is entirely devoted to animal production.

The line of demarcation, which runs roughly from Northwest to Southwest, was established after a study of the rainfall and the duration of the rainy season, it being estimated that about 250 mms. of rain, spread over a period of 70 to 80 days, is the minimum required for any form of useful crop production.

Thus, the most interesting part of the territory at our disposal would lie immediately to the North of this boundary.

The Cattle

This is a rangy animal, long legged and well adapted to the conditions under which it has to live. It is of the type known as Bororo, after the name of the Tribe of which it forms the most important possession. It is high at the withers with a narrow chest and rump. The brisket is well developed and often hangs in folds. The hump is not too big and is carried erect.

Maturity is reached quite late and five years should be the average. This late maturity is to be expected when one examines the environment in which these animals are raised. There is a great lack of available water and, hence, animals have to travel long distances between water and grazing, the distance increasing as the pastures become scarce towards the end of the dry season which is also the hottest time of the year. Watering of animals every second day is quite normal and it is, therefore, easy to conclude that this is probably the most serious single cause of loss.

As is to be expected, mortality of the young is very high. Again, accurate figures are not available. This high rate of mortality is probably a blessing in disguise: only the fittest animals survive and more food and water are available to them.

The Grazing Lands

We are here concerned with an area with a rainfall estimated at 190 mms. per year. This figure has been reached after examination of recordings made at established weather stations some considerable distance from the centre of the area.

Rainfall, as is to be expected, is very irregular. Even in the writer's short experience, grass is growing in green patches surrounded by the wilted grass of the previous year. Showers are sporadic and, particularly in the early part of the rainy season, two or three weeks elapse between showers. Ten automatic rainfall recorders have been set up at carefully selected spots and it is hoped that more reliable figures will be available in the future.

The Nomads rush with their cattle to the more favoured areas. Their supply of grass is soon exhausted and vast tracts of land are completely denuded of all useful vegetation. This phenomenon is particularly severe around the wells and it is not unusual to see the land quite bare within a radius of up to eight kilometres from the water supply.

The Water

At the moment, [illegible] are practically the only source of supply of water in this area. Most of these wells have been sunk by the nomads. Their depth varies between 20 and 50 metres, this being generally the thickness of the sand layer (quaternary). Little work is done in the harder layers underneath the sand and thus the depth of water at the bottom of the well is seldom more than one metre.

The Nomads have no means of extracting water rapidly enough to keep up with the in-flow while work proceeds and this has to stop when the balance of in-flow and exhaust has been reached.

Owing to the nature of the soil, wells are liable to collapse at quite an early stage of utilization. Shoring of the top few metres is then resorted to at an ever increasing pace and, in many cases, well mouths have a diameter of over ten metres with a sloping wall down to the water. More sand falls in due to the impact of the water vessel on the sides of the well. The cleaning out of such wells is an operation fraught with great danger and it is not surprising that the Nomads often prefer to sink a new well rather than face these dangers.

The Rainfall

As has already been said, this should be of the order of 190 mms. per year in the area with which the Project is concerned. It is assumed that the Southernmost part of the area, adjoining the agricultural lands, receives a slightly higher rainfall.

Rain begins to fall in early June, but showers in the second half of May are not unknown. It is, however, recognized that only the rain which falls in July and August is of any use. Early or later, showers are too sporadic to be of any account. In fact, as has been witnessed by the writer, early rains are harmful in that they promote early germination of the grass seeds and the young plants, with only small development of their root system, soon wither and die.

Rainfall has a very pronounced tropical characteristic. Many storms are extremely violent and are usually preceded by winds of up to 130 kms. per hour. These storms are very localized and it is not unusual to see a tract of territory looking like a green oasis surrounded by a semi-desert.

Due to the nature of the soil, moisture is not retained near the surface and the high rate of evaporation further decreases the water available to plant life.

Marketing

Properly organized marketing of cattle is non-existent. This causes serious losses to the breeder. Among breeders, the most important numerically are the Bororos, an offshoot of the Fulani of Northern Nigeria. Their only source of income is their cattle, sheep and goats. Their day to day needs, which are very small, are usually satisfied by the sale of a sheep or a goat. They are very reluctant to part with their cattle and only resort to such a measure as a last extremity. The number of cattle a Bororo owns is, to him, the sign of his standing in the social scale and such animals are sold or slaughtered to satisfy special demands, such as a payment of taxes or for ceremonial purposes, such as a wedding.

Cattle also mean security to the Bororo. It is a reserve on which he can draw in time of need. It is, also, the object of barter, should the owner be in need of goods, the value of which would warrant parting with a beast. This is when the Nomad is the loser.

The middleman has the advantage of offering goods, the individual value of which is comparatively small. Under various pretences, their value is grossly exaggerated, particularly when offered at a place hundreds of miles from the nearest market. On the other hand, the breeder disposes of one single unit of barter of great value. He is, therefore, greatly handicapped in his dealings with the middleman and usually loses in the exchange.

These operations take place either in the grazing lands or at recognized cattle markets, depending on the season. The traditional way is for each middleman to serve a certain number of breeders. These come to him year after year. The middleman contends that his only profit is in the commission which, according to him, is about 1% of the value of the animal. But discussions between middlemen and exporter are held in the absence of the breeder and, therefore, the latter never knows what price has really been paid for his beast.

This system has certain advantages for the Nomad. It is not unusual that some of the beasts are in very poor condition, very often so weak as to be unable to face the hardship of a long journey to market. The middleman will purchase these animals at a ridiculously low price but even that is better than a dead cow.

It is obvious that all these proceedings are not to the advantage of the Nomad. There are far too many middlemen, sometimes as many as four.

The State itself is also a loser. The cattle exporter arrives from Nigeria with merchandise which, in many cases, has been smuggled across the Border. Some of these goods are sold, others exchanged for cattle. The animals thus purchased are smuggled across the Border in the reverse direction. The money obtained in Nigeria is again converted into merchandise and the whole operation starts again. There is, therefore, a considerable loss in customs dues and no hard currency, of which the country is badly in need, is made available.

In fact, only the buyer shows any profit in this sequence of operations.

Conclusions

The Devebpment of Animal Production in the East of Niger will depend on the following factors:

1. The training of Animal Husbandry Officers with particular stress on Pasture Management in semi-arid areas. These officers should be empowered to enforce any regulations concerning the utilization of water and grass. They should be mobile and prepared to stay out for long periods, particularly during the dry season.

2. Water should be provided and the distance between wells and/or boreholes should be such that animals are not required to travel long distances, and that they could be taken to water at least once a day.

3. The grazing is to be done under control. Families of nomads should be grouped and their cattle is to be grazed in a fairly well defined area so long as water and grass are available. This will necessitate the introduction of a discipline to which the Nomads are not accustomed and against which they may rebel, but education will prove to them that, in the long run, they will benefit by it.

4. Stock drives must be provided across the agricultural zone, with water points at regular intervals and a distance not exceeding a day's march. These routes would allow the Nomads to reach their export markets even during the rainy season.

5. The utilization of stock-pounds should be controlled and their approaches so arranged that animals cannot foul and contaminate the water and thus spread internal parasitism.

6. A thorough study should be made of the incidence of internal parasitism and measures introduced to reduce it to a minimum and keep it under control.

7. There is an urgent need for a complete organization of the marketing of livestock. A central Authority, properly administered, is probably the best means to this end.

8. Lastly, grass fires must be brought under control and heavy punishment imposed upon all offenders.

LA: SF/SD/66/PM/4

DESCRIPTION AND LOCALISATION OF THE INTEGRATED DEVELOPMENT PROJECT IN THE DALLOL-MAOURI VALLEY (Republic of Niger)

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The main purpose of the project is to determine the economic justifications and the technical possibilities for carrying out an integrated development project, to determine the favorable areas and to localise with precision the pilot demonstration sites for future development.

This project will be divided into 2 successive phases:

a) The first phase, to last over a period of 2 years, will be devoted to general studies (pedology, geomorphology, hydrogeology, agronomy, agrostology, socio-economics, socio-agronomy). These studies should demarcate the limits and the locality of pilot sites.

b) The second phase, lasting 4 years, will be dedicated to exploitation and agricultural and pastoral extension, strictly speaking. A synthesis will then be made of the general studies and results from pilot areas.

The Dallol-Maouri watershed extends over 65,000 sq. km and stretches over about 650 km before running into the Niger River valley south of the city of Gaya. The project as such only concerns the Dallol-Maouri side located between the 14th parallel and the Niger River, that is, an area of 8,000 sq. km including the middle and lower part of the basin.

It is bound:

- to the North by the 14th parallel.
- to the East, from North to South: by the eastern boundary of the Department of Dosso and the Nigeria frontier.
- to the South by the Niger River between Gaya and Nigeria frontier.
- to the West, from North to South: approximately, the line where the waters of the Dallol Fegha separate from the Dallol-Maouri.

The population of this region amounts to about 200,000 inhabitants, that is, about 25 sq.km - which represents one of the areas of highest density of the Republic of Niger and almost 1/15 (one-fifteenth) of the total population (3,127,000 population 1963 estimate). The inhabitants belong to different ethnic groups: Djermas, Maouri (houssaphone), Dadis, Peuhls, ect.

The climate is typically Sahelian, the average yearly rainfall varying between 550mm in the North and 850mm in the South. The rainy season varying from 3 months in the North to 5 months in the South, with great differences from one year to the next.

The relief is on 3 levels:

- a plateau which slopes in 2 directions: North/South following the course of the Dallol (290 m at Dogondoutchi, 220 m at Gaya); and East/West: 290 m Dogondoutchi - 270 m Dosso.

The edges of this plateau are widely indented by the small "koris" affluents of the Dallol, which have sometimes dug small creeks.

- an intermediary level, a sort of shelf with the appearance of a terrace which joins the plateau with the bottom of the valley, and which is hollowed out with affluent valleys.

- The bottom of the Dallol-Maouri is the third level of this whole area. It is a vast plain, slightly undulated (small piste of 1-2 meters wide) hollowed out by small basins where water accumulates and stagnates.

There is no run-off to speak of into the plain, except locally over short distances, and starting from the Fogha and Maouri confluent to the Niger River. The affluents are often exposed to temporary swellings, due to rains or local storms.

Water stagnates in a good number of temporary or permanent pools, fed by flow or resurgence of water tables.

The level and regime of groundwater basins are influenced by the rainfall regime which could follow an interannual cyclical regime.

The preliminary surveys of the land have brought out all the factors favorable to integrated development (surface water, artesian possibilities, soil quality, existence of permanent or semi-irrigated cultivation on the edge of pools, breeders and agriculturists association, ingenuity of the inhabitants, density of population).

The Dallol-Maouri has no mean water channel, nor permanent or temporary run-off over its entire course. There may be temporary localised flows between two sand-filled zones which feed the pools which form in the basins.

Hydroagricultural management systems are unknown and yet, dam sites, flood water derivation works, areas favorable to irrigated perimeters are numerous.

It is certain that the necessary investments for the development of this region would exceed by far the possibilities of the Niger - at short and medium terms.

Nevertheless, following the example of other regions of this country a number of simple management systems could be realized with human investments by a more efficiently employed rural labor force.

The studies, experiments, and trials effected in the past have shown that it was possible to increase vegetable and animal production by proceeding with local management systems based on the introduction of selected seed, controlled farming, new cultures, irrigation, drainage, parasite control, proper management of pastureland, etc.

Farming is of two kinds:

- Rainy season farming (river and industrial) stretching from 3 to 6 months.
- Farming on pool edges or semi-irrigated farming, practically permanent. Annex 1.

As one can see from Annex 1, yields are very low despite the fertility of certain soils, and the water resources (still poorly known) are very little used for agriculture. There is too small a scale of farming and varieties. The use of fertilizers and manure is rare, and what is more serious, parasites abound.

Traditional cattle-raising is current, it is extensive and follows the traditional methods found everywhere in the Sahel zone.

Semi-nomadic herds of cattle, sheep and goats live on this side of the Dallol-Maouri basin. For the Dallol-Maouri and Fogha one can estimate as follows:

Cattle	200,000
Sheep	100,000
Coats	200,000

Seasonal transhumence is a rule. The sedentary populations are also cattle owners but the nomad population guard the latter.

While representing undeniable wealth this cattle is not the object of particular care as far as food is concerned. In addition, there is no "retirement" of old females, sterile animals, or bas sires.

One must note that these animals live and reproduce themselves very poorly, sometimes not at all. They eat, drink and occupy the grazing areas to the detriment of the healthy animals.

Thus we may conclude that although the project is located at the far edge of the Sahel zone, the agricultural activities have all the characteristics of the Sahelian agriculture (rainfall, seasons, choice of cultures, farming and breeding methods, etc.)

ANNEX I

PRODUCTS	AREA (ha)	PRODUCTION (tons)	YIELD (kg/ha)	VALUE (millions Fr.)
Millet	1) 200,000	140,000	700	2,100,000
Sorghum	48,500	40,250	830	603,750
Niebe	1) (61,000)	7,650	125	76,500
Voandzou	18,300	14,775	800	295,500
Groundnuts	1) (30,000)	14,450	480	216,750
Rice	200	244	1,220	3,460
Manioc	2,300	19,740	8,500	493,500
Cotton	850	210	246	6,720
Maize	220	165	750	4,950
Sweet potato	20	300	15,000	6,000
Onions	26	580	22,400	14,500
Market-garden products	15	300	20,000	30,000
Tobacco	0.5	0.3	600	60
Sugar cane	40	615	15,575	6,150
TOTAL	270,000	239,270.3		3 857 840

1/ In conjunction with the millet

LA:SF/SD/66/PM/5

THE SAVANNA FORESTRY RESEARCH STATION: ITS ROLE IN DEVELOPMENT OF THE SAVANNA IN NIGERIA

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A forester coming newly to the savanna regions of Africa soon becomes aware of a number of characteristics of the Savanna with significance for forestry and agriculture. First, is the tremendous area of Savanna - some 5 million square miles or over 3 billion acres - about half the area of this large continent. Second, is the low present productivity of the savanna land. Third, the poor methods of soil and vegetation management now generally in use. Fourth, the relatively great potential for increased production of forest and food crops. And fifth is the rapid rate of human population growth and the prospect that the population will continue to multiply rapidly for some time.

If one assumes that both population and the level of per capita consumption are on the increase in the savanna areas, then the need for increased production of forest and farm crops is evident. The magnitude of the required increase will be seen from estimates of population growth and rises in living standards.

Because any rapid increase in the standard of living in underdeveloped areas generally calls for importation from abroad of capital goods and technical "know how", it will be desirable to produce as much as possible within the country and to increase exports of the region's natural products. Following such a policy in the Savanna will mean large increases in production of everything which comes from the land.

The establishment of the Savanna Forestry Research Station in Nigeria was predicated on the correctness of the above assumption. It is the purpose and function of this station to supply the technical and scientific bases for the establishment of forest plantations which will meet the needs for wood in the savanna regions 30 years from now, and to train Nigerian counterpart personnel in various fields of forestry research.

The Savanna of Nigeria covers over 190 million acres - some 85 per cent of the land area of the country. This region supports 35 million people or about 65 per cent of the total population.

Mr. S. Thulin, FAO Forest Economist assigned to the Savanna Forestry Research Station Project, recently (1966) estimated the annual consumption of forest products in the Nigerian Savanna as follows:

Firewood	785 million cu. feet
Poles for houses	22 million cu. feet
Other round wood in houses	21 million cu. feet
Sawlogs	11 million cu. feet
Pulpwood	1.3 million cu. feet
Transmission poles	0.04 million cu. feet
Total	840 million cu. feet

Mr. Thulin also estimated the consumption of forest products in the Savanna in 1980 and 2000, based on two different sets of assumptions. In Alternative A, population was assumed to increase at the rate of two per cent per year and the rate of per capita income growth was also assumed to be two per cent. In Alternative B, both rates were assumed to be 2.5 per cent. Future wood requirements on these assumptions are as follows:

Estimated Consumption - Million Cubic Feet

	1980		2000	
Product	Alt. A	Alt. B	Alt. A	Alt. B
Firewood	820	950	865	1,230
Poles for houses	26	30	31	44
Other round wood in houses	21	27	21	35
Sawlogs	20	22	44	61
Paper	8	11	45	97
Transmission poles	0.2	0.3	1.2	1.8
Totals:	895	1,040	1,007	1,469

The acreages of plantations needed to produce the wood requirements shown above were estimated and are shown below. It was assumed that firewood yields would be 150 cubic feet/acre/year, sawlogs 100 cubic feet, pulpwood 200 cubic feet, and that the requirement for both small and large poles would be met from the thinnings from plantations established for sawlogs.

Thousands of Acres

	1980		2000	
Product	Alt. A	Alt. B	Alt. A	Alt. B
Firewood	5,466	6,333	5,766	8,020
Sawlogs	200	220	440	610
Pulpwood	40	55	225	500
Totals	5,706	6,608	6,431	9,130
Total Sawlogs and Pulpwood	240	275	665	1,110

It is generally assumed that fuelwood and poles for house construction will continue to come from the natural savanna woodland and from farm trees. It is also assumed that an increase in production from the southern rain forest area will be needed to meet the economic growth expected in that densely populated region. Also, sawlog production from natural savanna woodland is about 4 million cubic feet annually - equivalent to 40,000 acres of plantation production. Thus, the need for new forest plantations to meet the estimated future wood requirements of the savanna region of Nigeria amounts to 200 to 235 thousand acres in 1980 and 625 to 1,070 thousand acres in the year 2000.

The species native to the savanna woodland are generally of low value and slow growth and it is not believed that production from natural woodland can be greatly increased. Thus, the task ahead for Nigerian foresters in the Savanna is the establishment of plantations of exotic species which are adapted to the available sites and will produce high yields of wood and other forest products suitable for a variety of uses. Trials of exotic species have not been extensive enough or of long enough duration to yield results on which to base a large program of plantation establishment. It is a principal task of the Savanna Forestry Research Station to expand greatly the species elimination and species growth trials which will be the basis for larger scale afforestation.

The staff of the Savanna station consists, or will consist, of a number of FAO and government counterpart specialists carrying on research which will help answer the questions of what species and races of trees to plant, what kinds of sites to plant them on, how best to prepare the available areas for planting, what planting methods to use, how to control economically unwanted competing vegetation, how to control injurious tree diseases and insects, what rates of growth and yield to expect and how to develop, manage and protect plantation forests.

The central core of the Station's program is silviculture with emphasis on choice of species, site requirements, establishment of plantations, and yields. The best locations for plantations may often represent a compromise of biological and economic factors. The forest economist will indicate the areas best suited from the economic viewpoint. The silviculturists will indicate those areas best suited to give high yields at low costs. They will be assisted by the soil surveyors who will locate the areas of best soils for each species.

Before the very best sites can be located it will be necessary to determine the characteristics of these sites through studies of the site and growth requirements of each important species. This will be the work of the silviculturists, the tree physiologist, the soil physicist, the soil chemist, and experts in pathology and entomology. Such studies will require considerable time but in the meantime best judgment will be made based on existing general and specialised knowledge of tree-site relationships.

It is anticipated that the principal physical site factors limiting the growth of tree species in the Savanna will be the availability of water and nutrients. The long season with no precipitation and low humidity creates high moisture tensions and internal water deficits affecting growth. There is evidence of serious nutrient deficiencies, especially in some of the residual soils. Shifting cultivation, annual fires and sheet erosion undoubtedly have contributed greatly to these deficiencies although the long periods favourable to rapid decomposition of organic matter and weathering of minerals, plus heavy wet season precipitation also make an important contribution. The problems relating to availability of soil moisture including infiltration, percolation, retention storage, and evapotranspiration losses will be the particular province of the soil physicist. The soil chemist will be concerned with the nutrient status of soils and the mobilisation of nutrients. He will work closely with the physiologist and silviculturist on problems of tree nutrition and on soil fertility factors affecting site quality, tree establishment and growth. The tree physiologist will be involved in studies of diameter and height growth in relation to season of year, tissue moisture deficits and (in co-operation with the soil physicist) the availability of soil and atmospheric moisture; the effect of nutrient deficiencies and the relation of intensity and duration of light to growth will also be studied. A forest pathologist will evaluate species in relation to pathological factors and will investigate the occurence and control of forest tree diseases.

The economical establishment of large scale plantations requires effective, low-cost methods of clearing existing Savanna, planting trees, and controlling competing vegetation until the tree canopy closes. This will be the work of the silviculturists, a mechanical tree planting expert and a forest herbicide specialist.

Species growth trials are planned for the major soil types in each of six different climatic zones of the Savanna. For reasons of economy, and to accumulate data completely describing each site, experimental plots will be concentrated as much as possible at one locality in each zone. The major meteorological factors affecting plants will be measured at the principal locality chosen and the physical and chemical properties of the major soils determined. Growth and yield measurements will be made for each principal species and yield tables prepared. Species growth trial studies will be supplemented when necessary by field, nursery and laboratory investigations.

To sum up, the Savanna Forestry Research Station is a regional (no political significance) forestry research station of the National (Federal) Department of Forest Research. The Station will draw heavily on the talent, experience and past work of foresters working in tropical savanna areas and on the Institute for Agricultural Research which is also located at Samaru and which has been concerned for many years with agricultural problems of the Savanna. In turn it is hoped and expected that the Station can contribute substantially to the fund of basic knowledge required to solve the problems of the Savanna. Of particular and immediate importance are the plans of government foresters to meet future wood requirements. But it is also expected that the Station's work will be useful in the general classification and best use of the land, on problems relating to future water supplies, and in some other programs designed to raise the standard of living of the Savanna peoples.

Samaru
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LA:SF/SD/66/PM/6

SOIL AND WATER RESOURCES SURVEY OF THE SOKOTO VALLEY

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1. INTRODUCTION

The Sokoto Valley Project is situated in what is generally described as the Sudan Zone Savanna. This project, which is primarily a resource survey, came into operation in March, 1962 as a result of a request from the Government of Nigeria for assistance from the United Nations Special Fund to develop this particular Savanna area. The United Nations Special Fund appointed the Food and Agriculture Organization as Executing Agency to carry out this resource survey.

The broad purpose of the project is to provide the Government with reliable soils, hydrological, topographical and agronomical data needed for planning water control measures, such as storage, detention of floods in reservoirs and in watershed, drainage of water-logged areas and supply irrigation water. These data will help to achieve the improvement of the river regime of the Sokoto and Rima rivers and its tributaries which is essential for the increase and diversification of agricultural production in this densely populated area. Although agronomic measures, together with social and economic betterment, are needed for such an improvement, the most important pre-requisite of any improvement is water control both in the flood plains and in the watershed.

2. GEOGRAPHICAL POSITION

The Sokoto Valley Project includes the catchment area of the Sokoto and Rima Rivers, covering almost all of Sokoto Province and a small area of Katsina Province, giving a total land area of 35,000 sq.mls. The catchment area may be roughly divided into two major zones, the first southeast of an almost straight line, from Fakku 11°N, 40°30' E, to Moriki 12°53'N, 6°28'E, where lies the upper catchment in the geographical division of Nigeria known as the High Plains of Hausa-land. The lower catchment area lies to the Northwest of the above and is geographically classified as the Sokoto Plains.

3. VEGETATION

Most of the catchment area is situated in what is generally described as Sudan Zone Savannas. The typical Sudan vegetation is more open and favourable to man than the savannas to the south, known as Guinea Zone. This openess is certainly in part man-induced, especially by his burning which annually sweeps this zone injuring the trees. / Although the typical fire-resistant species possess remarkable powers of recuperation, fresh sucker growth is annually burnt back and the trees grow gnarled and crooked and are useless for timber. The predominant trees are fine-leaved thorny trees, usually acacias about 30-40 ft. high. There is a more or less continuous grass cover, the grasses being short and feathery and contrasting with the tall, coarse, tussocky grasses typical of the Guinea zone. Many valleys carry a continuous belt of fringing forest. This consists of a dense tangle of dry-zone species with isolated larger trees and patches of tall grass, and is very different from the dense gallery forest of the Guinea zone. As elsewhere in the territory, the vegetation has been extensively modified by man, the modification being most striking in the closely farmed areas around the larger towns. Here the original plant cover has been more or less completely obliterated and replaced by continuous stretches of arable land dotted with farm trees.

A number of trees grown without reducing crop yield are Parkia clappertoniana, Adonsonia digitata, Butyrospermum parkii, Leucinia gauce and Tamarindus indica. Acacia albide, which is leafless during the rainy season, has been found even to increase yield. Most of these trees are leguminous and their leaves are used as green manure increasing the fertility of the soil. / The nitrifying bacteria living on the roots of the trees add valuable nitrogen to the soil. The leaves and fruits of most of them are eaten by the local people in the dry season when other food is scarce.

The extreme northern part of the catchment area is located in the Sahel Zone. The vegetation of this zone consists mainly of open thorn savannah with a sparse short grass cover. Acacia trees can be found in the low lying sites.

4. CLIMATE

Temperatures over the area range between a maximum of 43°C and a minimum of 8°c and a rainfall at an estimated average for the whole Project Area of 35" to 40" annually. From Sokoto to the Niger Republic border the average would range between 25" to 30".

5. POPULATION

The area of Sokoto Province is, according to the latest census, 36,477 sq. miles with a total population of 4,334,769, giving a population density of 118 per square mile. The actual distribution of the population is governed by water availability, in which respect the Sokoto and Rima Valley are in the position to support large numbers of people.

6. TOPOGRAPHY AND AERIAL PHOTOGRAPHS

Since there were no reliable maps available in the area, aerial photography and primary levelling were completed before beginning the project under contract. Two scales of photographs were produced. The Fadama area, otherwise known as the flood plain, was on a scale of 1:10,000 while the entire area was on a scale of 1:40,000. These photographs, and the uncontrolled mosaics, formed the base maps for soil survey, detailed topographic survey for dams an reservoir surveys.

7. HYDROLOGY

One of the main aspects of the project was the collection of hydrological and meteorological data. The data so far collected were computed and annual year books published. From April, 1962 to March, 1966 about 2,800 discharge measurements were taken and 12,000 sediment and water samples obtained and analysed. In all, 450,000 observation data were collected in the field and these, with other available data, give a fairly good picture of the hydrological as well as the meteorological data of the project area.

The main part of the project area where development seems most promising is the catchment of the Sokoto, the Gagare and the Bunsuru. The total runoff of the Rima upstream from the confluence of the Zamfara is estimated at 1,800,000 to 1,900,000 acre feet per year as the average of a long series of years. 80% of the runoff originates from the upper catchment of the above three tributaries where suitable reservoirs were selected. With a total storage volume of 1,800,000 acre feet it is possible to control 80% of the runoff from the upper catchment from which a safe yield of 1,250,000 acre feet can be assured.

From the soil survey, there are 250,000 acres of good irrigable land in the project land while the conserved water is only sufficient to irrigate 100,000 to 150,000 acres for two season crops. This is mainly due to the need to release water under control for the farmers who depend on the flood waters to cultivate their fadama land down stream.

8. RESERVOIRS

With the hydrological data available and the detailed topographical surveys carried out, the following reservoirs have been selected for the control of the flood waters as well as conserve water for irrigation. The actual construction, of course, will depend on the availability of funds and the rate of development envisaged by the Government.

Name of Place		Storage in acre/ft.	Approximate cost for Dam only
(a)	Bakolori	315,000	N.£2,820,000
(b)	Kauramamoda or	201,000	N.£2,650,000
	Yautabaki	273,000	N.£2,810,000
(c)	Kaya	150,000	N.£1,800,000
(d)	Zobe	200,000	N.£2,000,000
(e)	Gusau	100,000	N.£3,420,000
(f)	Zurmi	55,000	N.£1,928,000
(g)	Kachera I	423,000	N.£5,629,000
	Kachera II	235,000	
(h)	Bukkuyum	207,000	N.£3,000,000

9. SOILS

The catchment area has many different kinds of soils. Some are good, others of poor quality. Nearly all present some problems in connection with their best use and management. All do not require the same kind or amount of soil and water conservation measures. Some need such special measures as drainage or flood control before they are suitable for cultivated crops. Others require irrigation to secure the maximum production, whilst some should not be brought into cultivation because of their high erosion potential or very productive capacity.

Generally speaking, the soils in Sokoto Province are well drained, acid in reaction and vary from sands through sandy loams to loams. They appear to contain sufficient nitrogen for most crop needs as responses to moderate dressings of nitrogenous fertilisers are, on the whole, almost negligible. They do, however, respond very greatly to phosphate and to farmland manure. There does not appear to be any deficiency in potash. They are very low in organic matter.

Some of the soils show a tendency to compact in the surface and many set hard in the dry season and are difficult to work. In those areas where continuous cultivation has been practised for many years, fertility has been seriously affected and a number of problems regarding the most satisfactory way of restoring them have arisen.

Under a rainfall of about 20" and supporting a vegetation of thorn savanna, the soils of the Northern part of Sokoto Province are composed of pale-coloured sands believed to be drift sands of aeolian origin and re-sorted old alluvium. The soils in the extreme North, which are pale coloured and show no profile development, have been classified as Regesols. Those soils further south that show some top-soil development and textured gradation have been classified as Thom Thicket Ochrosols with a topsoil pH of 5.5 - 6.0 and a lower horizon pH of 5.0 - 5.5.

In the north-western part of Northern Nigeria, which include Sokoto Province, the drift sands overlie sediments of the Gwandu group. When the more argillaceous beds approach the surface, there is a tendency to form neutral Gleisols. However, it has to be established whether or not there is any accumulation of sodium salts in these soils of the very far North.

This soil group occurs along the north boundary of Nigeria. The largest area occurs on the drainage basin of the Sokoto and Rima Rivers. A high percentage of the soil is in cultivation because of the high population density in the Sokoto and Katsina Provinces. The soils of the area are highly susceptible to erosion by wind and water.

The drift deposits derived from the desert sands of the last arid period furnish the most important groundnut soils of West Africa. Depth of drift is variable and independent of latitude, but texture becomes finer towards the southern margin. The southward increase in fineness led to distinction of two major soil groups, the Zaria and the Northern Drift soils, although further sub-division can be recognized.

The Zaria type represents the southern part of the drifted area, where the covering material, although up to 14 ft. in depth, is very fine in texture. In consequence, the soils are heavy and relatively difficult to work, tending to become waterlogged with heavy rain and to dry out and crack during the dry season. Farther north the drift is coarser, resulting in light sandy soils of low to medium fertility and easily worked. They are well suited to crops such as millet and groundnuts, which are less exacting in their requirements than cotton, a characteristic crop in the Zaria type of soil.

According to the Senior Soil Surveyor of the Project, there are three main divisions of soils and lands characterized by complex soil conditions:

A. Soils on young parent material such as recent sediments, or soils on parent material very resistent to weathering and leaching.

B. Soils on relatively young parent material, soils on river terraces, and in areas where soils are regularly rejuvenated by sheet erosion on relatively rich parent material.

C. Soils on parent material having been subjected to deep weathering, etc.., either at their present location or in situations before they were transported and the transport exercized no rejuvenating influence.

The divisions, A, B, and C, roughly coincide with differences in natural chemical fertility. As a rough estimate, A has a relatively high fertility and totals 3.5% of the catchment area, B has moderate chemical fertility and totals 52% and C has a low chemical fertility and totals 42% of the catchment area.

Problems of soil and land use are related to soil and landscape forming factors, such as parent materials (geology), climate, hydrological conditions and man, fauna and vegetation.

The dominating factors in the project area are the extreme climatic conditions which govern, to a high extent, the geomorphology, hydrology, vegetation and fauna, as well as human behaviour.

Some aspects of the influence exercised by the semi-arid climate on soil and land use in surveyed territory are:

(i) Sheet erosion - the strong natural superficial sheet and sheet-flood erosion (intensified by overgrazing and burning) originates on rather shallow relatively young soils. This is especially apparent in the higher (south-east) parts of the area. The shallowness is a disadvantage; the relatively rejuvenated character of the soil is an advantage (chemical fertility). However, previous to the present climate, more humid climatic conditions weathered and leached very strongly part of the parent material. Where these materials (mainly tertiary and cretaceous sand, grits and clays still existing in the far Northern part) were not totally removed by erosion, the present soils are very poor. More arid periods also preceded the present climate. During those times, aeolic and fluviatile sandy drift material covered the area for a great part. Strong superficial erosion has levelled the original dune pattern of the aeolic sands.

(ii) Loss of organic matter: The intensity of the dry season causes a quasi-total loss of organic matter, even in the most waterlogged areas. Only the most recent sediments have a reasonable organic matter content. The lack of organic matter is the cause of a very low storage capacity for plant nutrients (P and N especially). Also the water-bearing capacity of the sandy soils is unfavourably influenced.

(iii) Salination: During the long dry season there is often an upward movement of groundwater, especially in the very fine sandy soils in the lower part of the area. Occasionally in the flood plains this has originated already natural alkaline soils (solidized solonetz). Real salinity is not found under natural conditions. After irrigation, however, the artificial rise of groundwater aggravates the danger of salinity. Experience has shown that already after one year of irrigation originally non-saline soils turned into saline soils. Some of the soils with the highest potential show the highest liability to salinity.

10. LAND USE

Agriculture, together with livestock, provides the main source of income in the Province which is predominatingly agricultural. The following table shows the estimated land use pattern for the years 1957-1959 and are the latest available official figures:

Sokoto Province	Total Land	Land Under Crops	Forest		Settlement Areas	Other Land
			Reserved	Unreserved		
	23,340	1,820	4,920	2,880	140	13,580
		(in thousand acres)				
	100%	8%	21%	12%	1%	58%

A great deal of the land, other than that listed under crops, is utilized by the Fulani cattle herds. From the above figures alone it is obvious that land availability is not the limiting factor to increased crop production. In this connection it is possible that, for the next ten years, Government production requirements can be met by increasing yields rather than by increased acreage, and this can probably be achieved by the issue of new and improved seed, more up-to-date farming techniques and a considerable increase in fertilizer use.

Adjacent to, and within the boundaries of the main towns, factories and industries are springing up such as cement, textiles, curing of hides and skins and others on a smaller scale. In the event of large-scale land development, factories and processing plants, complementary to agriculture, will be a necessity.

The forest land provides not only livestock grazing, but firewood for the towns. The recorded output of timber and fuel issued on permit in Sokoto Province in 1962 was 290,000 cu.ft., valued at £290,500, 188,332 cu. ft. consisted of firewood valued at approximately £183,332.

Land use in the Province is largely controlled by climate and rainfall. In the south and south-east, with its higher rainfall, a high rate of farming is obtained, while, to the north, with its lower rainfall, livestock becomes the predominant factor.

11. Livestock contributes a very valuable quota to the economy of the North as the following figures for the 1962 census clearly show:

	Northern Nigeria		Sokoto Province
Cattle	4,256,114		641,585
Sheep	3,481,591		208,029
Goats	6,359,314		1,090,231
Swine	90,978		-
Horses	278,513		41,211
Donkeys	765,657		189,343
Camels	3,632		2,645
Poultry	17,900,000	(1957)	1,700,000
Total all livestock	33,135,799		3,873,044

The large number of livestock involved imposes many problems as regards grazing, and presents a serious challenge to the Government. Available land for controlled stocking is not the main difficulty, which really lies in persuading the Fulani cattle owners to adopt a more sedentary planned existence, and in the provision of water where no facilities at present exist.

A large export in hides and skins brings a great deal of revenue to the Region. Of particular importance are the skins of the famous indigenous goat, the Sokoto Red. The Total export value of hides and skins (sheep and goats) for the year 1962 was £ 3,304,000. These figures refer to the Northern Region as a whole, giving the following breakdown: Cattle hides £1,403,000, sheep skins £335,000 and goat skins £1,566,000, much of this revenue reverted to the Sokoto Province.

The Government is fully aware of the problems it faces in effecting a general improvement in livestock, and has undertaken - and is still undertaking - vigorous clearing of the TseTse fly areas, breeding and cattle improvement and better marketing facilities.

12. PRESENT ECONOMIC CONDITIONS

Sokoto Province is not a rich Province, but it does possess great potential, more especially in the fields of agriculture and livestock. Until recent times the peasant farmer existed at subsistence level, and this is true of many at the present time. But, in general, a distinct continuing improvement in the agriculture is discernable with a consequently higher standard of living. This improvement is directly due to the Government policy of free seed issue of improved varieties, the supply of subsidized fertilizer, and the encouragement given to the farmer to purchase oxen, ploughs, etc. If this rate of progress can be maintained, and indeed it must be maintained, the next ten years will show a great improvement in yields, and with better marketing, an increase in prices for produce.

13. TRAINING

In the original Plan of Operation of the project certain funds were set aside to provide fellowships for Nigerians, but, with the agreement of the Government, this was later converted into a fund designed to operate a School of Irrigation with staff largely provided by the Organization.

This school has been for some time established in Sokoto and is designed to train suitable Nigerians in the field of elementary hydrology, building, survey irrigation design and other allied subjects. Some difficulty has been experienced in recruiting students with the required educational background and the original syllabus has been revised to cover a lower standard of training.

14. EXTENSION OF THE PROJECT

As the reserve neared completion, the Nigerian Government requested the Special Fund to extend the Project by 18 months so that a feasibility study could be undertaken by the Team for the proposed dam at Bakolori with a view to obtaining foreign finance for its construction. The Special Fund agreed to extend the project from April 1, 1966 to September 30, 1967 to meet the Government's aspirations. The extension was to carry out the feasibility study as well as to continue the training of technicians at the Irrigation School at Sokoto and at the School of Agriculture in Samaru.

Since there was no reliable information available as to crop responses to irrigation, an Agronomist was assigned to the Project to carry out trials.

The results of these irrigated trials will indicate what level of production may be expected under intensive agriculture and the application of water. It will also give and idea as to what crops can be grown in the dry as well as in the wet seasons.

The trials also have proved useful to demonstrate to the local farmers what irrigated farming is. This is quite evident by the interest shown by the farmers in the trial area.

LA:SF/SD/66/PM/7

HYDRO-AGRICULTURAL SURVEY OF THE SENEGAL RIVER BASIN

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I. BACKGROUND

The Governments of the Republic of Guinea, the Republic of Mali, the Islamic Republic of Mauritania and the Republic of Senegal have agreed to co-operate closely with a view to the integral utilization of the resources of the Senegal River Basin. To that end, they have appointed a Comité inter-états pour l'aménagement du bassin du fleuve Sénégal - C.I.E. (Inter-governmental committee for the development of the Senegal River Basin). The purpose of the latter is to promote and co-ordinate the studies and works projects necessary to the end in view.

The CIE has secured UNDP aid for six projects listed below (in chronological order) :

1) Pre-investment survey for a project to regulate streamflow of the Senegal River (Gouina dam) ;

2) Hydro-agricultural survey of Senegal River Basin (1st phase - General Studies) ;

3) Hydro-agricultural development of the Senegal River Valley (2nd phase - Pilot irrigation districts and stockraising areas) ;

4) Study on water use in the Upper Basin of the Senegal River ;

5) Study of transport on the Senegal River ;

6) Hydro-agricultural development of Fouta-Djallon.

Projects 1, 2 and 4 are currently being financed to an amount exceeding, in the aggregate, US $ 8,000,000 including Government counterpart contributions (about 20 %).

The general pattern of the proposed development of the Senegal River Basin is as follows :

1) Upper Basin. A series of reservoir-dams for hydro-electric power production and stream stabilization will be built, the largest being that at Guoina at a site some 200 km upstream of where the Upper Basin terminates, giving way to

2) The Main Valley. Here a series of structures will be provided to control the water level for both agricultural and navigation purposes and with a view to a gradual expansion of irrigation farming. The present report is about this second area.

II. THE PROJECT AREA DESCRIBED. PRESENT SITUATION OF AGRICULTURE (INCLUDING ANIMAL PRODUCTION).

The project area comprises the Senegal River valley downstream of the Gouina falls, to a total length approaching 1,000 km, consisting of 800 km of floodplain and 800 km not so subject, plus the so-called delta. The area thus lies on the western end of the savanna belt, on the southern edge of the Sahara.

The width of the floodplain varies between 10 and 20 km, resulting in an area of approximately 9,000 km^2 for a total length of 650 km. The valley gives way to a delta approximately 5,000 km^2 in size, all in all some 14,000 km^2, including the uplands bordering the valley.

Climate : Sudano-sahel type, characterized by a very pronounced dry season from October to May, and a rainy season lasting from June to September.

Rainfall : increases from West to East, 370 mm yearly being recorded at Saint-Louis, 522 mm at Matam and 749 mm at Kayes.

Temperature : the daily mean ranges between a maximum in April-May (Matam : 34°C) and a minimum in December-January (Matam : 24°C).

Relative Humidity : Minimum in March-April (Matam : daily mean 32 %) ; maximum during the rainy season (Matam : daily mean, August : 75 %).

Floodwaters : The floodwaters of the Senegal are governed by rainfall in the Upper Basin. Depending on the year and the point of the valley under consideration, the highwater season occurs in June-July and again in October-November.

Soils : The soils of the valley are alluvial and of recent deposition, their texture depending on the frequency and duration of the time they have been under water. By reason of the shifting of the normal bed of the river, a process that is going on even to-day, the amount of arable land varies, but for the most part, their agricultural potential is high.

In the so-called delta, soils again are of the hydromorphic type, their degree of saltiness being governed by the proximity of saline groundwater.

As things stand, farming depends on rainfall and the flooding of the river, while irrigation farming is virtually unknown (less than 10,000 ha, entirely given over to rice growing).

Rainfed farming is carried on in the uplands overlooking the valley, and yields, particularly as concerns their pattern of distribution, are a function of the water supply from this source. Crops, which are very much a matter of chance in the West, can show yields of 500 - 800 kg/ha in the East. Millet is the staple crop.

Floodplain farming. Land in the valley is cropped when the floodwaters recede. The area involved is in direct ratio to the extent of flooding and the date the waters subside. To these uncertainties must be added those represented by the hot and dry east winds, blowing from January to March. Yields vary greatly. Sorghum is the staple crop.

Cattle farming. Cattle are raised on nomadic or semi-nomadic lines. Herds leave the valley during and after the rainy season, to return thither at the end of the dry season. Transhumance of the kind creates problems for the crop farmers of the valley - and this will be true even when irrigation farming is introduced.

Forest cover. There is still considerable forest cover on the floodplain, the main species encountered being the gonake tree (Acacia scorpioïdes), which is quite tolerant of periodic submersion.

Fisheries. Fish is a main protein food in the Senegal valley and is caught chiefly when the floodwaters recede.

III. PURPOSE

The project calls for surveys with a view to the progressive development of the valley and so-called delta of the Senegal River Basin through irrigation. Any such management scheme, however, is a long-term undertaking, whose effects will be felt only with the passage of time, and the changeover from present practices to those demanded by irrigation farming, once this is introduced, can only be brought about gradually. Two stages, therefore, are envisaged :

1) annual flood control by means of a reservoir dam at Gouina in order to improve conditions for floodplain farming (and also to regulate to some extent the regimen of the Falémé river) ;

2) a gradual changeover to irrigation farming as the irrigation and drainage projects in the valley reaches are completed.

The general studies making up the first stage will be supplemented in a second phase by the creation of pilot irrigation districts and stockraising areas as a feasibility study, on a life-size model, under the actual conditions in which the proposed management schemes will be brought into being (and this from the economic and social, as well as the technical, standpoints).

IV. DESCRIPTION OF THE PROJECT

The first step will be to collate available information - of which there is a considerable quantity relating to the area under discussion, having accumulated in studies of this kind over several decades. Then will come operations to complete the map coverage on a scale of 1 : 150,000 of the valley and delta regions of the Senegal river.

With the hydrological, climatic and topographic data already available, it will be possible to proceed with studies on a mathematical model of the river downstream of the Gouina falls. The chief purpose here is to simulate the natural regimen of that river and to study the hydrological effects of building a dam at Gouina in respect of a number of operational assumptions in its regard.

A soil survey of the entire valley will follow, leading to the compilation of a 1 : 50,000 scale land-use map in both the valley and delta areas.

The findings of all the studies here described should provide the basis for a general development scheme for the region and justify commencement of the hydraulic engineering studies.

A hydro-geological survey of the Senegal delta area will provide information on drainage and control of salt encroachment.

All the aforementioned general studies will be supplemented by special studies on fisheries, forestry, agronomy and public health.

The final stage, that of the socio-economic studies, is intended as a means of determining in what direction economic activities may best be channelled, under the development programme, and to consider action with a view to providing vocational training in agriculture.

V. THE NEXT STEP - PILOT IRRIGATION DISTRICTS AND ANIMAL HUSBANDRY SCHEMES

A second stage envisaged, though not as yet approved, calls for the creation of pilot irrigation districts and animal husbandry schemes. The intention is that these would become operational one year following the commencement of the first stage of work.

Exploiting the technical findings emerging from the agronomic research, the pilot irrigation schemes will also provide an opportunity to ascertain local reactions - in the economic and social sense - to the radical transformation that this changeover from floodplain to irrigation farming represents. A further consideration is that these same experiments will provide information on the approach to adopt in rural promotion and extension work.

The pilot husbandry schemes will be created in the upland areas bordering the valley. At the present time, the land in those parts is given over to winter (rainy season) crops and nomadic stock raising. Now, the fact is that the development of irrigation farming in the valley itself will permanently exclude stockraising as currently practised. Accordingly, in order to offset difficulties of all kinds likely to arise from the new situation, a study will be made of (a) ways and means of keeping the animals on the upland pastures throughout the year, if a satisfactory network of watering points and a carefully planned pasture rotation can be introduced, and (b) the complementary character of the present extensive grazing and the intensive crop growing methods that should become feasible in the irrigated valley areas below.

As with the pilot irrigation districts, the problem with these animal husbandry schemes is as much economic and social as technical.

VI. THE CONTRIBUTION OF THE PROJECT TO THE MEETING ON SAVANNA DEVELOPMENT

Irrigation is possible along all the great rivers of Africa and their tributaries. At the present time, soil and water resources are utilized whether for cropgrowing or stockraising along traditional, and for the most part extensive, lines.

A radical change would have to be effected in the habits of the local populations, in both the activities mentioned, following on any development of these parts. Thought must be given in advance to such a change so that, when the time comes, the authorities may be able to deal with the problems inherent in the farming of newly created irrigation schemes.

The Senegal valley lies on the western edge of the savanna belt. Physical conditions are comparable to those of the basins of other major rivers in the region such as the Niger, Logone and Chari. Now, since an intensive and scientific utilisation of soil and water resources in the savanna belt is fundamental to economic and social development there, the solutions emerging from the hydro-agricultural survey of the Senegal river basin should be applicable, mutatis mutandis, to other river basins. For the present, however, in view of the fact that the project is not yet operational, it would clearly be better to learn such lessons as emerge from projects already completed or still going forward elsewhere in the savanna belt.

LA:SF/SD/66/PM/8

LAND AND WATER RESOURCES SURVEY IN THE JEBEL MARRA AREA

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1. General

Field operations started February 1963, duration of Project four years, ending January 1967.

The Project is operated for the main part with direct recruitment of UN experts, but with special parts handled under sub-contracts with private firms (Hunting Technical Services for soil survey and surveys of land use and natural vegetation, Lerici Foundation for geophysics and further contracts with Autair for helicopter services and with the Dornier Factory for aircraft pilots). For the sociological survey, a sub-contract with the University of Bergen, Norway, has been considered, but for practical reasons two closely co-operating experts were finally given individual contracts: one field expert and one senior consultant responsible for the over-all interpretation of the data.

Five associate experts from Sweden, Holland and Belgium have re-inforced the team.

On the Government side the Ministry of Irrigation was appointed as operating Ministry with participation of the Ministry of Agriculture, Animal Resources and Finance and Economic Planning and the departments of Forestry, Geology, Topographical survey, Meteorology and Land Use. Some special rounded-off tasks are handled under contract between the Ministry of Irrigation (the Project) and the Survey Department.

The Project area (about 32,000 km^2) is exceptional in the Savanna belt through the high mountains (over 3,000 m.) which causes a cooler climate and higher rain fall than is normal for the surrounding areas.

2. The Project forms phase 2 of the survey of the area.

A short reconnaissance survey was already carried out in 1957 for the Government of the Sudan by Hunting Technical Services. The recommendations of the phase 1 study are, in principle, the terms of reference for the present phase 2 survey.

The survey can be divided into 3 parts:

(a) the inventory of resources: water, land, natural vegetation, present land use and the sociological survey and the health aspects;

(b) determination of technical possibilities: agriculture, both rainfed and irrigated, including field crops as well as horticultural crops, water management, grazing and animal husbandry, forestry, roads and communications;

(c) appraisal and recommendation of future development: social-economic consideration will be decisive in this last part of the Project which is not yet concluded.

3. To elaborate on results of the survey is not possible within the scope of this statement. To summarize briefly we found:

A generally impervious basement complex area with, apart from the actual mountains some 100,000 acres good lands in the piedmont and some 150,000 acres of river alluvia, receive rainfall limited to 4 summer months, of 600 to 900 mm/yr (on mountains over 1,000 mm) and have available some 200 million m^3 of surface water in the Wadi Azum system. To bring water to the piedmont soils the construction of surface reservoirs is needed, while in the lower valleys the alluvial aquifers can supply excellent underground storage.

The mountain offers unique possibilities for the production of softwood and the possibilities of temperate zone fruits should be further investigated. Seed potatoes are also promising.

The piedmont already supplies excellent citrus fruits. Irrigation water has probably to be used here mainly for horticultural crops. Rainfed tobacco may be possible (hail damage). Further controlled intensified grazing is possible in the lower mountains and piedmont. Eucalyptus plantations are doing very well here. The economic relationship between these possibilities has still to be worked out.

In the lower valleys the best lands are already occupied by very able farmers who are longing to obtain modernized means of production. Irrigation from pumps can be greatly extended. Rainfed agriculture, especially sorghum and millet will continue to be important. For the production of cash crops the marketing possibilities are at present decisive. A system of "almost all weather" roads should bring enormous changes. Next to horticultural cash crops, tobacco is very promising. The large areas of mainly shallow basement complex soil between the main Wadis are mainly used for seasonal grazing. Intensification by construction of more watering points will probably lead to accelerated erosion.

Considerable areas of black clays are hardly used at present because the available tools are too light for the soil. Development of such areas is investigated elsewhere in the Sudan.

4. As special aspects of the Jebel Marra Project worth considering in this meeting, the following can be mentioned:

(a) The alluvial aquifers of the lower valleys give excellent possibilities for underground water storage with as advantages:

- no heavy initial investment in dam construction is needed, and development can take place gradually;
- very small evaporation losses;
- seepage losses from irrigation return to the reservoir.

(b) Sociological studies were carried out by 2 anthropologists instead of the farm management studies which are usual when we deal with more sophisticated societies.

(c) A special study was made of the Haraz tree (Acacia Albida) and its very important role in the agricultural cycle.

(d) A limited program of road construction was carried out within the survey project. The most urgent problem is probably how to create all weather access to the area with a minimum of costs.

(e) Urgent need for co-operation with other projects exists among others in:

- the development of heavy clays in South-Western part of the project area (Nuba mountains);
- the development of the sandy Kordofan soils, East of mountain;
- the Economics of groundwater extraction from superficial aquifers;
- Forestry;
- Processing of agricultural products.

5. Special Needs and difficulties experienced during the project.

(a) Preliminary over-all appraisal needed periodically in order to adjust program and priorities. Examples:

Relation between water and land resources.
Groundwater volumes and groundwater discharges.
Search for extra stock water - where needed.

(b) Shortage of qualified counterpart personnel. Consider possibility of adjusting current observation methods to the means available.

- In Jebel Marra hydrology simplified discharge observations by locally engaged personnel stationed on the spot during wet season.
- Use of computer for calculation of topographic data saves time and makes strict adjustment possible. Also computation + plotting contour maps by computer.

(c) Operation and maintenance of project aircraft planned to be Government responsibility failed when Sudan Air was reorganized. Completely different approach to be considered.

(d) Maintenance of vehicles and other project machinery needs more preparation and to be specified in much more detail.

(e) Co-operation between different Ministries and Departments is often difficult.

(f) Most important: the local population cannot understand the need for surveys and studies. A combination with some development is needed. In our project, road improvements needed for the project are at the same time the beginning of development, easily understood by everyone.

(g) Different fields are not at all equally advanced: forestry better developed than grazing.

(h) Combination of project management with full technical responsibility for important field can easily be too much. In our case support from associate experts formed a partial solution.

6. Follow-up projects

An all important gap between survey and actual development lies in the realization of technical possibilities under farmers conditions.

If the development takes the form of a large centrally controlled project it is the task of the direction of the development organization to close this gap.

If however - as is the case in important parts of our project area - either land or water resources are scattered, and an experienced population of settled farmers is available, it is necessary to make a separate effort at pilot-demonstration of development growing from the existing farming.

This is all the more true if the area is isolated and far away from the capital. Controlled investigational development is also needed for large scale groundwater exploitation where the behaviour of the groundwater surface has to be closely followed.

For similar reasons but in a completely different field, we propose that during a follow-up project social change will be measured at regular intervals.

Although the survey will be completed, investigations have to continue. Even where the responsibility for such investigations can be effectively turned over completely to the Government, consultant advice may be very useful. This should also be included in a follow-up project.

LA:SF/SD/66/PM/9

STATEMENT ON THE FORESTRY RESEARCH AND EDUCATION PROJECT, SUDAN, AS IT RELATES TO SAVANNA DEVELOPMENT

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The Forestry Research and Education Project in the Sudan became operational in February, 1962 for a five year period; it is likely to be extended for a further period of 12-18 months.

The Research aspect of the project covers Silvioulture, Wood Technology Sawmilling and, more recently, Botany. Since all the Sudan, apart from the desert area of the north, which covers between a quarter and a third of the country and small areas of closed forest in the south, comes under the category of savanna, the project's main work is in the savanna area.

Silvicultural research under the project is divided into four areas, the Arid Zone with a rainfall up to 300 mm falling mostly in 2½ months of the year with both clay and candy soils, the Eastern Region with a rainfall of 250 to 950 mm with mainly heavy clay soils, the Western Region with a rainfall varying from 350-800 mm with mainly sandy soils but some clays and the Southern Region with a rainfall varying from 800 to 1500 mm or more with mainly lateritic soils.

The Silvicultural research program can be divided broadly into the following categories:-

1) Investigations into the natural savanna vegetation, its rate of growth, its coppicing and productive capacity, the effect of fire and of protection against fire, grazing and biotic factors.

2) Investigations into the silviculture and management of the economically important indigenous savanna species, some of which grow under special conditions such as Acacia nilotica, locally known as 'sunt' associated with seasonally flooded areas near rivers, which produces a heavy hard timber used for railway sleepers and which also produces from the fruit pod an excellent tannin material for the treatment of hides and skins; Hyphaene thebaica, the Dom palm, which also occurs along water courses and which produces a very durable timber, also fibre from the leaves which is used extensively for making brushes, mats, rope etc. and the nut which provides a good fodder and is also used for making buttons;

Boswellia papyrifera which occurs, sometimes gregariously, on stony slopes with a rainfall of about 800 mm and which produces a timber used for match boxes and for particle board, both of which are made in Khartoum.

3) Investigations into the Silviculture and mangement of exotic species, grown under irrigation and under rainfall conditions, which have been introduced in the past, some of which are already having, or will soon have an impact on the rural economy of the savanna population, and later on the country's economy; examples of these are Eucalpytus microtheca, grown under irrigation in the Gezira cotton growing scheme area, which provides for the main needs for building poles and fuel for the large tenant population living in the area; Eucalyptus tereticornis, which is grown on the fertile silt soils along the Blue Nile and which produces an excellent pole - once the problem of preventing splitting can be solved - suitable for telephone and electricity transmission lines; Tectona grandis - teak - which is being grown on a considerable scale in the southern part of the country; Cupressus lusitanica which is the main softwood species being grown in the Imatong Mountains in the south and on Jebel Marra in the west, which will provide for the future softwood needs of the Sudan, and a number of other species which show promise.

4) Introduction of other exotic species, which are likely to have a chance of success under different conditions in the savanna area in the form of aboretum trials consisting of about 25 trees of each species. Those which show promise in the arboretum trials are investigated further on a larger scale in species trials, following which, if still successful they can be planted on a field scale.

The Wood Technology research program is designed:

i) to investigate the properties of the natural savanna species in order to try and find uses to which these species can be put either in the raw state, or after some form of preservative treatment, or in a converted state such as a constituent of particle board.

ii) to investigate the properties of the exotic species which have been introduced and are growing under conditions sometimes very different from their natural ones, which may have considerable effect on their properties. This applies particularly to species grown under irrigation which have ample ground water but whose foliage is subjected to extreme heat and very low humidity. A good example of this is Eucalyptus camaldulensis which grows extremely fast but when cut, certainly in the younger stages, splits badly and produces a very unstable timber.

The Sawmilling program covers investigations into the most suitable equipment and Sawing techniques for converting the savanna species, mostly the larger ones in the south such as the mahoganies, Khaya grandifoliola and K.senegalensis, Isoberlinia doka and Afzelia africana and also Acacia nilotica in the north, into sawn timber of sizes which are in demand. It also covers the kiln seasoning of the timber, which is an important aspect if the timber from the more humid south is going to find a ready market in the main consuming areas in the north where the humidity is very much lower.

The Botany program covers the study of the savanna vegetation, the building up of a herbarium, including a carpological collection of fruits and seeds, many of which are used for a variety of purposes by the rural population, and the preparation of a handbook of the more important trees of the northern Sudan.

The savanna area of the Sudan generally is one of a low human population density but of a high animal population density, particularly of goats near any habitation; the natural savanna vegetation should be retained as long as possible to prevent erosion, mainly wind erosion in the drier areas, assist water conservation and provide fodder and shade for animals, particuarly at the dry periods when no ground vegetation is available, and also by providing, as it does now and will continue to do so for all time if not destroyed, the requirements for fuel and for rough poles for building purposes in the rural areas: with the rising standard of living, a better quality pole is likely to be demanded in the future for building. If development is to take place in savanna areas which entails large scale clearing, it is essential that sufficient natural vegetation should be left to cater for the needs of the population, which may increase considerably with development. An appropriate method is to leave strips of vegetation which will form shelter for crops and animals. The effect of shelterbelts is being studied on the project.

If some form of cheap preservative treatment can be given to the natural poles, those species now used will last considerably longer and the demand will be correspondingly less; other species not now used may also become utilizable; this is a problem which is being tackled on the project.

A further matter which is being investigated and which requires more investigation, is the coppicing capacity of the savanna species, whether the time of coppicing influences the production of healthy coppice sheets and what effect browsing has on young coppice sheets.

The problem of fuel and pole requirements arises near the main centres of population where both are in short supply. It is near these centres - not so close that town planners will be eyeing them in a few years time as has so often happened in the past, - or in suitable and accessible areas not too far away, that plantations of fast growing species are required and where a considerable amount of the project silvicultural work is being carried out both in irrigated and in non-irrigated areas. A wide variety of mainly exotic species are being raised in arboretum trials to find out what species will grow well and whether the produce from these species is suitable for the local requirements. Two species among others, which show very considerable promise in the young stage are Conecarpus lancifolius, which is a native of Somalia, and which is growing very well under irrigation in the Khartoum Greenbelt and elsewhere, and which produces a good general utility timber from tests done by the Wood Technologist and Eucalyptus exserta from Australia, which is doing well on sandy soils under rainfall of approximately 400 mm.

The importance of good screening trials for new species over a period of years cannot be over-stressed. A good example for this is Azadirachta indica the ubiquitous Neem - which grows well as a plantation species for the first two years after planting out in the sands of Kordofan under rainfall of approximately 430 mm, but which then deteriorated rapidly and mostly died, probably through competition for the available water.

The Sudan is fortunate in having an indigenous species Acacia senegal which grows, in some places as a pure crop, on both sand and clay soils in the 280 to 450 mm rainfall belt and which produces the 'gum arabic' of commerce. It is an ideal species for savanna conditions since it is the main constituent of the fallow period of the agricultural rotation. It can be raised successfully directly from seed, it starts producing gum after 3-5 years and then becomes a cash crop, very conveniently during the dry season; it also provides good fodder. When the land is required for agriculture, the trees can be clear felled and the produce provides large quantities of wood for charcoal and firewood - unfortunately it is not straight enough to produce reasonable poles. It withstands several years of ruthless cutting back while agricultural crops are grown and when left, it will shoot again and start another rotation which again produces gum and cash - all this at no cost -

while the land is left fallow. This is an ideal example of forestry and agriculture working together. The restocking of natural 'gum gardens' as they are called, is being encouraged by the Forests Department who are also sowing up new areas by mechanical means. The Forest Department Gum Research Officer is also a project counterpart so there is close coordination in this work.

In savanna areas with a rainfall above 1100 mm, teak is being grown successfully; it produces an excellent pole which is very durable, and if it will grow to timber size, it will produce a valuable but hard timber. The project program for the south included work on the silviculture and management of teak but unfortunately little work has been possible. The importance of this species for savanna development in the higher rainfall areas and on good soils is fully appreciated and it is almost certainly a species of the future for these areas. Some experimental work on raising teak with agricultural crops - the well known taungya system - has been done and has shown that this method is very suitable; general experience has proved that the taungya system is successful only where there is definite land shortage for agriculture.

In the higher altitude areas of the Imatong Mountains in the south and on Jebel Marra in the west, plantations of conifers, mostly Cupressus lusitanica, but some Pines, are being established. At present all softwood requirements for the Sudan are being imported, the 1965 imports amounting to 24,014 metric tons to the value of £S907,000, which was approximately half of the amount imported in the previous year. The higher altitude areas capable of growing softwoods are most important for the country and are developing rapidly; the crops are still in the young stages but promise well; project work in the south has been limited but on Jebel Marra a variety of experiments are in progress with the aim of finding out the best techniques for good establishment and growth of the softwood and other species, mostly Eucalyptus. Numbers of arboretum trials have been started to find the most suitable species under different conditions and many sample plots have been laid out to follow the growth of those species already planted on a field scale. Tending and thinning experiments will be started as soon as the crops reach sufficient size.

Experiments on planting conifers in lowland areas were also started in the south; some species have promised well and there seems little reason why quite large scale development on these lines should not follow.

Development requires staff and equipment. The education aspect of the project includes the training of counterpart, field and laboratory staff in research and practical techniques and assistance to the Forest Rangers College by the provision of teaching staff and equipment for the 26 students who are undergoing a two year course. A considerable amount of equipment for field, workshop and laboratory work has been purchased with project funds and is in use.

Sudan
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LA:SF/SD/66/PM/10

THE SOIL SURVEY PROJECT AS RELATED TO SAVANNA DEVELOPMENT IN SUDAN

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The Sudan - United Nations Soil Survey Project has several purposes but the central goal is to help to establish and organize a Soil Survey Division which can serve the needs of Sudan for Soil Surveys and interpretation of soils information. To accomplish this the following general program was proposed.

(a) Conduct soil surveys including laboratory studies of specific areas in various parts of the country. These surveys are at the reconnaissance, semi-detail and detail levels of generalization. In doing the surveys the staff obtains "On the Job" training in the various kinds of surveys, studies field survey methods and procedures, sampling procedures and the collection of relevant soils and agronomic data.

The laboratory is under the direction of an FAO Soil Chemist who gives training in chemical analysis of soils - including methods and procedures. In addition, studies are made relative to the kinds of analysis needed for various types of soils and interpretation of results. The field surveyors are also trained in interpreting laboratory data. The areas surveyed are of interest for the Government Development Program and the recommendations will be useful in planning their utilization.

(b) Soil Classification and Correlation and Soil Survey Interpretation studies are continuous throughout the project. All the field staff receive some training in both types of study but one senior counterpart is receiving intensive training in soil survey interpretation, and another in soil classification and correlation. Each specialist first obtains experience at various levels of field work from soil mapping to report preparation and then intensive training in his speciality. Soil Classification is based upon the 7th Approximation. Soil Correlation studies cover all the work by the Division as well as that completed by Consulting firms working in the country, other Government Departments and other FAO projects.

The soil survey interpretations are to be made for various purposes. First interpretations are made for important cultivated crops in both irrigated and rainland areas. Available crop yield data are assembled and analysed according to certain soil characteristics. Results of this study are then used as an aid in determining land suitability classes. Similar procedures will be followed for pasture crops, forestry and, if requested, engineering uses of soils.

A small cartographic section is included to service the field parties with needed base maps, to compile field sheets into finished soil maps and to prepare land suitability maps. In addition, this unit will prepare maps for publication and help with the reproduction of reports and similar materials to be distributed by the Division.

(d) Training is carried on throughout the project - from administration, transportation, communications, records, field and laboratory methods and procedures, interpretation of results and presentation of findings. This is accomplished by example, personal instruction, classroom lectures, recommended reading and other exercises and a limited number of fellowships for study abroad. The goal of the project is to have a sufficient number of well trained persons available to carry on successfully the work of the new Division. At present there are 15 University Graduates and 14 Technical staff of the project.

For background information it is noted that almost all Sudan's exports are agricultural or livestock products with cotton accounting for more than 60% of the total. All the Egyptian type cotton acreage and over 90% of the American type cotton produced are within the Savanna belt. In addition 90% of the dura acreage, 98% of the millet, 97% of the sesame and 79% of the groundnut acreage are grown in the Savanna belt. Irrigation is extremely important in that dura yield for example, under rainland cultivation, may be about .374 metric tons per feddan (as in 1961/62) compared to .638 metric tons per feddan for irrigated areas. Cotton (American) yield differences are even more striking - .452 metric tons per feddan under irrigation and .119 metric tons per feddan under rainland.

In summary this means that the Savanna area of Sudan produces more than 90% of the agricultural exports and probably more than 75% of the food products.

Most of the scheduled soil surveys are located within the Savanna belt. Thus the Survey Program should be able to make a contribution to the development of the Savanna area through the performance of its assignment. The project is still in the organizing and data collecting stage. Soil surveys have been completed for about 1,300,000 feddans and chemical data is just becoming available. So far, yield data for the Gezira areas has been compiled and tentative recommendations have been made relative to evaluation of Alkali soils. Little work has been done as yet in evaluation of rainland areas.

It is proposed that the Soil Survey Project could furnish assistance to the development of the Savanna area by the following:

(a) Soil studies to identify and map the various kinds of soil in the assigned areas. The kinds of soils will be classified so that they can be correlated with similar soils of other areas. Thus research data and observed cultural and management practices can be evaluated and applied to similar soils throughout the Savanna.

(b) Collection of Agronomic data relative to cultural practices - type of cultivation, crop sequence, kinds of crops, yields under various conditions and by kinds of soil, natural vegetation and fertilizer or manure used, if any. Such information should prove helpful as basic information in evaluating the level of management common to the area and as an aid in helping to recommend improvements in management.

(c) Chemical and physical evaluations by kinds of soil. Both chemical and physical properties of the soils need to be determined. These determinations should include moisture holding capacity, permeability, bulk density, compaction and mechanical analysis as well as cation exchange capacity, exchangeable bases, pH, electrical conductivity, exchangeable sodium percentage, nitrogen, available phosphorus and potash. All of these characteristics must be evaluated relative to soil response to management or as an aid in evaluation of the plant environment.

(d) Estimation of the erosion hazard by various kinds of soils and making recommendations for control. Other forms of soil deterioration should also be evaluated - fertility depletion, structure deterioration, loss of organic matter during cultivation etc. These evaluations can assist in planning management practices.

(e) Land suitability studies to determine the kinds of crops best suited to a given soil and to predict the relative yield that might be expected at different levels of management. This can be done by collecting yield data and evaluating it by kinds of soil and kind of management followed in obtaining the determined yields. Land suitability classes can then be assigned based upon yield information and taking into consideration chemical, physical and cultural practices.

(f) Cooperation with other workers in the same and related fields. Information should be freely exchanged relative to soil mapping and classification and criteria used in determining Land Suitability Groups.

Much information is available from forestry departments, pasture management specialists, agronomists, fertility experts, ecologists etc. All of this can be utilized in preparing the best possible recommendations for use and management of the Savanna soils.

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AGRICULTURAL TRAINING AND DEMONSTRATION PROJECT OF BOBO - DIOULASSO, UPPER VOLTA, IN RELATION TO SAVANNA DEVELOPMENT

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The Agricultural Training and Demonstration Centre (Centre Agricole Polyvalent) UNDP - FAO Project, founded in 1963, is located 10 km. from Bobo-Dioulasso in the South-Western region of the Upper Volta Republic. Following is a brief statement of the aims of the Project, and of its programme for raising the standard of farming in this region of Tropical Savanna.

DESCRIPTION OF ENVIRONMENT AND RESOURCES

The area of the Upper Volta Republic is 274,000 $km.^2$, situated 800 km. from the sea, between 9° 12' N and 15° 30' N. The country has three distinct climatic zones:

Sahelian type in the extreme North:
North-Sudan type in the centre:
South-Sudan type in the South

The climate is characterised by a very marked alternation of seasons; a dry season lasting about eight months from October to June, with dry easterly winds (Harmattans), and a short rainy season of four to six months (June to October).

The average rainfall varies from 500mm. (20 inches) in the North during 50 - 60 days, to 1,350mm. (54 inches) in the South and South-West during 80 - 90 days.

Rain distribution is irregular and extreme variability exists from one year to another, and from region to region. 70% of the rainfall occurs during the months of July to September, with the maximum in August.

The countryside consists of high plains traversed by a few permanently flowing rivers and a multitude of small, seasonal, streams which dry up completely during the dry season.

The vegetation is typical savanna, with bushes and thorn scrub in the North, and broad-leaved trees in the South, with a dense growth of grasses during the rainy season.

In 1965 the population of Upper Volta was estimated at 4,816,000, with 16 people per square Kilometer. The annual rate of increase is about 2%. The population is essentially rural (94%). There are about 510,000 peasant families. Almost 300,000 people of working age migrate annually to neighbouring countries in search of temporary employment.

Soils are typical of savanna zones, being of medium fertility, sandy in texture, poor in mineral colloids and organic matter; markedly deficient in phosphorus and nitrogen; and subject to rapid loss of moisture.

The traditional method of shifting cultivation, with burnt fallow, is universally used, the fallow period varying from 2 to 8 years in different regions. In areas with high density and constantly increasing population, as in the Mossi regions, shifting cultivation is diminishing and fallow duration becoming shorter, causing considerable impoverishment of soils.

The area of arable land is 9,000,000 hectares (32% of the total area) of which about 2,500,000 hectares (28%) are cultivated annually.

Farming activities are concentrated into 160 - 170 days during the rainy season, from the middle of June to November. On river banks and marshes the cultivation season is longer.

Sorghum and Millet are the two main subsistence crops, while Maize is also important in certain areas. Rice is cultivated in muddy land and swamps. Groundnuts are mostly used for local consumption, and partly for export. Cotton is mostly grown as a cash crop. Following are the total quantities of main crops produced in 1964, in tons:-

Maize	126,000	Millet	377,000	Groundnuts	136,000
Sorghum	877,000	Rice	39,000	Cotton	14,500

Only a very small proportion of production is commercialised within the country. 15% of sorghum, maize, millet and rice; 9,000 tons of cotton; and 5,000 tons of groundnuts were exported in 1964. Agriculture is predominantly subsistential. Yields per hectare in dry farming are generally poor, of the order of 520 Kgm. of sorghum; 410 Kgm. of millet; 550 Kgm. of maize; 500 Kgm. of groundnuts; 200 Kgm. of cotton.

ANIMAL PRODUCTION

Breeding of cattle and sheep is the most important economic resource of the country. 2,000,000 head of cattle and 3,000,000 head of sheep and goats are raised annually, and of these about 110,000 head of cattle and 260,000 sheep and goats are exported to neighbouring countries. This export makes a very valuable contribution to the national exchequer.

Breeding of cattle is distinct from crop farming, though small livestock, such as sheep, goats, pigs, guinea fowl and poultry, are frequently raised by sedentary farmers.

85% of exported products are agricultural, of which two-thirds are livestock.

STANDARD OF FARMING

An average farmer invests about 100 - 110 days in crop production and his wife about 60 days. Employment is almost entirely during the growing season. Throughout the rest of the year there is almost complete unemployment, which makes for an enormous loss of human energy. Soil is cultivated by traditional conservative methods, using only hand-tools: hatchet, hoe, coupe-coupe, etc., Draft animals are very rarely used.

The area cultivated by a family depends on the size of the family and varies from 2 to 10 hectares, about 0.5 ha. per person. The possibility of increasing the cultivation area is limited by two main factors:

1. Low labour efficiency, due to old-fashioned farming techniques:
2. Seasonal bottlenecks: at the beginning of the rainy season the available time for soil preparation and for sowing is relatively short: and, during the growing period when heavy rains delay weeding and hoeing.

Handicrafts, gathering of wild roots and herbs, both edible and for medicinal purposes, fishing and hunting, are generally associated with farming. The average annual income of a rural family (including food consumed by the family) is estimated at 20,000 - 50,000 francs, depending on the size of the family. According to a recent survey, the daily average intake of calories is almost sufficient but intake of proteins, and especially of animal proteins, is very low.

PROBLEM OF RURAL DEVELOPMENT

Constant growth of population is followed by demographic modifications. Urban populations are increasing steadily, and the average educational standard is gradually rising. There is general resentment among the young people against the ancient modes of life. Economic and cultural needs are permanently growing and the State has to provide ever increasing social services.

Economic expansion and increased national production are vital necessities. Agriculture is, at present, the essential resource which, by developing even part of its potentiality could contribute most importantly to the social and economic progress of the country.

STEPS TO BE TAKEN FOR IMPROVING AND INCREASING AGRICULTURAL PRODUCTION

1. Improving technical methods of soil cultivation, good soil preparation, correct sowing.

2. Using of selected seeds.

3. Applying the use of manure and artificial fertilizers (the total fertilizer consumption in Upper Volta last year, was 595 tons, which is an average of 0.2 Kg. per hectare).

4. Employing rational crop rotation, which includes adequate food production.

5. Introducing the use of draft animals, primarily oxen.

6. Improving farm tools, and introducing appropriate new ones.

7. Spreading the practice of irrigation, where water is available.

8. Applying soil conservation methods.

9. Carrying out pest and disease control.

10. Introducing cattle and poultry to sedentary farms with the aim of developing mixed farming.

11. Enlarging family farms.

12. Producing grain for feeding livestock.

13. Improving farm management systems in the traditional villages by allocating specified areas of land to farmers.

14. Resettling villages, and establishing new villages in reclaimed areas.

The realisation of all these objectives requires, first, higher standards of farming, and second, adequate capital for investment. The classical tool for raising the technical standards of farmers is extension-service example and training. Where extension services in Upper Volta are concerned, only some 850 technical agents and rural monitors are at present employed by Government services and by the various aid agencies. It is vitally necessary to increase the number of professional staff engaged at different levels of extension work: extension officers, agriculturists, farm leaders, etc.,

In the light of this situation, and with the aim of assisting the Government in promoting farm production and raising the living standard of farmers, the Agricultural Training and Demonstration Centre of Bobo-Dioulasso was created.

AIMS AND ACTIVITIES OF THE AGRICULTURAL TRAINING AND DEMONSTRATION CENTRE

The agreement between the United Nations Special Fund - F.A.O. and the Government of Upper Volta for the establishment of an Agricultural Project Training and Demonstration Project was signed in February 1962. The Project became operational in April 1963. Training activities began in October 1963, and farm activities in January 1964. The Project comprises three fields of activity which are mutually interconnected within the framework of rural development: Training, Demonstration and Pre - Extension multiplication.

EDUCATION AND TRAINING

There are four categories of training activities in the Project:

1. AN AGRICULTURAL COLLEGE: For the training of rural agents and extension officers, to provide medium level professional personnel for the various Government and bi-lateral aid organisations, research stations, etc., students are admitted for three-year courses of theoretical instruction and field work, with a fourth year of probationary service out of College, at the end of which they attend three months of supplementary courses. After successful final examinations students earn the title of Agricultural Technician (Agent Technique). In 1966, enrolment rose to 78 students. This is the only Agricultural Institute in the country.

2. ACCELERATED BASIC TRAINING COURSES: Their purpose is to enable selected young farmers, with 5 to 6 years of schooling, to attend practical and theoretical courses for a full cropping season in order to become rural monitors. Trainees devote 50% of their time to field work. They are divided into groups of five, each group being allocated 2.5 hectares, a pair of oxen, and tools. Trainees carry out a full cropping programme designed for them. Work is done, on their own responsibility, under the guidance of the Project's Specialists. In 1966, 50 trainees were admitted. After completing the Course they are posted by the Rural Development Societies to undertake extension work at village level.

3. REFRESHER COURSES: Refresher courses are organised periodically during holidays when agricultural officers of different extension services attend courses and receive up to date technical information of improved farming practices. So far, 400 agents have participated, in groups of 20 - 25, for periods varying from two to eight weeks.

4. PRACTICAL TRAINING OF FARM LEADERS: Practical training of young married farmers as farm-leaders is undertaken at the Centre. The training period lasts 8 - 9 months and is carried out during the entire cropping season. Trainees live in typical mud-brick huts. Each couple is allotted a field of two hectares where they cultivate different crops. They are introduced to crop rotation, use of fertilizers, tillage systems, rational feeding of live-stock and the use of draft animals. These farmers receive the full proceeds of their crops, after reimbursing the Centre for seed and fertilizers. In exchange for food and housing the trainees undertake two days work per week for the Centre. On returning to their villages, the trainees act as agricultural promoters under the guidance of the regional agricultural services. 40 farm leaders have been trained during the past two years.

A MODEL VILLAGE OF FIFTEEN PROTOTYPE FAMILY FARMS

With the aim of finding suitable means for bringing about improvement in farming methods and in the organisation of the family farm, a small village of fifteen families was set up at the Centre. Three prototype family farms are being investigated and demonstrated, with the following factors principally in mind:

1. Size of farm unit feasible for each prototype.

2. Use of fertilizers, rational rotation, better land preparation with the purpose of increasing yields.

3. Suitable proportion of cash crops to subsistence crops to be cultivated in each prototype.

4. Introduction of improved tillage methods and tools.

5. Suitable combinations of livestock breeding and field cropping with the object of developing mixed farming.

6. Application of rational employment and distribution of labour in each prototype, throughout the different seasons of the year.

7. Study of investment requirements of each prototype.

8. Study of returns on investments of cash and labour.

9. Study of social adaptation to more modern farm conditions.

One of the essentials in the planning of these family farms was to determine improved patterns applicable to each of the different climatic and ethnic regions, for the purpose of growing food and crops, adequate both in quantity and quality, together with cash crops capable of multiplying the annual family incomes some three to four times, i.e. from 20,000 - 30,000 francs to 80,000 - 100,000 francs.

Requirement of capital investment is being investigated and it seems plausible that a minimum of 125,000 francs ($500) is needed for the establishment of a medium-sized family farm unit comprising of 5 hectares of cleared land; a mud-brick square house consisting of two rooms and kitchen, with a corrugated aluminium roof; a pair of oxen; a heifer; tillage tools; a cart; a small shed; a mud-built granary and a poultry house.

It is foreseen that the development of such a farm to full productivity will take three to four years: the first year to be devoted to cleaning of land, construction of house and farm buildings, and cultivation of a field of two hectares. In the second year the cultivated area is increased to 3 - 3 1/2 hectares; draft animals, tillage tools, poultry and a heifer are introduced.

In the third year the cultivated area reaches the final stages of 5 hectares: fruit trees are planted: hay and silage are prepared: and the farm proceeds to improved cultivation techniques and a rotation system. This is the first year that higher yields will be expected. During the first three years prototype farmers are individually guided and supervised. From the fourth year onwards farmers manage their farms independently, guided by the ordinary extension service. In the fifth year farmers begin paying their debts.

The study of the fifteen family prototype farms will be carried on for five years. Technical and economic as well as social conclusions drawn from this experiment will serve as guidelines for the future planning and establishment of advanced farms and villages in the development regions.

Students and trainees at the Project are benefiting by the presence of the model village at the Centre, enabling them to observe methods and practices which will be applied by them in their future service.

Following is the programme of a prototype family farm proposed for the South - Western and Central regions of Upper Volta - progressive stage:

I. FARM LAYOUT

Area of farmland unit	7.35 Hectares
Farmstead	0.10 "
Orchard and Vegetables	0.25 "
Annual Crops	7.00 "

Variety of crops:-

Sorghum	1.00 Hectares
Cotton	1.00 "
Groundnuts	1.00 "
Legumes and Various	0.50 "
Forage and Hay	1.50 "
Fallow	2.00 "

Annual working days of farmer, wife and children 460

II. CAPITAL INVESTMENT IN THE FARM UNIT (IN FRS. C.F.A.)

Construction materials for house and farm buildings:	20,500
Subsistence allowance for family during first two years:	25,000
2 Oxen:	26,000
1 Heifer:	9,000
Equipment and Tillage tools:	21,500
1 Cart:	15,000
Fruit trees:	4,500
15 Hens:	4,500
Miscellaneous:	5,000
TOTAL	131,000 = $534

III. ANNUAL FARM EXPENSES (INCLUDING REPAYMENT OF DEBTS)

Seeds		300
Fertilizers		21,150
Insecticides and Fungicides		4,000
Veterinary medicines		2,000
State Taxes		1,500
Depreciation of Buildings and Equipment		9,200
Interest		4,290
Repayment of Capital (over 10 years) 1/10		13,100
Miscellaneous		1,000
	TOTAL	56,610 Frs.

IV. ANNUAL FARM INCOME IN FRANCS C.F.A. PROGRESSIVE STAGE

CROP	YIELD PER HA. IN KGS.	TOTAL PRODUCTION IN KGS.	RETURNS IN CASH	VALUE OF PRODUCTS USED BY FAMILY	TOTAL GROSS INCOME
COTTON	1 200	1 200	39,600	-	39,600
GROUNDNUTS	1 400	1 400	22,500	1 260	23,760
SORGHUM	1 600	1 600	-	9 800	9,800
LEGUME AND VARIOUS	1 400	700	3,000	7 500	10,500
FRUIT AND VEGETABLES	12 000	3 000	18,000	6 000	24,000
PER HEAD					
CATTLE MEAT	250	250	10,000	-	10,000
MILK	200	200	-	5 000	5,000
EGGS (15 HENS)	100	1 500	10,000	5 000	15,000
MEAT	2	30	-	3 000	3,000
TOTAL			103,000	37,650	140,660

ANNUAL GROSS FARM INCOME	140,660	Frs. C.F.A.
" " " EXPENSES	56,610	
ANNUAL FAMILY NETT INCOME	84,050	Frs. C.F.A.

This farm scheme shows the possibility of tripling the nett annual farm income of a medium-sized family, composed of 5 - 6 persons, in the soil and climatic conditions of the South and South-Western areas of Upper Volta provided that:

1. The farmer and his family invest 460 working days on the farm during the year:

2. The farmer has available, on loan, about 130,000 to 150,000 Frs. at 3% interest for a period of 10 years:

3. The farmer is supervised and trained individually, at least during his first three years, by an appropriate professional service:

4. The farmer is interested, willing, and persevering.

The achievements of the fifteen prototype family farms established two years ago are most encouraging.

PRE - EXTENSION AND MULTIPLICATION FARMS

A pre-extension and multiplication farm was established at the Centre with the aim of reproduction of seeds of the main Upper Volta crops: cotton, peanuts, corn, sorghum, forage plants, fruit nursery stocks, as well as selected cattle and poultry breeds. The centre obtains the foundation stock and seeds from research and experimental stations. Selected seeds and breeding stock are primarily intended for distribution to farmers who have received training at the Centre.

Another purpose of this farm is to examine, on a larger scale, the qualities and behaviour of new varieties and breed stocks obtained from experimental small plots at various research stations.

69 Hectares of different varieties of cotton, peanuts, maize, sorghum and fodder crops have been cultivated this season. A citrus grove, and a collection of tropical fruit trees comprising different varieties has been established. A wide selection of vegetables, and nurserystocks of fruit trees, intended for later distribution, are grown. The animal husbandry section at the reproduction farm consists of:

1. A poultry branch for the production of hatching eggs, with 750 selected laying and meat-type birds, and a modern incubator:

2. A selected beef cattle herd of 75 head:

3. A milk production cattle breed of 25 head:

4. 40 draft oxen, for the use of the trainees, and for demonstration purposes.

The utilisation of tractors and modern tillage equipment on the multiplication farm is designed also to investigate the feasibility and the profitability of using modern machinery under local conditions.

S U M M A R Y

The following operations have been carried out since the beginning of the Project:

250 hectares of land have been cleaned and contoured:
120 hectares of pasture land have been fenced:
7,800 square meters of residential and farm buildings have been built:
Irrigation (10 hectares) and drinking water systems have been installed:
A dam has been built for dry season water storage, and 3 Km. of water-main is now being laid, using a trenching-plough constructed by workers in our own Workshops:
A model village of 15 family units has been built:
A village comprising 20 huts for seasonal training of farm leaders has been built:
A power-house, with a total capacity of 200 KVA, and a general mechanical workshop have been built:
A system of roadways and field-lanes has been built.

The Project is sponsored professionally and administratively jointly by the F.A.O. and the Upper Volta Government.

An international team of F.A.O. Experts in collaboration with an Upper Volta team are managing the Project. It is planned that after five years the full responsibility will be assumed by the Upper Volta staff.

The Project is equally financed by the United Nations Special Fund and the Upper Volta Government, and partially assisted by the State of Israel.

The various activities associated with the training of agricultural officers, rural monitors and farm leaders, combined with demonstrations of improved farming methods, given daily on the family farms in the model village, as, also, on the multiplication farm, are among the most important features of the Bobo-Dioulasso Project, dedicated to the improvement and development of agriculture in Upper Volta.

LA:SF/SD/66/PM/12

LAND AND WATER USE SURVEY OF THE KORDOFAN PROVINCE (COMPLETED PROJECT)

NOTES ON ITEMS FROM THE RESULTS WHICH OFFER POSSIBILITIES FOR APPLICATION TO OTHER PARTS OF THE AFRICAN SAVANNA

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INTRODUCTION

These notes presume that the reader already has a general knowledge of what the Kordofan region is like, what the Project was about, and its general results. The notes are strictly confined to outstanding items which (a) appear to break new ground in terms of technology or methodology, and/or appear to have some special features which could be useful for application in other regions.

CATCHMENT TANKS

How the Catchment Tank works

Rainwater is collected on an artificial catchment apron and then runs into a covered-in water-tight tank where it is kept in store till it is needed. Sizes vary from a 'family' tank of a few thousand gallons (five or ten cubic metres or more) to a few tens of thousands of gallons (a hundred cubic metres or two, or more) which is suitable for a village unit or a stock unit. The total capacity required in a given place is obtained by installing a number of units, each of the appropriate unit size.

Constructional techniques

1. Certain particular designs and specifications were developed, through the Kordofan Project, to suit local conditions. These suffice to prove that the catchment tank solution is practicable, at acceptable cost. In other regions, the "Kordofan types" may easily be unsuitable and some quite different specifications will need to be evolved. Even for Kordofan, improvements can be expected and should be sought. It is essential to realise that any type-design which is to make the fullest possible use of the local skills and other resources, must of necessity be specifically designed for the purpose. The particular designs and constructional techniques which are demonstrated through the Kordofan Project are offered only as examples to show that the principle can be realised and not as patterns to be adopted elsewhere.

Fundamental points of Hydrological Design

2. Catchment tank aprons have areas ranging from a few tens of square metres to a few thousands. Total capacity, as required, is obtained by multiplication of units.

Since the catchment aprons are very small, run-off percentages are very high because the rainwater only runs on the surface for a few seconds before it is in the tank.

Consequently, for purposes of hydrological design, the catchment apron can be treated virtually as if it were a rain-gauge, with an efficiency-ratio applied arithmetically to the rainfall records.

This means that the variability of yield, probabilities of extremes, etc. can be deduced directly from the rainfall records.

In turn, this means that wherever there are sufficient rainfall records for statistical interpolation and extrapolation, the hydrological features of catchment tanks can be calculated without further hydrological studies, i.e. without delay. The run-off ratio needs to be established by direct trials, but as the units are small these trials are easy and cheap. In cases of great urgency, a very liberal 'factor of ignorance' can be substituted for direct data, in the initial stages of a construction program, until experimental data are available.

3. As regards the question of the overall adequacy of the rainfall, the following considerations cover most of the practical applications. Wherever catchment tanks are needed it is because people want to live there. Almost always they want to live there in order to grow crops or graze animals, and they can only do this if there is enough rain. And whenever there is enough rain for crops and pastures there is enough for catchment tanks.

METHODOLOGY OF LAND USE PLANNING - A RADICAL ADVANCE

4. In any region where the practicability of catchment tanks has been established, it follows that the land use planners can have water wherever they want it, and in any quantity they may wish to specify, neither more nor less. This introduces some radical advances in the methodology of land use planning.

5. For example, suppose the land use planners wish to make policies and plans for developing a certain region which has been delineated on the map. Suppose they have to make plans for upgrading the existing water supplies in all the existing agricultural villages, and also make plans for establishing new agricultural settlements all over the 'empty' areas where the land is at present unused for lack of drinking water. Since the practicability of catchment tanks has been established, they can make their plans on the basis of best land use, socio-economics and similar factors, and without having to worry about the water supply because they know that the catchment tanks can always provide a solution if no other way is preferable.

6. When the land use planners have specified where they want water, and how much they must have, the water engineers come on the scene. They make normal surveys to see what sources are available (from surface waters, or groundwaters, or by piping from afar) and then they decide which is the best to choose, with catchment tanks as the certain standby.

7. The catchment tank solution also makes it possible to estimate costs in the land planning stage, i.e. before the actual localities have been chosen and before the water engineers have done their surveys and investigations on the spot. The reason for this is that since (ex hypothesis) the catchment tank solution has been established as being practicable, its costs can be predicted within the usual limits for planning budgets, and this cost represents the highest cost for the water required. The subsequent surveys and investigations may reveal cheaper sources, such as copious borehole supplies; but whatever happens the catchment tanks can always provide the necessary sources. In this sense, the catchment tank is a catalytic agent. Catchment tanks might even be used, on paper, for planning, without ever being built at all, if preferable sources were revealed by the post-planning survey.

The radical - indeed, revolutionary - change is that with the catchment tank, land use planning as a whole can precede investigations for water, whereas the present practice requires that the search for water must precede the planning.

8. A subsidiary but most important consequence arises when catchment tanks can be made cheaply enough to warrant their use for watering herds of livestock in the grazing grounds. In such cases, the supply of water can be adjusted, precisely, to the estimated carrying capacity which a given water-source can properly serve. The reason why this can be done is as follows. Provided the catchment apron is designed so that it will fill the tank on the minimum expected annual rainfall, the tank will always be filled up, except of course for the very exceptional low year which can never be provided for by any practical system. When the tank has been filled up, it can hold no more. Any additional water will pond up and evaporate very soon. It follows that apart from the very exceptional low year, the annual amount of water made available by a catchment tank so designed will be exactly its constructional capacity, minus the appropriate allowance for losses.

This design-basis is of course optional. It may often - or usually - be preferable to design tank capacity to fit the average run-off, so that the benefit of the years of good rainfall is not lost.

SOIL MOISTURE CONTROL BY MOISTURE TRAP AND MICRO-IRRIGATION

These items relate to one particular aspect of the peasant land use, i.e. the production of fresh vegetables and fruits by the individual peasant, for his own family consumption, in a small household garden next to his home, with an area of a few hundred square metres. The techniques may be capable of wider and bigger application, but that is another matter.

Soil Moisture Trap

9. This device gave successful results, with limited trials. Further experiments and development are needed, but the actual results show that the potentialities are substantial.

The 'trap' consists of a sheet of plastic which is perforated, laid over the plot of soil in the household garden, and covered over with a couple of inches of sand or fine gravel. The rainfall quickly saturates the material above the plastic sheet and the excess water then flows, under gravity, through the perforations and into the soil beneath. When the rain stops and high evaporation begins, the superficial soil or sand dries out quickly and then forms a protective mulch, because the rate of capillary flow upwards through the perforation holes cannot keep pace with the rate of evaporation from the whole surface which is exposed to the sun and air.

10. Since the membrane is buried it is protected from the damaging effect of the sunlight, and the wind, and other causes of damage. Therefore it can be very thin

indeed, and consequently very cheap; far cheaper than a black polythene sheet laid on the surface.

This soil moisture trap can be used in several ways. First, it can help with vegetables during the rainy season itself, by bridging the gap between falls of rain. Second, it can be used to charge up the soil moisture under the membrane during the mass of the rains, and then grow vegetables into the dry season. Third, a vegetable plot of, say, a couple of hundred square metres can be kept bare through a whole rainy season, storing the trapped soil moisture so as to augment the next rainy season's supply. Fourth, the trap can be used in conjunction with deep-rooting plants such as trees for fruits, or deep-rooting fodder plants. In this case, the soil immediately under the plastic membrane does not itself carry any plants, but is kept bare so the trapped water percolates down to the lower strata where the plant has the bulk of its roots.

All the foregoing applications can be augmented by having a bare catchment apron adjoining the garden plot, so that the plot gets its own direct rainfall, plus the run-off from the adjacent apron. The vegetable plot is surrounded by a little earth ridge to keep the water ponded.

Micro-irrigation

11. The auxiliary catchment apron, used in the way described above, augments the supply of water to the vegetable plot or fruit trees, but does not distribute it chronologically. When it rains, the plants get an extra supply, but when there is a drought the catchment apron is no help.

A catchment tank can be interposed, however, between the apron and the plot, so that the run-off is stored in the tank and can be used for irrigation, during the drought, when the plants need it.

12. Used in this way, a catchment tank will be filled and emptied for irrigation several times during the rainy season because its function is to fill in the gaps in the rainfall. It can also be used, however, to sustain deep-rooting plants, such as fruit trees, during the dry season. During this season they draw on the soil moisture which has percolated down to the lower soil zones during the rains, and the addition of a comparatively small amount of irrigation water makes a difference out of proportion to the quantity.

13. If the cost of irrigation water from the catchment tanks is judged by standards of cost derived from conventional systems it may appear high. But what matters is actually transpired by the useful vegetation, i.e. the crop of vegetables or the fruit trees. When the cultivated plot is very small, and the value of the crop is very high, and the individual man can water each individual plant from a tin by hand, the efficiency is very high indeed. In fact, with a fruit tree carefully watered two or three times a week with a petrol tin, the efficiency can easily approach 100%, i.e. nearly 100% of the water given is transpired by the tree.

USE OF MASSIVE SUPPLIES FROM RESERVOIRS

The Rahad Lake Project offers the only opportunity, in the Project Area, for massive reservoir supplies. At the first stage of development it could provide an assured quantity of 17 million cubic metres per annum.

14. The proposal is that this water should be spread as widely as possible over the region it can command, to provide drinking water (primarily) for man and beast, and

also to provide some pockets of village-based irrigation to produce fresh vegetables for purely local - or at least regional - consumption. By this method, the existing rural economy will be fortified throughout, because the existing land use is far less efficient than it could be if there were plentiful drinking water, well spread, with an improved diet augmented with fresh vegetables and fruits. In consequence, the water distributed has an economic benefit which is out of proportion to its amount; it provides, so to speak, a key or a lever.

This method, and the principles underlying it , may have applications elsewhere in the savanna belt, as an alternative to the more usual policy of using the water from the new reservoirs for irrigating a concentrated area as near as possible to the dam.

CONCLUSIONS

A. The Kordofan Project has revealed several specific items which break new ground in technology or methodology. These are:-

(i) Catchment Tank technology.
(ii) Consequent radical advance in methodology of planning land use.
(iii) Soil Moisture Trap.
(iv) Micro-irrigation by Catchment Tank.

B. There appear to be substantial possibilities of application of these items in the other parts of the Savanna Belt in Africa, and probably elsewhere.

C. The following action would serve to establish the extent of such other applications, i.e.

(i) A reconnaissance in these other regions, followed by:-

(ii) A program of practical trials in those regions where the reconnaissance has given positive results.

CONCLUDING REMINDERS

These notes are not intended to give a balanced summary of the results of the Kordofan Project in general. They are concerned solely with items which appear to break new gound technologically or methodologically, and which offer opportunities for application elsewhere, in other parts of the savanna belt. The particular designs for the catchment tanks which have been developed through the project are demonstrated as proof, in principle, that the catchment tank solution is practicable at acceptable cost. There are many different methods of building catchment tanks and the actual choice in any given case depends upon the actual circumstances.

LA:SF/SD/66/1

SOILS AND LAND FORMS IN THE SAVANNA BELT OF AFRICA

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The Savanna Belt of Africa refers to an area roughly between 10° and 18° latitude but extending southward into parts of Ethiopia, Somalia, Kenya and Tanzania. This area is characterized by a relatively dry type of vegetation consisting primarily of grasses with some low growing trees. Rainfall averages between 200 and 1,000 mm per year but there is a relatively long dry period. Climate is probably the most important single factor influencing the soils and vegetation.

The soil parent materials of the area range from marine deposits, river alluvial deposits (from basic, acidic and mixed materials) aeolian sands and silts, colluvial deposits, volcanic ash, and residuum from several kinds of rock including basalt, gneisses, schists, granites, and sandstone. From these parent materials Entisols (on the younger deposits), Vertisols (on the clayplains), Inceptisols, Aridisols, Alfisols, Ultisols and Oxisols are most extensive. More humid climates in the past seem to have influenced the formation of some of the present soils.

Under present conditions the most active soil forming processes are mechanical weathering and chemical alterations (mostly salinization) which are influencing the Vertisols, and Aridisols. Soil forming alterations of the Ultisols and Oxisols are probably very slow.

Plants occur in patches or are scattered, thus much of the soil is exposed to the wind and sun. It is therefore very susceptible to water erosion during the rainy season and wind erosion during the dry periods. Long dry periods are the rule, yet plants in the depressions may suffer during the rains from excess water. Therefore, soil management and utilization must cope with these as well as other conditions.

The following is an attempt to present a general evaluation of the soil resources of the Savanna Belt and to discuss some of the problems of agricultural development and soil management. Most of the comments are based upon observations in Sudan and Tanzania plus a review of literature concerning other parts of the Savanna.

Kinds of Soils

It is usually not possible to make specific agricultural recommendations for soils based upon the higher categories of classification - for example: Entisols or Oxisols. However, soil in each of these categories or orders have specific characteristics which affect use and management. Those kinds of orders of soils occuring most extensively in the Savanna Belt are listed in the introduction. These kinds of soils are the result of the total effect of soil forming processes acting on the parent materials available at a given place.

By way of review, the soil forming factors are climate and the vegetation, acting on parent materials as conditioned by relief over periods of time. It is noted that representatives of at least seven of the ten Orders of soils as described in the 7th Approximation occur in the area.* These are briefly described below:

A. Entisols are primarily young or weakly developed soils lacking definite horizons other than an A horizon. They include very recent alluvium or in some instances quartz sands that have been in place for many thousands of years. Thus the Entisols of the Savanna Belt may include many of the soils formerly classified as Alluvial soils, Regosols, Lithosols and Low-Humic Gley soils. Many of the Alluvial soils occur on nearly level slopes of the flood plain or colluvial deposits. They are relatively limited in extent but very important to agricultural production. The Entisols formerly classed as Regosols and Lithosols may be nearly level to very steep. They are used primarily for forest or grazing, but the units occurring on favourable slopes and having medium to fine textures are moderately fertile and productive.

B. Vertisols include the cracking clays so common in the Gezira area of the Sudan and parts of the Pangani Valley of Tanzania. They are characterized by fine textures - more than 35% clay of the expanding lattice type (2:1). These soils usually have more than 30 milliequivalents exchange capacity, form wide cracks when dry, have slickensides and gilgai and usually self mulching surfaces. They may form on Alluvial materials as well as residuum on nearby level to steeply sloping positions. Parent materials are usually derived from basic rocks such as basalt and limestone. The vegetation is normally grass or herbaceous annuals with some drought-tolerant woody plants. Permeability is slow to very slow except into the cracks but fertility levels are usually high. The Vertisols are extensive and with good management, including irrigation, good yields are often obtained. Unirrigated areas are largely used for grazing.

C. Inceptisols of the Savanna Belt include those soils developed on relatively young surfaces without extreme weathering. Such soils were formerly classified as Humic Gley, Low-Humic-Gley, Lithosols, Regosols and Brown Forest soils. Inceptisols lack developed textural horizons, are often permeable but may have a high water table. They are limited in extent and may occur in depressions as well as in colluvial positions or gently rolling uplands. Fertility and water holding capacity is dependent upon kind of parent material and texture.

D. Aridisols include soils formerly classed as Desert Soils, Red Desert Soils, Sierozoms, Reddish-Brown soils and Solonchak. Most of these soils are calcareous throughout and have a calcic, gypsic or salic horizon and conductivity greater than 1 millimhos per cm. at some depth. Only a few examples have been observed in the Sudan but they may be

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* Based upon Soil Map of Africa - Publication No.93 1964
Commission for Technical Co-operation in Africa.

extensive in other countries. The areas observed occur on gentle slopes, are permeable, moderately fertile and moderately productive when water is available.

E. Ultisols are found most extensively on residuum from granitic or gneissic rocks. They include soils formerly called Red Yellow Podsols and some Reddish brown Lateritic soils. Ultisols are very limited in extent and occur primarily in areas of higher rainfall. They are very susceptible to erosion, have a relatively low fertility, but respond well to additions of fertilizers and animal manures.

F. Oxisols are usually red in colour, occupy old land surfaces, are very highly weathered, have low fertility and are usually very permeable. Many Oxisols contain plinthit and some have a high water table. Most Oxisols on the Savanna were formerly classed as Latosols, Ground Water Laterites or Ferruginous tropical soils. They are used primarily for forest or tree crops. Within the Savanna Belt most of the Oxisols are relics of an older soil weathering cycle but important areas (Latosols) do occur overlying granitic parent materials.

Agricultural Development

The development of an area for agriculture will be influenced by the people, their needs, available soil and water plus certain other factors such as markets, schools, health and cultural facilities and transportation. This discussion, however, is limited largely to the utilization of the soils. Thus the major points for consideration are:

1. Choice of soil.
2. Most efficient use of available water.
3. Maintenance of soil fertility and productivity.
4. Choice of crops and methods of cultivation.

Most of these points are inter-related.

Often a cultivator has to utilize the available soil with only a limited local choice. If this is true then the cultivator can be helped most by advice upon means of improving his soil, introduction of better adopted varieties of crops or new crops, and help in increasing yields by better methods of cultivation and/or use of fertilizers. When a choice of soils is available the cultivator should be assisted in choosing the best available land for the crops to be produced.

Within the Savanna Belt, relief and physiographic position are very important for soil utilization. They determine the land form and thus influence the intensity and type of cultivation that can be applied to a given field. They also affect to a large extent the water regime.

For rainfed cultivation, preference should be given to the use of those soils which have permeable surface and a high capacity for holding available water. Such soils are usually deep, have a medium textured surface, and medium to moderately fine textured subsoil. Roots should be able to penetrate freely. The same conditions would be ideal for irrigated areas. However, fine textured soils that are permeable, either by cracking or natural structure, can be utilized for both, rainfed and irrigation systems.

Water can be encouraged to enter the soil by one or more of the following methods. The method used depends upon the slope, physiographic position and nature of rainfall.

a. Level terraces can be constructed to hold water on the soil, thus facilitating maximum penetration. This procedure must be used with care to prevent possible damage by erosion. If excess water is collected and breaks over the terrace it may cause serious loss of soil.

b. Water spreading devices are especially beneficial in introducing the available water to as much of the area as possible so that it can more uniformally penetrate into the soil rather than flow in a channel. This is used successfully in places like the Gash Delta of Sudan. Water is taken from the channels and spread over a given field.

c. Water retarding structures may be used to slow water in stream channels so that more can penetrate into the substratum. This procedure is commonly used to recharge the groundwater supply so that more water is available for wells.

The available water in the soil should be used for those crops having a low water requirement relative to production. In addition, cultivation should be in such a manner that evaporation is reduced and weeds controlled.

In general, a field capable of high yields uses the water more efficiently than one capable of only low yields. Those soils which are fertile or will respond well to additions of plant nutrients should be given priority in water distribution. For example, most of the Oxisols should be avoided for cultivation if possible, because of low fertility and relative low response to added plant nutrients.

Again in irrigated areas one has a wider choice of possibilities. More effort can be expended on cultivation and on application of fertilizers. Soils having high salinity or alkalinity should be avoided. However, if sufficient water is available at a given location, reclamation of saline or alkaline soils may be possible. It may be of interest that, in the Gezira, evidence indicates that Exchangeable Sodium percentage of up to 35 is not a serious limiting factor to yields of cotton, dura or groundnuts on the cracking clays. Further research is needed to determine the limiting factors on these kinds of soils.

The choice of crops should be such that the maximum needs of the community are best satisfied - food, fibre, cash crop or export crop. This, of course, must be within the feasibility of available water. Variety selection or plant breeding may help in providing those crops which are most efficient in water utilization.

Certain kinds of soils lend themselves to extensive mechanized types of cultivation. The clay plains are difficult to cultivate by hand and yet good yields can be expected. These areas are best suited to mechanized systems especially if the soils occur in large enough areas to justify the investment. Medium textured soils, sandy loams to silt loams, can be hand cultivated so that smaller size units can be managed. Clay soils, especially the non-cracking clays, must be cultivated within a rather narrow range of moisture conditions to prevent damage to soil structure.

In conclusion, the soils of the Savanna area should be identified, classified and mapped; the various kinds of soil then grouped into units of Land Suitability based upon such factors as texture, structure, slope, erosion, fertility, depth, permeability, salinity and/or alkalinity and expected response to management. Yields may be predicted based upon evaluations of available yield data from experimental plots or farmer records by kinds of soils and known inputs of management. Maps showing the areas of suitable soils can then be used for planning development, taking into consideration the local social conditions, markets, communications etc. Considerable data is available in the Savanna Belt but much more data is needed in order to make accurate predictions.

LA:SF/SD/66/2

CLIMATOLOGY

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INTRODUCTION

Climate, the predominant part of the physical environment, requires detailed consideration whenever assessments of the natural resources of an area are made with a view to estimating its agricultural productivity potentials. Climate may simply be defined as accumulated weather. There is much repetition in the weather. Repetition in the weather of days following each other and repetition in the weather occurring at the same seasons, year after year. Climate analysis defines these repetitions and at the same time serves to show up and measure significant departures from normal conditions.

Climatology, in the first place, works out averages of the relevant meteorological elements over various periods of time for places or for regions with some uniformity of climate. Variations in time can then be estimated. Some are repeated at a regular rhythm; the most important being those which occur during the 24 hours of a day and during the course of a year. Those periods, which have the same climate, like consecutive years or months at the same time of the year, nevertheless show some differences from each other. The study of the nature and extent of this interannual variability is an essential part of climatology without which mere averages would be an oversimplification.

Descriptive Climatology studies the repetition, seasonal change and variability of the various meteorological elements, and their surface distribution. It need not, however, begin with a mere reading of thermometers and rain gauges. A more comprehensive understanding may be obtained if an examination of the mechanisms of the general circulation of the atmosphere is included in the study. This climatology is called dynamic or synoptic.

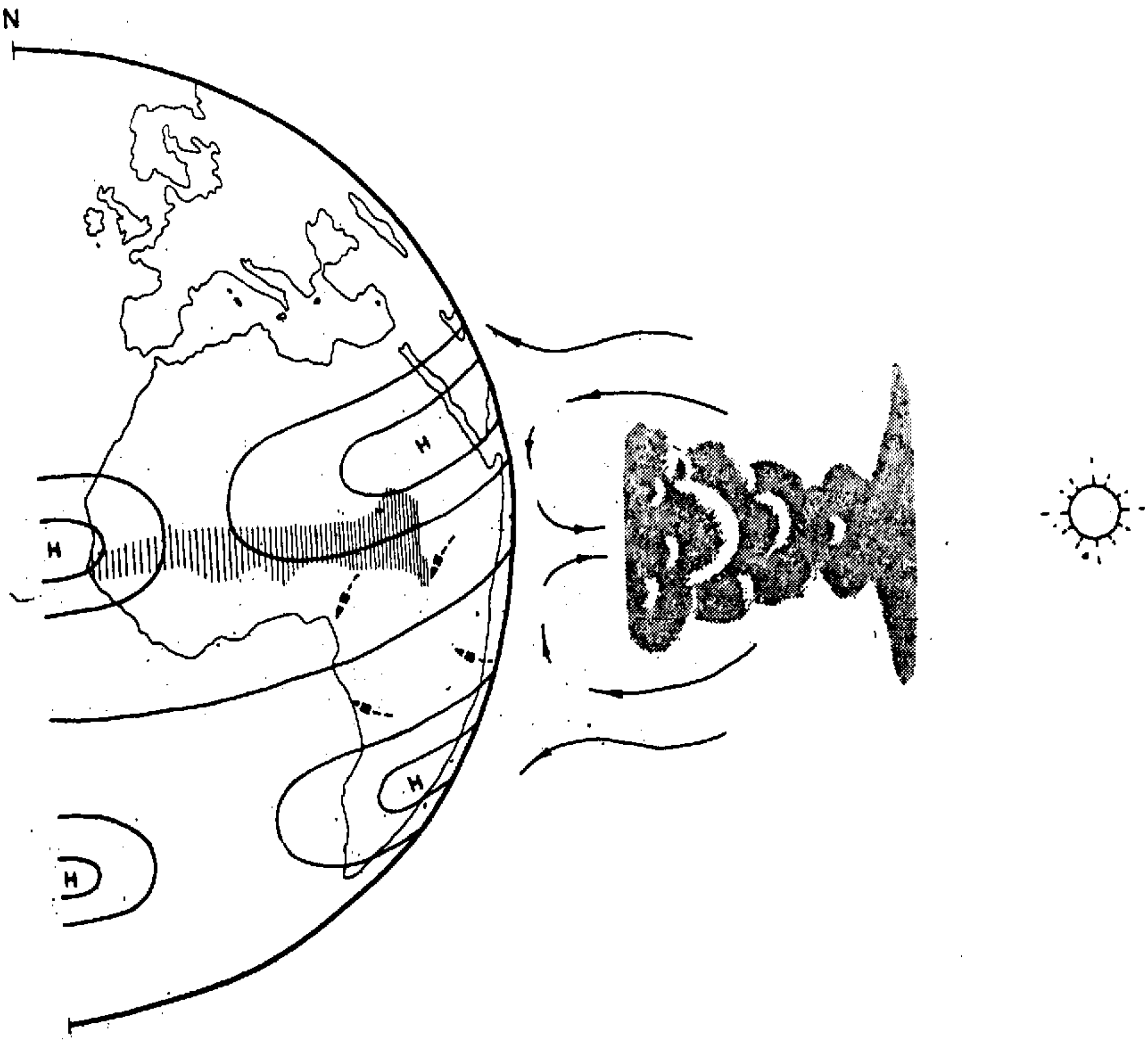

Fig 1. Diagram of general circulation over the equator and tropics at the solstices. The curved line represents the horizon, with the surface of the earth to the left and a vertical cross section of the atmosphere to the right. The arrows represent air movements in the vertical, and the broken arrows the Trade winds converging towards the equator. The letters H represent the centres of anticyclonic cells with concentric isobars surrounding them. The line marked E is the equator on which intertropical convergence rain can be imagined to fall. The hatched area is that of the FAO/UNESCO/WMO Survey.

DYNAMIC CLIMATOLOGY OF THE AREA

The atmospheric circulation features which condition the climate of the savanna belt of the northern hemisphere in Africa will be discussed briefly. They are illustrated diagrammatically at Fig 1. The air movements involved have to be viewed in three dimensions : two along the surface and one in the vertical.

At some distance north of the Equator there is a zone where the air generally moves downwards, becoming relatively hot and dry in consequence. At the surface this subsidence corresponds to a zone of relatively high pressure. It is in this high pressure belt that the great continental deserts are found. There is one such zone on either side of the Equator. Air tends to flow outwards from these high pressure areas and, because of the rotation of the earth, it moves in a spiral round the anticyclonic cells, clockwise in the northern hemisphere. This results in easterly winds, the Trade winds, found on both sides of the Equator, and converging towards it. Along this convergence, called intertropical, air tends to move upwards. As it ascends it is cooled, and it becomes relatively more humid until clouds are formed and rains falls from them. Thus we have, in the northern hemisphere, a wet zone, the intertropical convergence parallel with the Equator, and to the north of it, a dry zone, the subtropical anticyclones. The position of these two zones relative to the ground controls the seasonal weather of the savanna belt. They both move northwards in summer, substituting moist winds of southerly origin and rain for the dry harmattan winds originating from the northern anticyclones. The duration of these summer rains, often called the monsoon, varies with the geographical position : the further north the place the shorter the monsoon. The most northerly displacement and the most abundant rains occur in August. There seems to be a time lag of about six weeks between the earth positions of the sun at its zenith and the earth position of the intertropical discontinuity. Not only does the monsoon bring the water needed for growing rainfed crops but also causes less extreme temperatures and less dryness of the air in which most crops fare better.

AGROCLIMATOLOGY

Climatology becomes more specialised as the use to be made of it becomes more narrowly defined. Here we are clearly interested in agroclimatology within which again there is further specialisation and subdivision.

In the first place consideration is given to what may be called the <u>atmospheric climate</u>, or characteristics revealed by measurements from well exposed thermometer screens and other standard instruments such as rain gauges. Later the scale can be narrowed down to the climates of the soil and air in close vicinity to the crops, and in various locations involving considerations of micro-climatology.

On a broader scale it is important to assess those factors which limit the growing seasons. Mainly, these factors are growth-inhibiting temperatures and availability of water. Even though crops like cotton may have a vegetative zero as high as 15°C, growing seasons are unlikely to be limited by low temperatures in the savanna belt except on high ground. On the other hand, temperatures prohibiting growth or development because they are too high may occur in the area, but are far more unlikely during the monsoon. High night temperatures may be a more commonly occurring adverse factor.

Availability of water is the paramount limiting factor in the savanna belt. To assess it we must first consider the characteristics of the rainfall regime. Later rainfall will be balanced against maximum possible loss of water by evaporation from the plants as well as from the soil.

RAINFALL

No less than 30 years' observations should be available to work out rainfall averages. With periods of less than half a month averages are upset by the occurrence of occasional heavy falls. To absorb them, series longer than 30 years, which are rare, are needed, and the labour involved in the calculations is seldom warranted. Graphical interpolation from the monthly means is more likely to give reliable results.

Estimates of the variability of yearly amounts lead to working the probability of obtaining given amounts in the future. This problem can be approached in two ways :

Empirically, the yearly amounts are arrayed in order of magnitude and separated into groups (say five groups of six values in the case of 30 year series), and the intermediate values between the groups, known as quantiles (quintiles when there are five groups), give the amounts likely to be equalled or exceeded 4, 3, 2 and 1 year out of five, if past records are thus projected straight on to the future.

Theoretically, the data may be looked upon as a sample of an infinitely large series which can be fitted to a mathematical function, and will then yield probabilities of occurrence with as much detail as may be required.

The simplest and most commonly used function is the normal distribution of which the parameters are the mean and the standard deviation. The standard deviation is a measure of the variation and, divided by the mean, it yields a coefficient of variability which allows comparison between places with different mean rainfall. The mean plus and the mean minus one standard deviation include a range of values occurring two years out of three.

In the center of the African Savanna belt and with mean annual rainfall between 500 and 1000 mm the standard deviation is about one fifth of the mean, a coefficient of variability of 0.2. Thus, if the mean annual rainfall is 500 mm, between 400 and 600 mm will probably occur two years out of three. Estimates of the normal distribution parameters of a 30 year sample can also be worked out graphically with sufficient accuracy, thus avoiding lengthy calculation of the standard deviation. The normal distribution will fit about 75% of the annual data series, and a disregard of one extreme value will increase this percentage by 10%. The logarithms of the values may be fitted to a normal distribution when the values themselves cannot, especially when there are some null returns. With such truncated series, if an electronic computer is available, an incomplete gamma function is appropriate and is at the moment employed by the US Weather Bureau. It is thought that for periods of less than one year, the empirical method of obtaining probabilities is sufficient to meet most needs.

Intensity, or the rate at which rain falls, also requires study. The amount of rain falling in 24 hours may be looked upon as an intensity. In the central and western portions of the savanna belt the average is 14 mm per day of rain, and seems fairly independent of mean annual rainfall. On the other hand the maximum amount likely to fall in a day, say, once a year, is related positively with mean annual rainfall. In the same area as above, where the rain is most regular, 50 mm in a day once a year corresponds to 500 mm mean annual rainfall and 60 mm corresponds to 800 mm. Intensity duration analysis deals with even shorter intervals using data obtained from autographic rain gauges. The shorter the interval the higher the maximum intensity. For periods of a few minutes rates of more than 100 mm per hour are not uncommon.

These studies are on the border line between agroclimatology and hydrometeorology.

Spatial variability is another important characteristic of rainfall. On a daily basis the amount of rain falling on places only a few kilometres apart may be quite different. Detailed biological observations at a station should not therefore be compared with daily falls at a meteorological station nearby. On a geographical scale it does not seem that dry or wet years occur simultaneously along the whole of the savanna belt. This is of interest from the point of view of the occurrence of widespread famine.

The times of the day at which rain falls varies from station to station in West Africa, showing that rain formation is not simply due to diurnal heating. Distance from source areas of disturbance lines has been suggested as a probable cause of this disparity.

EVAPOTRANSPIRATION

To assess availability of water mere consideration of the rainfall regime is not sufficient. As already indicated, rainfall must be balanced against potential evapotranspiration. This quantity which may be defined as the maximum amount of water which can be evaporated from a surface covered by close cropped vegetation entirely covering it, may be estimated directly with the use of special instruments like lysometers or evapotranspirometers or deduced from evaporating pan data.

At the moment, however, the safest way to obtain reliable results, which can be compared with similar values from other parts of the world, is to calculate from meteorological data. Penman formula is the most widely used and the most theoretically sound. It estimates the net energy available to evaporate water, and also the evaporating power of the air advected by the wind, weighing these two values in terms of temperature.

However, in a hot and dry climate, such as that of the savanna belt before the rains, the values obtained are high, as much as 8 mm a day, corresponding to much higher instantaneous rates in the middle of the day. This may be looked upon as a demand for water from the atmospheric environment which the plant may not be able to meet, and which, in consequence, will cause temporary wilting, even if there is plenty of water made available to the roots. This is important in terms of irrigation, which may provide water, but not the milder conditions of air temperature and humidity of the summer rains. The excessive heat and dryness of the air may be mitigated to some extent by the use of shelter belts, sprinkling etc.

AVAILABILITY OF WATER PERIODS

For the comparison of mean evapotranspiration estimates with rainfall the most convenient and reliable values to use are monthly means in view of what has been said about the unreliability of rainfall averages for shorter periods. On an annual basis evapotranspiration is about four times more variable than rainfall in West Africa. Graphically, the monthly histograms may be smoothed into continuous lines to obtain estimates to the nearest day as shown in Fig 2.

The most significant climatic events in this comparison take place when rainfall begins to exceed and stops exceeding evapotranspiration. These two dates delimit a period called humid when water surplus occurs, since all the rain cannot be evaporated. An allowance of, say, 100 mm, may be made for charging and storage in the ground up to field capacity. Another significant pair of climatic events are the moments when rainfall is half potential evapotranspiration at the beginning and at the end of the rains. These points delimit a period, here called moist, which corresponds quite well to the growing cycle of summer rainfed crops, especially if the amount stored in the ground is taken into account.

The beginning of the moist season agrees well with traditional sowing times, except perhaps with early millet when the hardiness of the seedlings and the low weight and consequently relatively low cost of the seeds makes pre-sowing worth the risk in the north of the Area where the rains are very short. The period extending from the first rains to the beginning of the humid season, here called preparatory, varies markedly in length in the regions of West Africa, being about 20 days in West Senegal and more than 50, well inland, for the same mean annual rainfall, say 600 mm. The two intermediate periods, on the other hand, before and after the humid period are, on the average, fairly constant in length. The humid period varies from 0 in the north to 150 days or more, depending on where the savanna belt is deemed to end. It was found that mean annual rainfall divided by the length of the moist period with ground reserve yields a constant value of about 5.5 mm. With effective rainfall, the amount estimated to be actually available to the crops, is 4 mm average daily value.

The relative positions of flowering and the humid period are important for maximum productivity. With cereals, the best time for the terminal inflorescence to bloom is shortly before the end of the humid period. With axial flowering, as in cotton and peanuts, the useful flowering, which corresponds to the fruits which are gathered, should for best yield occur during the humid period. On the other hand, during the final ripening of the cereal grains or the opening of the cotton bolls, humid conditions reduce productivity, mainly because they encourage parasitic action. Staple crops like sorghum and groundnuts have a multitude of ecotypes adapted to different lengths of availability of water periods. In practice it is found that the varieties traditionally grown in a given area are adapted by their length of cycle and dates of flowering to the local availability of water. Furthermore. sowings are mixed to ward against interannual variability in the duration of the period. (Example at Fig 3).

RADIATION

Solar radiation is the primary input of energy which makes dry matter production by plants possible by providing heat and light. Global radiation, which gives a measure of the light available for photosynthesis, can be measured fairly accurately with simple instruments like bimetallic actinographs or evaporating integrators. At the moment the places from which reliable series of such measurements are obtainable are regrettably very few. If sunshine records are available global radiation can be assessed. Potential photosynthesis may be derived from global radiation.

Dry matter production is largely conditioned by the relative value of daylight temperatures, night temperatures and global radiation. The ratio of global radiation to daily mean temperatures is appreciably lower in the savanna belt than in North West Europe. This might imply that in certain conditions shortage of light as well as high night temperatures limit productivity.

SCOPE AND SCALES OF CLIMATOLOGY

At the very beginning of the approach to a problem a world wide system of climatology, of the kind used for teaching geography, may be useful to experts without any previous knowledge of the region. However, because of the area involved (they often deal with the whole globe) such systems are much too coarse to be of direct help in formulating the agricultural policy of a country of which it is proposed to increase the productivity. As the problems are narrowed down and defined the climatology needed becomes more specialised. The factors which matter must be singled out and analysed in detail. For each problem a new system of classification is necessary.

Climatic elements distributed over an area are in fact continuous variables. It is for the sake of convenience and because of the limitations of the human memory that these variables are subdivided into classes. The class limits, say every 200 mm of rain, have in themselves no special merit and different limits may be needed for different problems. Fortunately it is now possible to store electronically the observed values of continuous variables without any need to split them into classes. For each need, new classes may be necessary and can be drawn from the store without difficulty.

The aim of applied agroclimatology is not to force case studies into the classes of a system, distorting the problem, if necessary, in order to do so, but to build climatic working models approximating as closely as possible the range of conditions which a particular crop is likely to meet in a given locality, and comparing it with what is known about the climatic needs and tolerances of the crop.

Thus, in problem of water availability, a theoretical model of the average atmospheric climate based on observed averages will first be evolved. Then the variability of this model is investigated. Next in the context of given crops, and soils, of known physical characteristics for storage and retention of water, typical sequences of rainfall amounts are postulated, and corresponding amounts of water made available to the roots deduced, bearing in mind corresponding values of maximum possible evaporation.

Finally it is realised that the development of plant breeding, the increased availability of fertilisers, climate control, in fact a general rise in the cultivation techniques, will increasingly mitigate the adverse effect of weather on crop production. As the climatic needs and tolerances of plants evolve, so must the applied branches of climatology concerned with agricultural productivity.

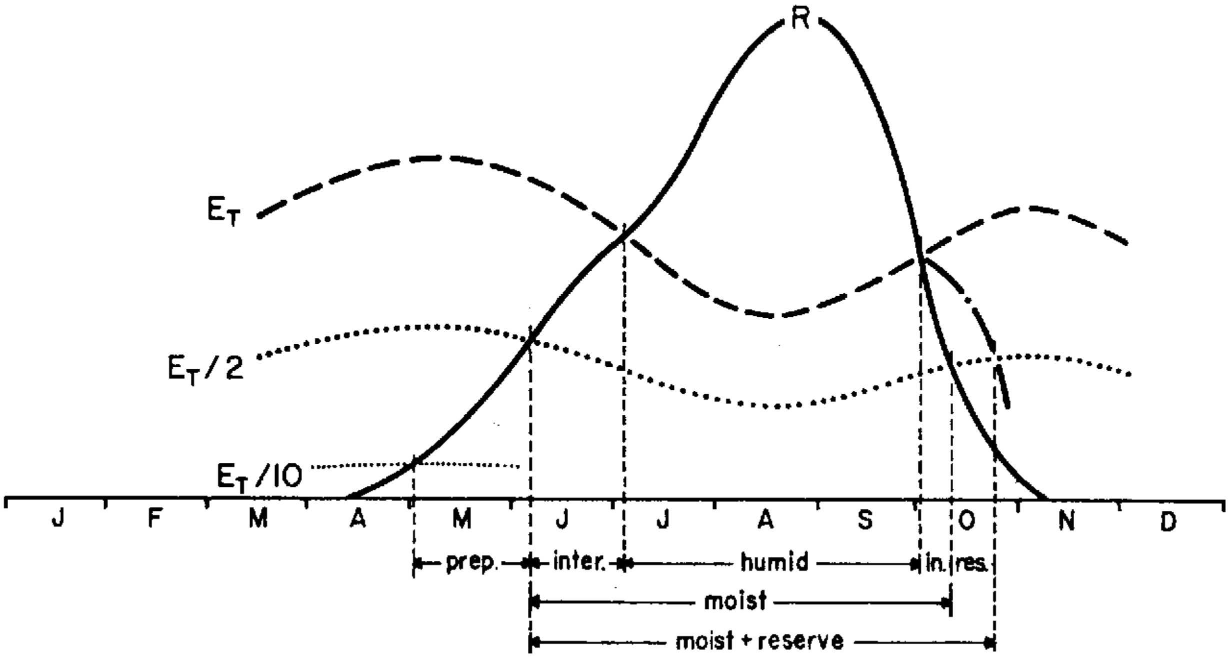

Fig 2. Typical mean rainfall and evapotranspiration regimes in west Africa savanna belt. R, rainfall; E_T, potential evapotranspiration. The area above the E_T line and below the R line represents water surplus. Without ground storage (say, 100 mm) it represents run off. The areas below E_T and above R represent water deficit. The area bounded by R, E_T, R + reserve and $E_T/2$ represents effective rainfall. The lengths of availability of water periods are indicated on the diagrams.

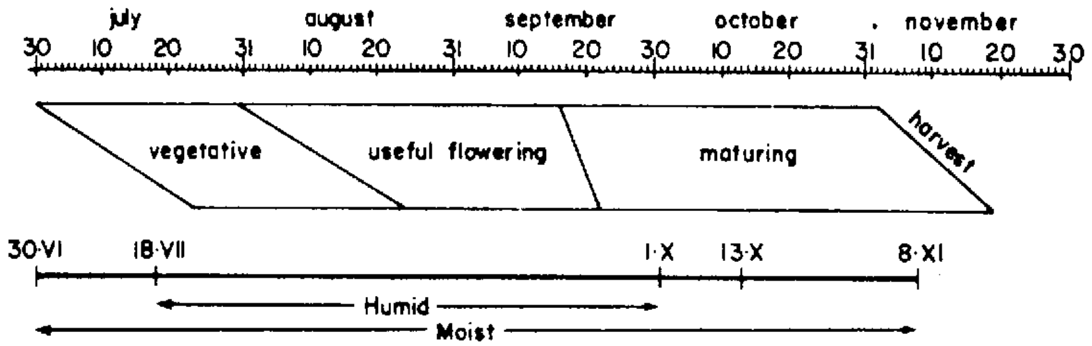

Fig 3. Recorded growing cycles of groundnut and average availability of water periods in the DIOURBEL district in Senegal. Sowing is carried out after the mean date of beginning of the moist period (E_T / 2). Useful flowering occurs entirely during the humid period whilst maturing follows it. Harvesting is carried out around the end of the humid period plus reserve. Biological data were taken from Delolme (1948), and the climatological data from the FAO/UNESCO/WMO Agroclimatology Survey Report (in preparation).

LA:SF/SD/66/3

WATER RESOURCES - INVESTIGATIONS AND DEVELOPMENT

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The purpose of this meeting is an exchange of experience and suggestions to make our work more effective.

All of us here are in some way acquainted with the Savanna Belt or with a specific part of it. We all know that in an area where practically no rain falls over half/three-quarters of the year, and where during the rest of the year the water supply is not always dependable, water is a key factor in development. The availability of land is almost always out of proportion to the very limited water resources. The water is generally the most important limiting factor for development. The type of development is generally determined by the amount of water which is available: rainfall, river flow and groundwater. We have to pay very careful attention to the investigation and development of these water resources.

As a general introduction to the subject, I should like to start with a formulation of problems of a general character which are common to several Projects represented here.

Next I will review the various types of water development for which the basic information has to be supplied.

I shall also discuss the elements of water resources to be investigated and conclude by drawing your attention to a number of points where, according to me, more co-ordinated action is needed.

1. Problems of a general character encountered in technical assistance Projects concerning water development in the Savanna Belt.

(a) Lack of existing data;
(b) lack of time: we have to produce basic information in a few years for cases where the normal standard in Western countries is at least 15 years of observations;
(c) lack of technical personnel;
(d) lack of accessibility to the points of observation;
(e) dualism in the task: we have to produce results, conclusions of the survey and we have to leave behind a service which will carry on the investigations.

These difficulties are given data with which we have to live in the best possible way. We have to arrange our Project and our program of work on the basis of such given difficulties.

(a) The lack of existing data makes it all the more necessary to make maximum use of what is available; this includes information collected elsewhere under similar circumstances.

(b) The lack of time urges us to work as efficiently as possible. For this we have to consider carefully the relationship between purposes, that is the future development of water resources and our system and program of investigations. It is also necessary to review this relationship periodically and adjust our work to it. For the short observation series obtained during the survey period, we have to find a link with some existing long observation series from which we can interpret our measurements and also arrive at an extrapolation to what has to be expected during exceptional years. In most cases we only have some long series of daily rainfall records.

(c) We have to accept realistically the shortage of qualified technical personnel and set up a program which can be handled and which makes the maximum possible use of the available man force including locally recruited personnel which has not yet had a specialized training in the field concerned. We may re-consider the applicability of observation methods which are normally used in Western countries and may find that simplified methods would be more effective under given circumstances. Also the choice of equipment may be influenced by the type of personnel available. It is useless to install very expensive equipment which is too complicated to be operated effectively in the given circumstances.

(d) The lack of accessibility of the stations can of course be overcome by road construction but this is often too expensive and takes too much time. Helicopter services are an excellent solution but may be too expensive for the full Project period. A small airplane needs many air strips and experience has taught that operation and maintenance gives many more problems than is originally foreseen. Another possibility, already mentioned above, is to find a simplified method of observation and station on the spot locally recruited staff during the rather short rainy season.

(e) Dualism in the task sometimes creates controversy. Producing results and building a service which will carry on later are sometimes difficult to reconcile. In each Project the best possible equilibrium between the two has to be decided upon. It is also necessary to distinguish clearly between observations which should continue if the UN part of the Project is closed, and special investigations to be carried out during Project operations only. One has to be very sure that a program of continued observations is balanced by the organization available to carry them out. (A well known example of failure is the UN specialist who does excellent technical work but creates a service which collapses with his departure.) The special investigations may serve the present Project, but one should make sure that they are not left behind as a dead weight of routine producing a continuous stream of useless data.

2. <u>Development of water resources</u> - Purpose of water resources investigations.

The type of development depends on the availability of water. Briefly, in order of decreasing availability, we have the following types of water utilization:

- Rain-fed agriculture, forestry or grazing;
- Perennial irrigation, orchards. The extent is determined by the seasonal minimum;

- Non-perennial irrigation. For instance during the months immediately following the end of the rainy season when much more water will be available than at the end of the dry season;
- Flood irrigation. Spreading of floods over the agricultural land;
- Domestic water supply;
- Industrial water utilization and the generation of water power are special cases by which the priority is determined by their economic importance.

Technically we need for this water development:

- Diversion system for irrigation;
- Surface storage of water varying from large reservoirs, in major rivers (Nile, Niger), to village or even household size tank (Kordofan);
- Extraction of water from superficial aquifers; if related to Wadi beds this may concern mainly underground storage of surface water (lower valleys in Jebel Marra area);
- Extraction of water from small and/or deep aquifers mainly for domestic and stock supply;
- Flood spreading for agriculture or grazing as well as for the recharge of aquifers;
- Flood protection or flood evacuation (polders and also culverts and bridges);
- Furthermore, we may have to deal with desalinization of water, water power (generally a secondary product only in semi-arid areas) and very often with silting of reservoirs.

On these large scale possible water development methods the emphasis is different in different parts of the area. It should be possible, through co-ordination of efforts and the exchange of information, to come to a division of tasks over a series of Projects for the benefit of all.

3. Survey of Water resources.

For the design of an observation program and a network of observation stations, we have to give careful consideration to the purpose of the investigations. We cannot afford the luxury of taking a hand-book and setting up a general scientific program attempting to obtain the maximum information on all aspects of the hydrological cycle. The normal task is to supply the best possible answers to a given set of questions during a period which is too short and with far less personnel than one really needs.

Normally a very general knowledge of the water resources is available beforehand. We have to decide "what is it we are looking for". Most important is to have an idea of:

- Quantities needed - large amounts for irrigation, relatively small amounts for stock water;
- The place where the water is needed;
- Which are the potentially irrigable lands;
- Need for storage;
- Importance of the quality of the water (salinity);
- Importance of sediment transportation (silting of reservoirs);
- Importance of flood peak, flood volume and of minimum discharges.

When during the survey information on other subjects such as land classification and possible dam sites becomes available, the adequacy of the program of hydrological investigations has to be re-considered and if necessary adjusted. On the other hand it is also necessary that the hydrologist makes available as soon as possible a preliminary appraisal of water resources for the use of other specialists: agriculturists, irrigation engineers, soil surveyors, etc.

The survey of water resources consists of various elements, mainly rainfall, surface water, groundwater, evapotranspiration and sediment transport and erosion. The water balance of the Project area as a whole gives an opportunity to compare results or to fill in gaps in our knowledge.

Of the rainfall we are interested in:

- the total annual amount during a "normal" year;
- the distribution over the area;
- the seasonal distribution;
- the overall yearly variation (what is to be expected in a dry year, very dry year, etc. but also how far do present project observations represent a normal situation);
- rainfall intensity and its relation to duration, area and probability is very important for problems of floods and of erosion.

Extremely important are the chances of drought and the relationship between rainfall (or drought), soils and crop behaviour.

How do we come to a practical definition of drought?

In a semi arid area like the Savanna Belt there may be a considerable difference between average and medium values. It is suggested that to represent the "normal" situation, medium values are used rather than averages (differences are often from 5 to 10 percent).

For all the elements listed above, we need the interpretation of the best possible observation series for a number of stations and we normally also had a considerable expansion of the existing network. One has to determine on a number of base stations and operate in addition a large number of subsidiary stations.

Rainfall recorders are needed for studies of rain-fall intensity but they need careful supervision and should always be accompanied by a normal rain gauge.

Totalizers may very usefully supplement the network with information on places which are difficult of access or where no reliable observer can be found. They may be also used for checking other observations (and observers).

Equipment should be of the type normally used by the national service. Observers should be checked whenever possible. Data brought by an observer should be checked before he leaves the office.

Surface water is more difficult to measure especially in wide sandy non-perennial rivers with sudden floods, as they occur frequently all over the Savanna Belt. Some base stations should be installed where accurate measurements (from cable ways?) are carried out by well qualified personnel.

With the selection of such base stations it is difficult to find the correct equilibrium between:

- suitability of the site in hydrological aspect;
- the urgency of knowledge about the discharges at certain points (future dam sites);
- the importance of the site for the hydrological system as a whole and the
- accessibility for the personnel.

Only a very limited number of such base stations can be installed. In addition, one can have a number of secondary stations where, for instance, next to water level observations, float measurements are carried out especially during floods.

Where feasible, measuring weirs should be installed or stable stage-discharge relationships may be artificially created. Stations with special purposes may also be installed, for instance temporary stations for dry season flows or discharges from springs.

Still, the problem of accurate measurements in wide sandy Wadi is sometimes almost without practical solution.

The installation and operation of sample catchments can be very important. The difficulties of such measurements should, however, not be under-estimated. More refined measurements may also be considered in follow-up Projects.

Care should be taken that continuity of observation is maintained and that actual observation data remain available for re-appraisal sometimes after many years.

Interpretation of the data for design purposes generally needs comparison with rainfall series and with observations and research carried out elsewhere. The decision on design floods for spill-ways and bridges needs especially a wide and expensive margin of safety.

Groundwater resources will be of varying importance in different Projects.

The main tools for these investigations are hydro-geological reconnaissance, observation of groundwater levels, geophysical surveys, exploratory drilling and pump tests.

Observations of groundwater levels should be carried out systematically and be continued over long periods for certain selected key points (wells). Under certain circumstances, the variation of groundwater storage in superficial aquifers may be quantitatively one of the most important elements in the water balance.

An approximation of the groundwater volumes which feed small perennial streams and springs can be obtained from the decrease of the discharges during the dry season. For superficial aquifers, the most suitable way of extraction of the water during different stages of the development process has to be given careful attention.

It is very difficult to measure the evapotranspiration under field conditions. Measurements of evaporation are in a simple form (often Piche evaporimeters) routine observations in climatological stations. They should at least be supplemented by some open pan observations.

For the rest it seems more effective to make, within the scope of general land and water resources surveys, an approximation of the expected evapotranspiration from observations of the basic climatological factors, by using a generally accepted formula.

From the water balance an idea of the order of magnitude of evapotranspiration under present circumstances can also be obtained.

Special investigations carried out in this field in some Projects will generally be of interest for others (Kordofan, Jebel Marra, Chad).

Sediment transport in rivers is normally measured by sampling the silt in suspension. In the Savanna Belt, the bed load transport in Wadis is of very great impc tance. A practical method of field observations which could be applied without too much difficulty is not known to me, apart from measuring the actual silting up of already existing reservoirs.

Co-ordination efforts and research on this subject seems badly needed.

4. Conclusion

Co-ordination of efforts in this field of water resources investigations in the Savanna Belt is needed and should be discussed here; as an introduction to this discussion, may I suggest the following points:

(i) Pooling, processing and dissemination of existing hydrological information.
(ii) Study of dynamic climatology for the area as a whole.
(iii) Agreement on a system of interpretation and extrapolation of relatively short observation series.
(iv) Agreement on a practical system of evaluation of chances of drought in relation to agriculture.
(v) Development of practical systems of determination of discharge and sediment transport in Wadis.
(vi) Practical studies of evapotranspiration.
(vii) Specialization in certain types of water development and co-ordination of results.

LA:SF/SD/66/4

GROUNDWATER IN THE SAVANNA BELT

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Introduction

As a good example of an arid and semi-arid zone, the Savanna Belt is one of the most typical areas in the world where the fullest use can be made of existing groundwater.

Any consideration of the development of the groundwater potential of the Savanna Belt should begin with an estimate of present and future water consumption, together with the geographical distribution. As usual, groundwater use should be a first priority for community water supply, in order to avoid all the diseases inherent in impounding surface water. The problem is the development of groundwater and sanitary engineering at village level, and not the quantity of groundwater available, calling for sophisticated groundwater surveys and investigations. As a second priority, the watering of livestock should present no supply problems. The difficulty here is to create an adequate network of wells according to the traditional cattle tracks and to formulate a sound strategy for bringing livestock to the slaughterhouses. Ultimately, small-scale irrigated agriculture from groundwater at village level should provide each year the necessary food, which at present depends entirely on climatic fluctuations. The demand is already pressing hard on the supply in some areas and seems likely to do so in others. As groundwater is now used mainly for irrigation, the most important thing is to find out the quantity available, which necessarily implies a groundwater survey.

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The Savanna Belt is the African tropical area defined by the transitional climate between the Saharan climate and the Sudanese climate. In the northern part of the belt, the so-called Sahel from the Arabic shore is bordered by the Sahara, from the south of Mauritania to the Red Sea through Timbuctoo, north of Lake Chad and north of Khartoum. The southern limit is defined by a line passing through Dakar to Kayes, Sansanding, Mopti, Say, south of Lake Chad through the Central Sudan, including Khartoum. The climate of the Savanna, in contrast to the Sahara, is characterized by a steady annual rainfall, still very low and occurring in the form of storms. The southern part of the Savanna Belt is wetter (between 300 to 500 mm. per annum during the three summer months) than the northern part (with less than 300 to 250 mm. per annum spread over a few days). The northern part is an arid zone, where vegetation is of desert character. The southern part is a semi-arid zone where the vegetation is denser and where some rainfed agriculture occurs (millet and ground nuts) and where there is also a little irrigated agriculture (rice and cotton). Moreover, the Savanna Belt is the most important stock raising area of tropical Africa.

Geology

The basement, made of crystalline or Precambrian rocks, is impervious. Groundwater commonly occurs in the weathered zone, very close to the surface. The Paleozoic is also impervious, with the exception of some weathered zone fractures, and some limestone interbedded in the Cambrian (Gondo aquifer) in the Devonian and Carboniferous. Some major sedimentary basins with very pervious sediments have been formed during the Mesozoic and the Cenozoic. Most of the main geological series are found to be almost identical over wide areas.

The major aquifers are found in three kinds of formation, two of which are geologic series: a related group of rocks formed in a particular period or epoch. One of the series is the main geologic feature underlying the Savanna: a sandstone series that recent explorations have shown to be of lower Cretaceous age. This sandstone, which in many places is interbedded with shale and marl, is more than 1,000 meters thick and rests on Paleozoic or Precambrian rocks that are impervious to water. The French name for it is the Continental Intercalaire; the English, the Nubian Sandstone. It constitutes an excellent aquifer.

Overlying this sandstone series is a limestone and marl series of marine origin, dating from periods when much of the Savanna was under water. About 1,000 meters thick, it is of upper Cretaceous and lower Eocene age and almost imperious to water. Above it lies the second major aquifer formation: a sandstone series of Miocene-Pliocene age. This series, also about 1,000 meters thick, is called the Continental Terminal and represents the second important aquifer of the Savanna. The third class of aquifer is represented by sand dunes, riverbeds and other surface formations dating from the Pleistocene and recent epochs.

Water occupies an aquifer under one or the other of two distinctly different conditions. If it is overlain by an impermeable stratum, it is likely to be under pressure that will cause the water to rise above the top of the aquifer when the aquifer is penetrated by a well. This is the condition described as artesian; the term is used whether or not the water rises high enough to flow at ground level. A large part of Savanna groundwater is under artesian conditions. If the water in an aquifer is not confined by an overlying impermeable stratum, it is said to be under water-table conditions. Such water is not under pressure and can be extracted only by pumping or by gravitational flow through underground canals.

Groundwater is seldom immobile in an aquifer. Artesian water in particular is likely to move over considerable distances from a recharge area. This movement is attributable to gravity. In the Savanna, evaporation is also a powerful mechanism of vertical movement: it operates as a huge pump to lower the head of the groundwater.

Evaporation from surface water can entail a discharge of more than 10,000 cubic meters a day per square kilometer. The effect is smaller, of course, for water lying below the surface. In the Savanna, however, evaporation or evapo-transpiration continues to have a significant effect at depths of 20 metres or more. If this subsurface evaporation were only between one thousandth and one ten-thousandth of surface evaporation (the figure is a matter of speculation for want of sufficient data) it could still represent a loss of as much as 3,000 cubic meters a year per square kilometer.

Evaporation, which probably accounts for the largest discharge from the aquifers, takes place in vast depressions. Under the more normal climatic conditions of the past, this depression would be a lake recharged by both rainfall and the artesian aquifers. Today the depressions are dry except during periods of rain.

The structure pattern is determined by some major faults crossing Africa in a north/south or northeast/southwest direction, breaking down the Savanna Belt into different basins. Some large sedimentary basins originate from these faults, in between which subsidence takes place in the Graben zones. The uplift of the faults is sometimes over 3,000 meters. The Tectonic fractures took place after the end of the Palezoic and in some places since the Precambrian. Subsidence is still active in some basins, for example in the Chad basin. The main characteristic subsidence basins are from the west, the Senegal, Niger and Chad basins. The Chad basin covers an area of 1,100,000 square kilometers. It is one of the largest closed basins in the world. The structure of the basin is somewhat complex. A graben, 300 km. wide, 4,000 m. deep, stretches in a southwest/northeast direction below the actual Chad lake. Artesian conditions are known to exist over an area of more than 300,000 square kilometers in the continental terminal and locally in the continental intercalaire. On both sides of the graben a thinner cover of Neogene sandstone is also a good aquifer under water table conditions. The main recharge areas are in the south from the Chari and Logone rivers and in the southwest in the Bornou region. The actual Chad lake represents a perched surface water reservoir fed by 35,000 million cubic meters per year, without significant recharge from the groundwater reservoir. The discharge area of the artesian aquifers is to the northeast of the Chad Lake in the Bodele depression, which can discharge to the atmosphere several cubic meters per second. The Chad basin was still closed in the Pleistocene period, as is shown by the evidence of a huge lake of over 500,000 square kilometers in extent.

The Niger basin is subdivided into the basin of Niamey and the basin of Timbuctoo, connected through the Strait of Gao. The Timbuctoo basin represents the Upper Niger, which was originally separate from the Lower Niger. The groundwater basin still represents the original feature and is mainly recharged from the so-called internal delta of the Niger river where the Niger floods 50,000 million cubic meters each year over the surface, of which only a small part contributes to the aquifer. The aquifer is in the continental terminal, a Neogene sandstone 100 m. thick. Groundwater flows to the north and reaches the depression of Taoudeni, where it mixes with water from the continental intercalaire aquifer and evaporates. The Niamey basin is a graben 100 km. wide, extending from Bourem southeast to Niamey, and a platform dipping slightly from the Air Mountain to the graben towards the southwest. The platform is overlain by sandstone and limestone ranging from Lower Cretaceous (continental intercalaire) to Neogene (continental terminal), the total thickness of which is about 800 m. on the platform and over 2,500 m. in the graben. The various aquifers are artesian to the southwest. The natural recharge of the Niamey basin is from the Niger river in the vicinity of Gao, from the Hoggar Mountains (Adrar des Iforas and Air) and the Sokoto River. The hydrostatic level is at an elevation of about 500 m. in the vicinity of Agades, where the groundwater divide is located between this basin and the Chad basin along the Agades-Zinder meridian.

Almost all the water-bearing formations are sandstone or gravel aluviums in the river beds. Limestone is almost inexistent. The soluble salts (alkaline, magnesium or calcium) are very rare, and as a consequence groundwater is not highly mineralised, in spite of the heavy evaporation of over 1,800 millimeters per year and of the low hydraulic gradient of the aquifers.

In the large area of paleozoic and basement rocks, originally impervious, the conditions of weathering play a major role in making the rocks porous. The nature of the strata is also of importance. The basic rocks of precambrian, older and richer in calcium than the younger volcanic rocks, are better weathered in the same way as the granites, calco-alkalines, are more weathered than the acid granites. Climate is also a factor. The same granite will produce 40 to 50 m. of impervious arena in a wet tropical area and only a few meters of very pervious arena in the arid zone. For instance, the paleozoic shales, assumed to be always impervious, represent in a few places of the Savanna Belt a sub-surface aquifer of some importance; while the paleozoic sandstones, assumed to be pervious, are sterile.

In the Savanna Belt the basic tools with which to approach an inventory of groundwater resources are studies of rainfall and of surface run-off, as these obey a few simple rules owing to the relative regularity of the annual cycle. The most important factor in the field of groundwater is the natural recharge of the aquifers. As a preliminary assumption, evapotranspiration deficit in the Savanna Belt is 400 mm. per annum in the barren zones, 500 to 600 mm. per annum in the Baobab Savanna. In other words, the natural recharge of the aquifers is by direct infiltration of the rain, when rainfall is over 400 mm. per annum in barren zones or 500 mm. per annum in Savanna zones. More precisely, below these figures, the natural recharge occurs only from run-off through recharge of the river beds or of the alluvial fans of the piemont areas. In the Savanna Belt, surface hydrology and run off deficit are the main means of discovering the amount of potential groundwater resources available yearly. The suppression of vegetal cover will result in an increase of the recharge from the run-off through the river bed.

The normal outlet of an aquifer is a spring or a perennial river bed, which is very rare in the Savanna Belt. Here the most frequent outlet is evaporation or evapotranspiration of the aquifer in the lowest part of the groundwater basin, such as depressions, fossil and recent river beds, marshes etc.

Any attempt to draw down the hydrostatic level by pumping in the discharge area would eliminate the losses occurring from evaporation and therefore make available a new water resource.

Groundwater development should concentrate finally on the alluvial water tables and aquifers easily reached by hand-dug wells or shallow boreholes. Taking into account the hydrogeological conditions, the location of wells should finally be a matter of strategy and planning on a large-scale basis. Wells will still remain the major problem, as skill is required whether for hand-dug wells or drilling techniques. For the last fifteen years, private firms were almost the only means, but proved very expensive. The final solution should be to create in every country a technical organization with the necessary modern equipment and trained personnel to carry out the execution of wells. Some problems could still arise from the pumping of the wells and from the necessary energy, whether by human, animal or mechanical means. However, some useful experience has been gained in this field.

The time has now come when it is no longer necessary to devote great effort to groundwater surveys and investigations, as the knowledge and experience of groundwater gained during the last fifteen years are valuable. The major action should be to plan and execute the necessary wells to supply water for human life and livestock and, wherever possible, for village irrigated agriculture.

LA:SF/SD/66/5

PLANT PRODUCTION AND POTENTIAL, INCLUDING RANGE AND PASTURE, FOOD, FODDER, FUEL, TRIAL FOREST SYSTEM (FORAGE RESOURCES OF THE SUDAN SAVANNA POTENTIALS AND PROBLEMS)

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I. INTRODUCTION

The half million square miles of savanna in the Sudan represents vast forage resources and challenging problems of exploitation and development. Some broad aspects of these resources and problems are briefly outlined in this paper. This example from the Sudan may be useful for orienting discussions of related situations in other countries and considering opportunities for resource development throughout the African savanna belt.

Emphasis on naturally-occurring grazing resources in this report reflects the viewpoint that these warrant first attention in a logical approach to the development of forage potentials in this area. These naturally-occuring grazing lands are often termed "range" to distinguish them from the sort of improved pasture that is commonly associated with cultivated agriculture.

II. SAVANNA CHARACTERISTICS IN THE SUDAN

Definition and extent:

The term savanna has been used by geographers to describe extensive areas of grassland in the hot tropics. More specifically, as described by Dansereau (1957), it is grassland with scattered trees; "an intermediate type between forest and grassland in many ways, but so peculiarly different from either that it can hardly be denied a character of its own".

This identified, woodland savanna can be correctly applied to half of the Sudan, the area south of latitude 14° north, where annual rainfall ranges between 300 mm and 1300 mm. Exceptions include small amounts of montane vegetation and a narrow strip along the Congo and Uganda borders where the climax vegetation would be rain forest.

Harrison and Jackson (1958), following Andrews (1948), recognised two primary subdivisions: low rainfall woodland savanna and high rainfall woodland savanna, the separation coming between 800 mm and 1000 mm of annual rainfall. They classified separately the enormous flood plain region which is inundated during the rainy season. However, the flood region can be considered a special area of high rainfall savanna since it is located within this rainfall zone and it has the grass cover, dry season, and prevalent fires that characterize savanna.

The area of savanna relative to other vegetation regions is approximately as follows (Harrison and Jackson, 1958) :

Regions (and annual ppt.)	Approximate Area Thousand sq. mi.	% of total
Desert (0-75 mm)	280	29.0
Semi-desert (75-300 mm)	190	19.6
Savanna:		
Low rainfall (300-800 mm)	266	
High rainfall (800-1300 mm)	134	
Flood region (800-1000 mm)	95	
Total Savanna	495	51.1
Montane vegetation	2.5	0.3
TOTAL	967.5	100.0

General land use and significance

The savanna is the primary grazing and agricultural areas of Sudan and vital to the livelihood of most of the population. The great majority of Sudan's people are subsistence farmers who characteristically own a few livestock. Nomadic or semi-nomadic people make up about one-third of the Sudan's population and own about 90% of the country's livestock.

Little more than 1% (2-3 million hectares) of the Sudan's land area is actually cultivated. About half of this (1.3 million ha.) is under irrigation in riverain agricultural and in large development schemes. The remainder (2 million ha.) is rain-fed cultivation largely on sandy soils in the savanna belt.

Shifting agriculture is the rule in dry farming, with a long period of fallow to allow for "regeneration" of the soil to support a few years of agricultural cropping. The fallow land is grazed along with surrounding range. A variation of this system, termed the gum-cultivation cycle, is practiced in some areas, gum arabic being obtained from regenerated Acacia senegal during the fallow period.

The large irrigation schemes are devoted to cotton - the principle export crop. Sorghum and millets are the staple food crops of rain-fed agriculture in the savanna. Other subsistence crops include lubia (Dolechos lablaba), primarily for cattle feed, and smaller quantities of groundnuts, water melon, sesame, and miscellaneous pulses and vegetables.

Forestry in the Sudan is somewhat unusual but an essential form of land use. Woody vegetation of forests and grazing lands is the only local source of fuel in a country lacking coal and oil resources and of undeveloped hydro-electric power.

Gum arabic, from the savanna belt, is Sudan's only forest export. It ranks second or third among exports, far below cotton but well above livestock (Rep. of Sudan 1966). Production of commercial timber for domestic use is confined to the vicinity of navigable rivers, railways or main roads.

Livestock numbers and trends

Savanna forage supports the bulk of Sudan's large and increasing livestock populations, estimated as follows (Halbrook and Yust, 1964):

Estimated livestock populations (millions of animals)

	1944	1954	1964
Cattle	3.1	5.3	10.0
Sheep	4.8	6.1	10.0
Goats	3.4	5.2	7.0
Camels	1.1	1.2	2.0

Although most of the camels and part of the sheep use the northern semi-desert and desert zones extensively, many of them migrate to the savanna zone during the late dry season for water and forage.

Livestock numbers have been increasing since the beginning of this country. A rapid growth in recent years, especially in cattle and sheep numbers, is attributed to a mass immunization campaign.

Livestock contributions to export earnings, however, are not increasing, and are disappointing in view of the large livestock populations. During the three-year period, 1962-1964, total livestock products averaged only 6 percent of total exports - less than one-tenth the value of exported cotton and cotton seed (Republic of the Sudan, 1966):

Commodity		£S. millions	Percent of Total
Ginned cotton		40.5	56
Groundnuts		7.4	10
Sesame		5.6	8
Gum arabic		5.7	8
Cotton seed		3.5	5
Oil cake		3.2	4
Livestock Products :			
Camels	2.5		
Hides and Skins	1.1		
Sheep	.6		
Cattle	.3		
		4.5	6
Other exports		2.3	3
Total domestic exports		73.0	100

Obviously there are marketing problems to be solved if livestock and the savanna forage resources are to make their potential contribution to the export economy of the country.

Climate

The savanna climate is classified as tropical continental climate with a wet-and dry trend (Dansereau, 1957). In most of the Sudan savanna, the rain period is 3 to 9 months and the dry period 9 to 3 months. Rains come with the inter-tropical front which moves northward across the savanna belt during the period March to July, and recedes southward during September to December. Thus, both the length of the rain season and the total amount of precipitation decrease from south to north. Humidity and cloudiness, of course, follow the same trend. Average annual rainfall ranges from 300 mm in the north to 1300 mm in the south, but it varies greatly from year to year. Temperatures tend to be highest in the southern part of the belt during January through March, but in the Northernmost part from March through May. Temperature extremes and differences between summer and winter are most pronounced at the driest, northern edge of the zone.

Soils

The fact that soil characteristics provide a useful and convenient criterion for ecological classification (Harrison and Jackson, 1958), reflects the marked influence of soils on vegetation in the Sudan. Very generally, soils of the savanna region are sands in the northeast, clay in the center and east, and latisols in the southwest. Various "hill soils" are associated with limited mountains areas, including the Jebel Marra massive.

Stabilized, soft dune sands, called "Qoz", form the northwest portion of the zone. Though low in mineral nutrients, the sands absorb all the rainfall and have better moisture relations and better vegetation than clays where rainfall is limited. Accordingly, the savannah extends farthest north into the semi-arid zone on sands.

The dark cracking clays of the flat, monotonous, clay plains support relatively poor vegetation considering their good mineral status (Harrison, 1955). These soils absorb little water after swelling closes the cracks. Above 600 mm of rainfall, surface flooding occurs. Most of the southern clay plain is in the "flood region" and affected by temporary flooding; a significant proportion is swamp.

The northern clay plain has less flooding and for a shorter period. This northern plain is providing the bulk of the land for extensive irrigation and mechanized dry-farming developments.

Non-cracking clays that are impermeable below the top few inches occur scattered in many localities as smooth clay flats. The alternation of these flats with slightly higher areas of stabilized dune sand results in a vegetation complex which Harrison and Jackson (1958) called the "Baggara Repeating Pattern". It is a prized grazing type in southern Darfur where the sand zone and clay plains merge. A comparable alternation of non-cracking clay with two kinds of cracking clay, one temporarily flooded, produces another ecological complex called "Raqaba Repeating Pattern" (Harrison and Jackson 1958).

Laterite catena soils, mostly red loams, are confined to the Ironstone Plateau of Southwestern Sudan. There rainfall exceeds 800 mm and the vegetation is high rainfall woodland savannah.

General vegetation characteristics

The wide range of rainfall and soils encompassed by the Sudan savannah results in an equally wide range of ecological situations and numerous plant communities. In line with the south-north gradient of decreasing rainfall, vegetation belts tend to be oriented east-west, although they are markedly affected by soil conditions. The vegetation as a whole is not well understood, although it is being studied intensively in the Kordofan and Jebel Marra projects. Relatively little is yet known specifically about forage values and other pertinent characteristics of most savannah species.

A survey by Harrison (1955) is the main present source of information on natural vegetation of the Sudan as a whole from the viewpoint of forage resources.

Although vegetation is most meaningfully discussed in reference to ecological units, a few general features of the savannah vegetation might be mentioned that relate to forage value or management.

One striking feature is the cosmopolitan distribution of the genus Acacia, which is represented by a number of different species in the different climatic situations throughout the savannah belt.

Non-thorny trees, however, become dominant in the higher rainfall zones. In varying degrees all savanna vegetation exhibits adaptation or tolerance to drought and fire. Tolerance of fire is best developed in herbaceous plants, which probably accounts for their prominence in the savanna flora. Annual grasses and herbs are unusually prominent relative to perennials in many situations. Besides special adaptation to fire, annuals can withstand heavy grazing best and they invade disturbed sites most aggressively.

The growth period in the savannah coincides with the rain season, most herbaceous species maturing and going dormant as soil moisture disappears in the dry season. Thus, only mature, dry herbage is available for several months. Annuals tend to mature first, often well before the end of the rain season. In perennials, the growth period usually is longer, making fuller use of available moisture and extending the "green forage " period. Woody plants tend to have the longest growth period and often comprise the only visible greenness on the landscape late in the dry season.

Although the herbage is most nutritious during the growing season, much of it remains palatable and usable when dry. Quality, however, varies greatly between species and between localities, or ecological situations.

III. PRESENT AND POTENTIAL PRODUCTIVITY

The best available measure of productivity of grazing lands in the Sudan is the livestock that are supported. An estimated 29 million total livestock (excluding horses and donkeys) amounts to 16,700,000 animal units, each equivalent to a mature cattle, five sheep or goats, or 0.6 camel. Of the year-long support of this total, three-fourths (the equivalent of 12.5 million) now comes from the various divisions of the savanna belt (Table I.) This is only half the estimated number the savanna is believed capable of supporting. Major limitations and practical approaches visualized for achieving the potentials are outlined in Table 2. These are made from the viewpoint that natural range will continue to be the major forage resource for the foreseeable future, although cultivated forages and feedstuffs also are necessary for effective exploitation of the natural forage in many situations.

Nomadism and range utilization

The nomadic seasonal migration of livestock that characterizes range utilization in the Sudan has both desirable and undesirable features. Basically, it is an effective adaptation of livestock management to important characteristics of the natural environment: 1) both regular and erratic variation in forage associated with climate; 2) seasonal and variable supplies of drinking water; 3) seasonal availability of major forage resources otherwise avoided because of flooding, soft soils, insect harassment and undesirable living conditions.

The features of mobility and group action developed in Nomadism can have practical application in improved range management. But the extent and distance of travel will need to be greatly reduced in many cases in the interest of both livestock welfare and practical management.

The viewpoint is adopted here that the most compelling former reasons for migration can be overcome with modern technology in insect control, water development and forage management; and humans can adapt to environments that are somewhat less desirable than may be preferred. Accordingly, the estimates and proposals outlined in Tables 1 and 2 visualize only restricted seasonal movement of livestock within zones or between adjacent zones.

Regional distribution of range use

Substantial redistribution of grazing use is essential to effective exploitation of forage potentials in the Sudan. Although the total grazing capacity is estimated at about twice the present livestock numbers (Table 1) (Halbrook and Yust, 1964), severe overgrazing is commonly observed - especially in the driest savannah zones and the adjacent semi-desert region. A relatively narrow belt running through El Fasher, El Obeid and Kassala now receives migrant livestock populations from both north and south and in both the dry and the rain seasons: camels, sheep and goats come from the north for water during the late dry season; cattle Nomads come from the south to escape biting flies and mud during the rains. The results are overstocking, range deterioration, competition for forage, hungry animals, excessive exertion in travel between water and forage, and great economic loss in terms of animal productivity. Nearly two million animal units (cattle equivalents) will need to be diverted elsewhere to approach the estimated proper capacity of the savanna portion of this belt of livestock concentration.

The surplus capacity is in the high rainfall savanna and the wettest portion of low rainfall savanna - particularly the clay areas. Although tsetse fly and trypanosomiasis inhibit use of much of the high rainfall deciduous woodland savannah at present, there appear to be good possibilities for overcoming this deterrent through prophylactics and drugs and fly control.

In other areas, the reasons for present neglect of great forage potentials seems largely related to established customs based on environmental preferences of the livestock owners. Major nomadic tribes, such as the Baggara, tend to avoid highly productive portions of the savanna belt during the rain season; reportedly because of intolerable mud and biting flies. Yet, other tribes use the flood region yearlong, at a high intensity of stocking, with only local migration as water levels rise and fall. The flood region example suggests opportunities for better utilizing wasted potentials in other savanna zones. This could be facilitated by harvesting forage for periods when grazing is restricted by water, by measures for reducing impacts of biting flies, and by feeding minerals where necessary.

Local grazing distribution and water development

Local distribution of grazing within regions also presents acute problems - particularly in the low rainfall savannah and adjacent semi-desert zone. Invariably, grazing values are destroyed where livestock concentrate continuously. Deterioration tends to grade away from permanent water, roadways and migration trails - grading from denudation at the concentration centres to relatively unutilized range at the perimeter.

Drinking water is the obvious key to local grazing distribution -- and also to grazing management. Attempting to make more range available and to relieve heavy concentration of livestock and overgrazing, the Sudan Government has spent large sums on water development. From 1957 to 1964, for example, the number of artificial water sites was more than quadrupled by constructing nearly a thousand water yards, reservoirs, and dams (Holdbrook and Yust, 1965). This is reported to have made 74,000 square miles of additional range available to cattle.

Unfortunately, however, improved management has received less attention. With little control or management of grazing use, the range is deteriorating around the new water points. Thus, the malady of range depletion is being spread by the treatment intended to cure it. Meanwhile, demands for additional water development continue to increase with the steady buildup of livestock numbers and the continuing decline in carrying capacity of deteriorating range. To stop this vicious cycle and avoid its predictable consequences, water development obviously must be accompanied by appropriate management to maintain range productivity. This fact is now being recognized in the Sudan.

Because water is so effective for controlling livestock distribution it is the most efficient management tool available for obtaining rotational grazing. Thus, the need for additional water development will grow as management is intensified. Emphasis will be on maximum distribution; with quantity limited to actual needs during the desired period of use. Closure of water points is as important to range management as is development of water.

Range fires

Fire consumes far more forage than livestock utilize in the Sudan, and it is the usual cause of forage shortage in the savanna region. In an avarage year, an estimated 80 percent of the savanna medium and high rainfall zones are burned, and 30 to 60 percent of the low rainfall zone (Baasher 1961). Although fire is a valuable management tool for improving forage quality and for ecological manipulation of the vegetation, promiscuous and "accidental" burning is incompatable with purposeful management and effective utilization of range resources.

A pilot scheme, started in 1954 in southern Darfur Province, has demonstrated the possibilities for increasing grazing capacity, extending dry season grazing, reducing migration travel, and improving livestock productivity by controlling fires and saving valuable forage that usually is burned (Baasher 1961). Preventing or controlling fire is clearly one of the most diffficult problems facing improved management of savanna grazing lands. At the same time, learning how to use fire mostly effectively and beneficially presents a challenge to range mangement and research.

Grazing management

Improved systems of grazing management are needed in the Sudan not only to provide adequate quantities of forage for the livestock throughout the year, but also to improve or maintain the quality of forage produced. The need for management is really appreciated where lack of forage is reflected by hungry animals. Less obvious, however, is deterioration in forage quality that frequently occurs through gradual replacement of the most palatable and nutritious species by less valuable plants. Some of the most desirable forage species have already disappeared from extensive areas of the semi-desert and adjacent portions of the low rainfall savanna. (Harrison, 1955). That this deterioration process is in progress elsewhere — undoubtedly accentuated by fire — is indicatedby a scarcity of desirable pernnials such as Andropogon gayanus in some areas where they are ecologically adapted.

Fortunately, range deterioration from grazing is not yet serious in the savannah belt as a whole; probably because relatively little of it has yet been used during the growing season. As use is intensified and extended toward the potentials, however, appropriate management practices will need to be devised that will provide high quality forage and also maintain yield by satisfying growth requirements of the best plants.

At present, grazing systems are needed for stopping and reversing deterioration in the heavily used low rainfall savanna areas; also for integrating range grazing effectively with forestry and agriculture.

A rotational grazing approach appears most promising since uniform distribution and control of utilization intensity are not feasible. Practical and effective management systems will need to tolerate the heavy use that is unavoidable near water and other concentration areas. Plant vigor and productivity of perennials will need to be maintained through periods of rest from grazing. The best practices will most nearly satisfy the requirements of both the livestock and vegetation. Although considerable study and experience will be necessary to define optimum management for the various ecological situations, substantial improvement ought to be easy to achieve. Practically any change from continuous grazing and repeated burning will be an improvement.

Intensive development with improved forages

Experience indicates that improved forage species can be established wherever crop agriculture is feasible. In general, this includes the entire savannah region. Theoretical potentials for producing forage and fodder, even with presently known plants and procedures, would be fantastically large on a regional basis; but probably meaningless from a practical viewpoint. Economic considerations suggest that less expensive methods of ecological manipulation offer a more practical approach for satisfying forage demands on the vast areas of natural grazing lands in the Sudan for many years. However, there are important exceptions to this generalization in local situations.

Integration of forage and livestock production into the large scale agricultural schemes of the Sudan is receiving considerable attention. To facilitate this integration, conversion of adjacent natural range to improved pasture would provide additional carrying capacity needed during periods when grazing is difficult to accommodate in the irrigated cropping schemes. Additional capacity also may be needed to replace the natural grazing usurped by the agricultural schemes.

At present the most widespread situation where establishment of improved pasture and forage appears clearly justified is around large villages to meet the needs of local livestock. Nearby grazing lands usually are so deteriorated that natural improvement is slow under village management alone. This situation is prevalent in the northern part of the low rainfall savannah and more so in the adjacent semi-desert zone. Presumably it could be alleviated through establishment of permanent pasture or incorporation of more forage into the prevailing system of shifting agriculture — logically in place of the natural fallow (Skerman,1966). A number of species appear adapted for this purpose: the legumes, Clitoria ternates (kordofan pea), Phaseolus trilobus (Philipsara), Cajanus indica (Pigeon pea), Crotolaria juncea (sunn hemp), Vigna spp. (annual cowpeas), and Stizolobium deeringianum (velvet beans); and the grasses Andropogan gayanus (hirta grass), Cenchrus setigerus (foxtail), and Panicum antidotale (blue panic grass).

Improvement of natural range by the introduction of desirable forage species also seems justified in special cases. This approach is recommended (Table 2) in three zones where palatable perennials are needed to improve forage quality during the dry season. Such range seeding would be of an extensive, low-cost nature in which the introduced species would be maintained and increased through ecological manipulation with controlled grazing and burning. The precise methodology for savanna conditions has yet to be worked out.

Integration of grazing with gum production and forestry

In a special variation of the crop-fallow system of shifting agriculture, gum arabic is obtained from regenerated Acacia senegal during the fallow period. This provides an additional cash crop of considerable value. The further inclusion of improved grazing into the system has been proposed (Skerman, 1966). This would appear to have practical application since gum production is concentrated in the low rainfall savannah where forage improvement is needed near villages. Observations suggest that improved forage plants and judicious grazing would not inhibit gum production.

Broader aspects of integrating grazing with forestry also warrant consideration in the savannah belt. Antagonism toward grazing among foresters in general has developed from repeated examples of grazing damage to forests in many countries. However, in most cases the damaging grazing was excessive and unmanaged. Damage can be avoided with adequate control of grazing intensity, season of use, and kind of livestock.

This has been demonstrated in other countries including the United States. In fact, grazing the herbaceous vegetation can benefit forestry under some circumstances by reducing fire hazards and also favouring establishment and growth of trees by reducing grass competition. Logic suggests that integration of grazing and forestry is necessary to fully utilize savanna resources, and that a multiple-use approach to management could benefit both forest and livestock interests.

IV. SUMMARY

1. Natural forage on the one-half million square miles of savanna rangeland half of the country's total area comprises the main forage resources of the Sudan. This forage supports roughly three-fourths of Sudan's livestock, estimated as follows (in millions): cattle, 10; sheep,10; goats, 7; camels, 2. This amounts to 16.7 million animal units equivalent to mature cattle; of which 12.5 million are supported by savanna rangelands.

2. The potential capacity of the savanna is estimated at 25 million animal units - double the present stocking. However, most livestock suffers from forage shortages at present. Difficult problems and serious limitations must be overcome in attaining the potentials.

3. Major problems and limitations include: excess stocking and deterioration in some zones, and little use in others; destructive fires; shortage of drinking water; and biting flies, mud and unfavourable living conditions during the rain season - the period of growth and highest forage values.

4. Proposed approaches for developing and exploiting the forage potentials include: redistribution of grazing use among savanna zones and development of yearlong maintenance within zonal regions without limited seasonal migration; fire control; water development in combination with effective grazing management; range seeding where needed to improve forage quality; co-ordination and integration of range grazing with commercial and subsistence agriculture, and with forestry and wildlife management.

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TABLE 2 PRESENT FORAGE AND USE CHARACTERISTICS, LIMITATIONS AND PROBLEMS, AND PRACTICAL APPROACHES TO ATTAINMENT OF GRAZING POTENTIALS IN MAJOR ECOLOGICAL AREAS.

Rainfall (mms.)	Type of Predominant Forage; Palatability; Productivity	Season Used Kind of Stock	Limitations; Problems	Practical Approaches Toward Potentials.
I.	**Low rainfall Savannah on Clay**			
	a. (1) Acacia mellifera thornland on cracking clay (northern clay plain)			
400–570	Short annual grasses; good palatability at all stages; yields low; minor contribution from browse.	Rain period and yearlong; all livestock	Overstocked; moderate deterioration.	Control Acacia mellifera where dense; reduce stocking; improve grazing management; prevent fire; integrate farming (irrigated and dry) with range grazing.
	a. (2) Acacia mellifera thornland on soils formed in situ (western Darfur)			
400–500	Short annual grasses; fair palatability; very low yields; moderate contribution from browse.	Rain period and yearlong; all livestock.	Excess stocking; deteriorated.	Reduce animal numbers; improve grazing management; prevent fire.
	b. Acacia seyal-Balanites thorn savannah.			
570–800	Tall annual and perennial grasses; high yielding; palatability of annuals becomes low after maturity; perennials mostly unpalatable.	Early dry season; cattle, sheep.	Fire and lack of water; flies and wet conditions in rain season.	Work toward yearlong use; water development with fire control; early grazing or harvesting of annual forage during growing season; seeding high quality perennials; integration with farming.
	c. Anogeissus-Combretum hartmannianum woodland savannah			
800–900	Tall annual and perennial grasses; high yielding; palatability varied, most annuals not grazed when dry in presence of mostly green and palatable perennials	Early or late dry season; cattle.	Fire and lack of water; flies and wet conditions in rain season.	As above (b) in regard to water, fire, and forage utilization; increase acreage of present perennials by management and seeding; overcome fly hazards.

TABLE 2 Cont'd

Rainfall (mms.)	Type of Predominant Forage Palatability; Productivity	Season Used; Kind of Stock	Limitations; Problems	Practical Approaches Toward Potentials
2	Low Rainfall Savanna, on Sand:			
	a. Acacia senegal thorn savanna			
300-450	Short annual grasses and herbs; generally low yielding; highly palatable, especially herbs; moderate contribution from browse	Yearlong; all livestock (migration from adjacent zones).	Overstocking; conflict with gum and cultivation; moderate fire incidence.	Develop policies to reduce friction between grazing and other land uses; reduce stocking; manage grazing through water control; develop distributed water in limited quantities.
	b. Combretum-Dalbergia-Albizzia woodland savanna			
450-600	Short annual grasses and herbs moderate yielding; highly palatable, especially herbs; perennial grasses, when present, unpalatable; moderate contribution from browse.	Yearlong in north southern part vacated after early rains; all livestock(camels minor in south)	Flies and wet conditions in southern part; moderate fire incidence, and water shortage.	Improve grazing management, especially in rain season; establish perennials adapted to sandy soils; prevent fires; develop supplemental water.
	c. Terminalia-Sclerocarya-Anogeissus mixed deciduous woodland savanna			
600-900	Annual grasses and herbs; with occasional tall perennial grasses; good palatability; moderate yield; minor contribution from browse (sheep benefit from leaf-fall after fires).	Dry season and early rains; cattle, sheep.	Flies; fires and water shortage in dry season	Work toward yearlong use; water development; increased stocking; fire control; introduce perennials; improve management, and feed minerals.

TABLE 2 Cont'd

Rainfall	Type of Predominant Forage; Palatability; Productivity	Season Used; Kind of Stock	Limitations; Problems	Practical Approaches Toward Potentials.
3	Low Rainfall Savanna Special Areas:			
	a. Toposa area — mixture of varied sites, eastern Equatoria			
500-700	Mixture of types of coarse perennials and short annual grasses and herbs; high contribution from palatable browse; moderate yields.	Almost yearlong; cattle, sheep, goats and game animals.	Fire; game competition; preditors in some places.	Fire control and water development with grazing management; develop policy for game-livestock coordination. (an isolated area with complex of problems).
	b. Hill Catena-mainly Nuba mountains and Jebel Marra massif.			
400-700	Mixed types of palatable and unpalatable perennial and short, palatable annual grasses and herbs with a high contribution from browse; moderate yielding; extensive cultivation.	Almost yearlong except heavy rain period	Temporary flooding of drainages and hill bases; flies; fire; deterioration.	Water spreading and establishment of good perennials; brush control on deltas and low areas of water courses; prevent fires.
	c. Baggara repeating pattern — alternating areas of sands and cemented clays			
600-700	Mixture: short and tall annual grasses and herbs of high palatability, and some perennials (in places) with prolonged period of palatable green forage; moderate yields.	Dry season; cattle and sheep.	Fire; partial flooding; flies; some water shortage.	Develop yearlong management; control fire; establish perennial forage species; control brush; develop distributed water; reduce fly hazards.
	d. Raqaba repeating pattern—alternating types in southern Darfur and Kordofan			
700-900	Tall annual grasses and herbs and browse on main areas between extensive water courses and temporarily flooded lowlands where palatable perennials grasses are green in dry season; high yielding.	Late dry season; cattle, some sheep.	Flies and wet conditions; fire; some water shortage in late season; preditors in some areas.	Prolong use and increase stocking through water development with fire control, grazing distribution and management, effective burning and brush control; use prophylactics and repellants, or control flies.

TABLE 2 Cont'd

Rainfall	Type of Predominant Forage; Palatability; Productivity	Season Used Kind of Stock	Limitations; Problems.	Practical Approaches Toward Potentials.
4	High Rainfall Woodland Savanna:			
	a. Anogeissus-Khaya-Isoberlinia deciduous woodland savanna			
900-1300	Excellent tall perennial forage species, remain green when grazed or burned; high yielding (where tree competition is limited).	Limited use by livestock and game.	Fly hazards; social and economic factors.	Good potential for livestock; use prophylactics and repellants for flies; allow for game use; maintain balance between trees and grass on watersheds.
	b. Woodland savanna recently derived from rain forest			
Above 1300	Excellent perennial grasses with almost yearlong growing season; high yielding where tree growth is controlled by fire, game grazing, or cultivation clearance.	Limited use by game animals	Tsetse and other biting flies.	Encourage livestock through suppression of biting flies and use of prophylactics and drugs; control woody growth; manage grazing and coordinate with forestry and game.
	c. Flood plain ("high land", intermediate land, seasonal swamp, permanent swamp).			
800-1000	Permanent swamp (small area): perennial grasses, sedges, and herbs of moderate palatability and yield. Seasonal swamp (small area): excellent perennial grasses; high yield. Intermediate (over 80%): perennials of mixed palatability; generally good. Higher land (minor): annuals and perennials, palatable and unpalatable.	Yearlong; mostly cattle. (Seasonal swamp, late dry season; Intermediate land, early dry season and early rains; higher land, middle and late rain period).	Flooding; flies.	Mechanical harvest of forage; water control in parts; control of unpalatable species (Phragmites, Imperata, Cyperus); controlled burning.

LA:SF/SD/66/6

BUSH CONTROL IN SAVANNA DEVELOPMENT

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The problem of bush encroachment

Savanna is essentially a type of vegetation in which a balance is maintained between a permanent grass cover and a variable number of trees or shrubs. Regular burning is often an important factor in maintaining the balance. Any factor disturbing the balance by reducing the competitive power of the grass (e.g. by overgrazing) or increasing that of the woody species (e.g. by exclusion of fire) leads to a thickening up of the trees and shrubs or bush-encroachment. Continuing operation of such factors leads, on the one hand, to the formation of dense scrub inaccessible to grazing animals, and on the other, to soil-erosion as a consequence of excess grazing pressure on limited areas and deterioration of the grass cover.

Benefits of bush control

The principal benefit to be obtained from controlling bush is increased grass production, mainly as a result of reduced competition for moisture. Few figures are available on the magnitude of the grass response under African conditions, but in savanna in Rhodesia under an average annual rainfall of 26 in., ringbarking of *Brachystegia* and *Julbernardia* is reported to have increased the yield of air-dry grass from 317 lb/acre (the average over 4 years) to 1300 lb/acre. In the U.S.A. chemical control of mesquite in an area of 16 in. rainfall has almost doubled the production of native grasses for a period of 6 years and the yield of a sown species has been increased three times. Additional benefits from bush control are increased ease of handling livestock in cleared areas and, in some cases, eradication of poisonous plants .

Methods of controlling bush encroachment

A. Biological control

Control of bush by the introduction of phytophagous insects has been spectacularly successful in a few instances, notably against *Opuntia spp.* and *Lantana*. The best results are obtained where a single species (preferably introduced) predominates over a large area and the chances of success on the normally mixed bush communities of Africa may not be very great. Nevertheless the Commonwealth Bureau of Biological Control in Trinidad is anxious to help in the development of control methods for any important plant pest and the possibility should be borne in mind.

Control by intensive browsing, normally by goats, has achieved limited success in trials in various parts of Africa. Goats, however, do not appear to be very selective between bush and grass, and are only likely to be of use on limited areas under conditions where the proportion of bush to grass is high.

The encouragement of vigorously competing grass is perhaps the most important method of controlling bush. This is more the province of the range-management specialist than the weed scientist, but it is worth emphasizing here that no bush control treatment, however successful, can provide a lasting solution to the problem without follow-up measures designed to restore the vigour of the grass cover.

B. Fire

In his recent review on 'Fire in Vegetation and its use in Pasture Management' West concludes that burning is much more effective in regions of high rainfall than in more arid regions and on good soils than on poor soils. Bush species of the savanna generally appear to be well adapted to surviving the effects of fire and, in this type of country it is unlikely that bush can be permanently eradicated by burning. As a method of keeping bush in check, however, and preventing its establishment in areas where encroachment has not yet become serious, occasional controlled fires can be very effective. Burning is a treatment which can be applied for a low cost, but to be successful a rest from grazing is necessary both beforehand and afterwards. Adequate firebreaks are an essential preliminary to burning and contact herbicides may be of value in preparing these.

C. Chemicals

The use of chemicals to control bush has the advantage over burning that no preliminary loss of grazing is involved. Their main disadvantage is expense. At high enough doses successful control of virtually all bush species is possible, but in rangeland only low doses are normally practical economically.

The chemicals most widely employed have been the growth-regulator type herbicides 2,4,5-T and 2,4-D, and on a much more restricted scale, fenoprop (Silvex). More recently picloram has shown considerable promise against certain species resistant to 2,4,5-T and 2,4-D, and is already in use in the U.S.A. (not yet in rangeland) and Australia. Soil applied herbicides, such as fenuron and monuron have been used on a limited scale for a few specific purposes, but are generally more expensive than the 'hormone' sprays and have the disadvantage of being non-selective for grasses.

Methods of applying chemicals must be adapted to the situations concerned. For killing trees, probably the most effective treatment is a basal bark spray applied with knapsack-type sprayers, using diesel oil as a carrier. This method involves relatively high costs in man-power and oil, however, and is only suitable for treatment of small areas. Foliar sprays applied from the ground are also limited in their application to low growth on land suitable for the operation of tractor-mounted sprayers or to the small areas which can be treated with knapsack sprayers.

The method of application which can be used in the widest range of situations and which is the most suitable for use on large areas is aerial spraying. Experience in Africa is limited, but in the U.S.A. aerial spraying of rangeland is done on a very large scale and, in fact, represents the only extensive use which has been made of herbicides for bush control in rangeland. Time of year and climatic conditions are critical for good results with this type of application, and these factors vary for different species and different chemicals. Much research is needed, therefore, to work out the best treatment for each particular problem, but once this has been done, surprisingly low doses of chemical are often found to be sufficient and the treatment becomes economically practical. In the U.S.A. satisfactory control of mesquite for 5 years or more can be obtained by aerial spraying at a cost of $2.00-2.50 per acre. On Quercus havardii (shinnery oak) similar results can be achieved for as little as $1.40 per acre.

Susceptibility of bush species to herbicides varies with different chemicals, but for all chemicals it may be expected that species with a large capacity to produce shoots from below ground will be more difficult to kill than those without. Unfortunately, adaptation to withstand burning often involves a root suckering habit or a root crown, and savanna species being commonly resistant to burning are also likely to tend towards resistance to herbicides. Information is available on the susceptibility of a number of bush species to 2,4-D and 2,4,5 -T. In general Acacias are more susceptible to 2,4,5-T than 2,4'-D, and large trees are more susceptible to basal-bark spraying than small trees. Suckering species, such as A. hockii and A.brevispica can be readily killed to ground level, but often regenerate. Combretum spp. generally tend to be resistant, Commiphora spp. susceptible.

D. Mechanical control

Mechanical methods effective enough to give lasting control are very expensive and can only be contemplated in potentially productive areas, as part of a program of clearing, reseeding and intensive management. Control methods cheap enough to be practicable for rangeland normally involve additional treatment in subsequent years in order to prevent rapid regrowth. The cheaper methods are perhaps best considered as preliminaries, helping to bring the area into a more suitable condition for burning or applying herbicide. Thickets, for example, must normally be cut if they are to be burnt satisfactorily and cutting is also likely to be necessary to provide access to ground-sprayers. There is little evidence, however, that the results of aerial spraying are improved by preliminary mechanical clearing, and with some types of bush, there is even a danger that mechanical control measures may make subsequent chemical control more difficult by encouraging coppice formation.

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ANIMAL PRODUCTION AND SAVANNA AREAS

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Animal production levels are conditioned primarily by the nutritional plane of the stock and, in the extensive regions covered by this meeting, are frequently jeopardised by the shortage or the unreliability of rainfall. These variable precipitation rates create alternating periods of livestock subsistence and productivity during the dry and wet seasons respectively; prolonged droughts occasionally disrupt animal productivity patterns and may cause a widespread decimation of numbers. In such environmental circumstances, continuous or seasonal migrations are so necessary to find feed and water for the flocks and herds that tribal leaders often carry tremendous responsibilities for their own and their followers'livestock. Both in truly nomadic and in the varying degrees of transhumance husbandry systems, animal movements are governed by tradition and ancient agreements but may also be effected locally by the verbal reports of the fodder situation in a particular year or district. Modern radio and transport systems help alleviate some of the effects of adverse climatic conditions but migrating flocks and herds are no more secure today than they were in the past.

Nomadic and transhumance systems are traditional adjustments to fluctuating forage and water supplies and only an extreme mobility can sometimes preserve the flocks and herds. However, high ambient temperatures and incident solar energy loads induce physiological stresses. In fact, the survival of indigenous species depends primarily on them being sufficiently adaptable to be able to adjust to the local nutritional, management, health and physiological circumstances. With increasing aridity, for example, livestock become more important than crops and smaller species tend to replace the larger ones which are generally more productive or faster growing under more favourable environments.

The normal practice is to accumulate livestock numbers as visible symbols of wealth and as insurance against periodic holocausts which occur when numbers become excessive and which are induced by disease, parasitism or a seasonal failure of grazings and water supplies. The retention of aged beasts in the herd is deliberately based on the knowledge that such older animals have usually recovered from and developed some immunity to intercurrent diseases. Such older cows may reproduce less frequently than younger animals but they do provide an insurance against recurrent disasters. This retention of older animals and of mature males, in excess of those required for breeding or work purposes, together with relatively high mortality rates of young stock result in herd compositions which are very different from those in developed areas. Any attempt to improve pastures, feeding or management conditions must be associated with a change in herd compositions if their maximum productivity is to be realised.

So far, this discussion has perhaps referred more to cattle than to other livestock so it is essential to mention that as feeding conditions deteriorate the size of the surviving cattle may be reduced. Beyond a certain point, however, cattle give way to sheep and goats and eventually, in severe environments, only the much maligned but resourceful goat can exist on the grasses, weeds and shrubs of the lands previously ruined by avaricious cultivators and their larger stock. Experts from developed zones, when advising the peoples of less developed regions, often over-emphasize cattle in areas where the smaller ruminants would be more appropriate and pay lip service to the vociferous, though often unfair, condemnations of the goat. The existence of feral herds in other parts of the world in harmony with their vegetative surroundings supports the view that it is its mismanagement and not the goat *per se* which has proved so inimical to certain surroundings.

Goats are more rustic than sheep but, when selected breeds are properly fed, they outyield sheep and rival certain cattle breeds in milk production. Some African goat breeds, such as the Red Sokoto, have justifiably acquired a world reputation for the leather producing value of their skins. In other cases, pituitary, chondrodystrophic or mixed types of dwarfism cause reductions in the body size of goats.

African sheep vary widely, according to breed and environment, from fine to coarse woolled and from woolled to hair breeds, from meat to milk producing strains, from fat-tailed to fat-rumped and to thin-tailed types. Perhaps the black-headed Persian sheep from Somalia have the greatest potential in the areas covered by this meeting, provided a too heavy worm burden is not encouraged by wet conditions.

Humped zebu cattle are adapted to a higher temperature and more intense solar radiation range than are the humpless types. Although there are breed differences in heat tolerance, ecological distribution and productive potentials, no sharp line demarcates *Bos indicus* from *Bos taurus* in economic potential. Size varies with soil fertility and level of nutrition while unfavourable conditions may cause stunting. Many wellknown breeds of cattle occur in the areas covered by this meeting - e.g., the Kenana, the Shuwa, the Boran and the Jidda.

Poultry contribute much to the nutrition of the people in Africa through their yields of eggs and meat. They are widely distributed in small, free-ranging units while large scale, modern, intensive, commercial enterprises are now being developed.

Livestock industries in developing countries are so diversified that no single measure can be universally applied for their amelioration. Each requires individual attention. In addition industries have not expanded at the same rate as have other branches of the national economy and there has been significantly less attention devoted to their advancement. Animal production is in fact the Cinderella of agricultural activities in spite of the ever-increasing demand for animal proteins to meet human needs. This is possibly because so much of the products are consumed in the country and so little surpluses have not been surrounded by the glamour attached to other more spectacular endeavours. Unquestionably in much of Africa, animal production activities are antiquated and inefficient but, nevertheless, could be greatly improved. Thus, there is a need to educate stock-owners in modern methods, to ameliorate managment and nutritional levels and to organize systems for the collection and marketing of their produce. Whereas in developed countries producers are continually challenged by the quality of their products, in developing areas it is the actual availability of these foods which is of paramount importance so that lack of technical knowledge must not interfere with livestock developments. Progress in animal disciplines must be based on a careful strategic planning in the particular environmental circumstances.

It is sometimes stated that it is easier to induce developing countries to expend larger sums in expensive industrial enterprises to serve as status symbols than to devote serious attention to the more prosaic animal production activities. Animal production is not an entity but a complex of several sciences (nutrition, physiology, genetics, etc.,) in combination with a wide variety of management practices, feed supplies, market opportunities and social requirements. Even a simple livestock problem may involve a number of specialists while the frequent lack of precise and reliable data is complicated by customs imposed by different faiths and traditional habits.

The lack of trained animal productionists in developing countries is deplorable. Attempts are made to disguise this by referring to the available numbers of agricultural and animal health graduate, and non-graduate staffs. The truth is that the key to development is sufficient people trained at all levels but there are extremely few persons trained to the required grades in animal production subjects. True animal husbandry thus remains a pawn over which agriculturalists and veterinarians continue to struggle; hence its teaching has been largely neglected due to lack of facilities and staff. What is urgently needed are the means to train (a) relatively few advanced or degree course students regionally (b) a larger number of animal husbandry extension workers in their own country and (c) farmers in their own districts in short-term local requirements. Only when these facilities can be introduced will there be any hope of being able to break the vicious circle derived from a combination of poverty, ignorance and an outmoded reliance on traditional systems.

Parallel with such an educational drive should be a determined attempt to introduce regular and organised livestock marketing practices. Irrespective of consumer demand, if marketing costs represent too high a proportion of the final prices, production may be uneconomic except on a subsistence basis. Equally, if meat vendors, butchers and middleman dealers take too high a share of the final price of meat, the sum offered to producers may be an insufficient incentive for them to sell. Inadequate attention has been devoted to such marketing difficulties and insufficient has been done to establish auctions on the basis of grade and weight, to licence traders, to control the movement of stock along stock routes possessing the necessary quantities of feed and water, to establish holding grounds and to break existing trader and butcher rings.

More accurate statistics of livestock populations and productions are required before improvement policies can be based on reality. Such figures are dull and in the early estimations are highly divergent. Statistical data is eschewed by many but is the testing stone of Government and private activities. Unfortunately, owners are often so suspicious that the date supplied by them is highly suspicious.

Many out-moded traditional husbandry patterns persist, sometimes in close juxtaposition with developing intensive units, but to increase their productivity the disease situation must first be assured. Improvements in feeding, management, breeding and marketing then follow logically. There is, however, no point in saving animals from disease if their numbers so expand that starvation deaths intervene so as to redress the balance with the nutritional plane.

Normally the better-watered and more fertile soils have been cropped under shifting-cultivation systems to permit soil regeneration. Increasing population pressures have necessitated an expansion of these cultivated units into sites formerly reserved for grazing. With this removal of their better grazings, livestocks have been forced on to diminishing areas of poorer productivity. This consequent overstocking has caused unfortunate changes in the vegetation of the grazing reserves but it is man and not his animals who is responsible for this degeneracy. Instead of shouldering his responsibility for this damage, avaricious man has blamed the goat because this has been the last domestic animal to wrest a living from the devastated areas. These nutritional limitations had to multipurpose stock and limit profitability but reduce risks.

As would be expected from the previous paragraph the first factor which claims attention, once relatively disease-free pockets have been developed, is the need to ensure that the animals feed requirements are met. This involves improvements in the pasture and fodder crop supplies, means for their conservation for use in the off-season, the correction of protein or mineral deficiencies and the feeding of supplementary rations according to the level of production. Usually the system of management involves confinement at night without feed or water. This should be changed where possible to permit night grazings and at the same time removing risks of losses from predators which are presently a restrictive factor. The management philosophy must be constantly adapting to the evolving husbandry circumstances.

It is axiomatic that the acquisition of scientific knowledge exceeds the rate at which it can be applied but, in spite of this, knowledge of feeding values, systems of feeding, livestock requirements at different ages and levels or types of production all need investigation in relation to costs and profitability. Rarely, however, do nutritionists get requested by Governments seeking livestock help, yet these are fundamental to any other type of animal productionist.

Systems of management are often closely integrated with nutritional regimes but much information is needed for all types of livestock, with different feeding systems, in different seasons and at varying ages and levels of production. Considerable studies are required bearing in mind that it is productivity per hectare and not per animal that is important.

Because of exposure to adverse conditions for long periods of time, indigenous stock may exhibit low rates of growth and production. Growth may however, be resumed, after intervals of subsistence, to a greater degree than is possible in more earlier developing improved breeds. Indigenous stock have developed in harmony with their environment and their physiological, heat adaptive reactions to ambient thermal stresses may be superior to those of higher yielding exotics.

As a result of segregations in accordance with existing nutritional levels many local breeds have been isolated. Sometimes their productivity reaches such low levels that a demand is made for their improvement. Far too frequently those concerned with the improvement of indigenous species have sought this by substitutions for or crossings with high yielding breeds from other areas, without concommitant augmentations in the nutritional and management practices. As might be expected the results have led to failure. At the same time, past emphases on pedigrees have lost their significance to some extent because selection is now increasingly made according to productivity and the ability to transmit this character to their offspring.

Whereas meat production must remain largely an extensive operation, there will be increasing opportunities to produce veal and baby beef in intensive peri-urban units. The economics of such endeavours need study. Milk production is also an intensive peri-urban activity which is rapidly being encouraged. Further out from the consuming centres will be farmers producing milk for butter, cheese or ghee, and these dairy activities need study and encouragement. Poultry production near the towns for eggs and broilers is being intensified and will never displace the need for extensive small units in the more remote villages.

Much of the African continent needs to re-orientate its thinking on animal production. This is a long term process but a start must be made in the collection of the basic information on which to organise the necessary changes. Such data may often first be collected through Special Fund projects so that instead of the exclusion of these activities, as has so often occurred in the past, efforts should be made to encourage their inclusion. Should this be done it is essential, however, to realise the greatest difficulty involved, namely with cattle. With these animals, the growth rate and productive cycles are such that it is not possible to test the progeny of any breeding activities within the space of a 5-year project. This can be done with the smaller farm livestock and with poultry.

Fads and fancies must be discarded and new and more realistic concepts established. Problems will then be capable of solution without prejudices and in the best interest of all concerned. Having determined animal improvement methods by investigation, it is essential to have adequate animal husbandry extension services in operation to ensure that the findings are translated into practice. This requires sound systems for teaching the various staffs involved.

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ANIMAL HEALTH AND ITS SIGNIFICANCE IN THE DEVELOPMENT OF SAVANNA ZONES

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The method of stock management at present practised in the savanna regions under discussion is "extensive" and is a method of husbandry which has been carried on from generation to generation for centuries, usually independent of crop farming. The level of production of meat and milk under this form of pastoralism is very low but has sufficed to maintain the people dependent upon it at a subsistence level. It has survived vicissitudes of the climate and ravages of animal diseases, although these latter have caused much human distress at one time or another. For instance, it has been recorded how the Fulani of Northern Nigeria recall the cattle plague which spread across their part of Africa in the 1890's, decimating the cattle population and causing much human misery.

The major diseases of stock kept in this traditional fashion are the "epizootic" diseases. These are the diseases which are easily transmitted from animal to animal and spread over an area in waves. Some may produce a high mortality, especially following the initial onslaught onto a fully susceptible animal population, for example Rinderpest (cattle plague), whilst others, e.g. Foot-and-Mouth disease, although no less dramatic, may not cause a high mortality.

Trypanosomiasis, generally speaking, has not been a serious hazard to stock because, in this zone, the tsetse fly is limited in its distribution to certain areas and the herdsmen have learned to avoid these "islands".

Diseases caused by both internal and external parasites are not generally of major importance in this form of pastoralism, although in certain localities under certain perhaps exceptional conditions, losses may be very serious - for example to Liver Fluke disease and Haemonchosis. The same comments apply to diseases of bacterial origin such as Anthrax, Blackleg and Haemorrhagic Septicaemia. Diseases caused by the protozoa, some of which are spread by ticks and other vectors are usually debilitating rather than killing but these can be serious in young animals for example Coccidiosis. However, the overall effect of all these diseases is to reduce still further the low productivity of this method of husbandry.

It should be understood at this stage that the epizootic diseases by and large can be controlled and are being controlled and in most cases the means to eradicate them are also known and have been successfully applied in some countries. Matters of cost and practicability (communications, technical staff, legislation, socio-political factors etc.) often stand in the way of implementation. It should be noted that Rinderpest eradication schemes financed by bilateral aid agencies are at present being conducted in several African countries which contain areas of savanna.

Attention must be focussed on another factor to be considered when assessing the economic basis for the eradication of, for example, Rinderpest. This is that "no country free from Rinderpest and situated outside Africa will accept the import of African meat so long as the risk of Rinderpest remains" - a quotation from the Final Report of Phase I of the O.A.U. Scientific, Technical and Research Commission Joint Campaign against Rinderpest (I.B.A.H. Vol. 14. p. 193). The presence of other cattle diseases may also hamper the free international movement of stock or meat.

The demand for more animal protein or other animal products consequent upon urbanisation or expanding export markets forces changes upon the rustic scene, the overall effect of which is a change from extensive to intensive animal farming. The herdsman can no longer plod his weary way - he must take positive steps to ensure that his animals are productive. It should not be necessary to add that the farming community are most conservative and it is difficult to change their way of life and traditional views. But they <u>will</u> change and <u>quickly</u> if the incentives are there. Indeed increased animal production motivated by fundamental economic demand, can be a major factor in getting the farmer out of the rut of a subsistence economy. The education and re-orientation of the farmer for this new role will be stressed by other speakers at the conference.

The changes from extensive to intensive animal farming alter the picture <u>completely</u>; animal disease control becomes an even bigger responsibility of Governments. It now becomes essential, not only to contain epizootics but to take more dynamic action to control them with a view to eventual eradication. The main epizootic diseases to be considered in this context, but, by no means a complete list, are Rinderpest and Contagious Bovine Pleuropneumonia of cattle, Blue Tongue and Pox of sheep, Newcastle Diseases and Fowl Plague of poultry and Contagious Caprine Pleuropneumonia of goats.

With intensive stock keeping the losses caused by epizootic diseases become of much greater economic consequence as high grade stock of improved productivity are involved. The Government and its agents have an increased responsibility to see that their plans and the farmers' prosperity are not jeopardised by calamitous scourges.

Unfortunately, with more intensive methods of stock keeping which involve changes in management, fencing, housing, feeding etc., other animal diseases may become of much more significance than they were under extensive management, especially internal parasitism, tuberculosis, brucellosis, mastitis etc. Due to changes in feeding methods, enterotoxaemias, deficiency diseases and other metabolic disorders may become more manifest and of considerable importance. Some of these diseases may also be significant as communicable to man (zoonoses) and thus be a source of danger to the animal owner himself - e.g. Brucellosis, and calling for special measures in their control out of proportion to their veterinary importance.

It would be morally reprehensible for any group of planners to persuade animal owners to change their way of life, invest in new methods, develop improved stock with all that is entailed and not to make adequate provision for extension services to deal with these diseases.

What does this mean for the planners? It means that, whereas for present conditions a fairly simple animal health field service is all that is required to cope with epizootics, in any development scheme involving changes in animal production methods, especially where intensive production is aimed at, whether it be poultry, pigs, sheep, dairying or beef production, a properly organized field extension service is necessary; this must be capable of quick recognition of animal diseases, have facilities for confirmatory laboratory diagnosis and follow up remedial action. Good communications are essential for these services to be effective.

It is no use expecting an already "stretched" field animal health service which has been designed for quite a different purpose to suddenly cope with half a dozen new specialized animal production projects.

The problems confronting the animal production industry which have been mentioned here should not be considered sufficient to deter development and they can all be overcome as long as the plans contain the means to overcome them. There have been enough failures to show the pitfalls and there is no excuse for being blind to animal production and health problems; there is a wealth of experience to call upon. The answer to many of the disease problems is known, only the application has to be planned and organized.

As regards disease hazards to animal production, timely planning can avoid disaster in the savanna regions. Man cannot be divorced from his livestock and any plan for development of man which excludes his livestock is unbalanced and will founder. However, the economic basis for animal production must be present - once this is established the economic basis of disease control becomes apparent. It "pays" to keep animals healthy, it pays even more if these animals are really productive.

In conclusion savanna development projects should include animal production schemes and provision for education of the farmer in the new methods of management required. This will entail the establishment of pilot projects to demonstrate the soundness of the schemes and to ensure that any initial losses are borne by the Government. Also in the original planning the provision of trained technical personnel for the additional extension and advisory animal production and health services (on the spot and not miles away) will have to be considered. These services require specialized equipment and facilities to enable them to function efficiently.

Such development plans should be drawn up after consultation and in cooperation with the various specialized agencies and Government technical departments which are involved.

The savanna regions have a potential for animal production and it is up to the various Governments to develop these resources to increase their countries' wealth and their peoples' well-being.

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FURTHER RESEARCH NEEDED FOR CONSERVATION AND DEVELOPMENT OF THE SAVANNA HABITAT

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Introduction

According to Hopkins (1965) 'Savanna is a type of vegetation consisting predominantly of grasses which are usually burnt annually. In addition to the grasses and other herbs, trees and other woody plants are normally present'.

This is the interpretation generally accepted for savanna in West Africa but the definition for savanna given by Kenneth (1963) is: 'Subtropical or tropical grassland with xerophilous vegetation and scattered trees; transitional zone between grasslands and tropical rainforests'. The term is derived from the Spanish word Sabana, meaning grassland.

In East Africa, the Rangeland Classification Committee has rejected the term 'savanna', in favour of the more precise terms 'grassland', 'woodland', 'wooded grassland', 'bushed grassland', etc. (Pratt et al 1965).

A great deal of research has been conducted in the past 50 years in the vast areas of savanna country in Africa south of the Sahara both from the agricultural and pastural aspects. Reference to the UNESCO Vegetation map of Africa gives some idea of the extent of savanna in this continent.

Cultivation and fire are unquestionably the major factors responsible for the formation and maintenance of savanna country, because bush fires have exerted so profound an influence on the vegetation of Africa for so long that fire has become an important limiting* factor almost equal in its effect to topography and climate.

This has resulted in the development of special fire-tolerant communities of plants and animals which are dependent on periodic burning for their existence. Two examples of these communities are the open grassy plains and savanna woodlands of tropical and sub-tropical Africa.

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* 'The presence and success of an organism or a group of organisms depends upon a complex of conditions. Any condition which approaches or exceeds the limits of tolerance is said to be a limiting condition or limiting factor'. (Odum 1959).

Although bush fires encourage the formation of grasslands, untimely burning exposes the soil to desiccation and erosion, the results of which are all too evident in the Guinea zones of West Africa and the plains and woodlands of East Africa.

Before man learned to use fire as a tool, burning of the vegetation must have occurred only occasionally as a result of lightning or spontaneous combustion in places where large amounts of dry organic matter had collected.

In the last two thousand years, however, the social development of human communities and recently the invention of the safety match have accelerated the effects of fire upon the African landscape, devastating the fire-tender forest edge and dry bushland. This process has in turn been assisted by shifting cultivation accentuated by a sudden and disastrous rise in the human population of Africa in the past 50 years.

Phillips (1965) reviewed exhaustively the influence of fire on the bioclimatic regions of Trans-Saharan Africa and described various aspects of research work carried out up to the present time in different parts of Africa.

Deflected sub-climax communities - The savanna regions of Africa are communities of plants and animals which have been 'deflected' from their normal course of ecological succession by the influences of cultivation, fire and grazing, exerted individually or combined, so that savanna communities dependent on these factors for their existence can hold the position of 'deflected sub-climax associations or associes' (Weaver and Clements 1938) without further deterioration.

In these savanna communities as in all living societies, there is perpetual competition for survival between individuals and an incessant striving towards a more highly organized type of association in which the components are in equilibrium with one another under similar climatic and soil conditions; but this equilibrium can be maintained in a deflected sub-climax association only so long as the deflecting influences (fire, etc.) continue to be exerted to an optimal degree. When these factors cease to operate, development is resumed toward the normal, more stable climatic climax, be it thicket or forest (Lester in Glover 1961). When the deflecting factors become over-accentuated deterioration sets in, resulting in lower and more primitive types of biotic communities and eventually, complete destruction followed by desert. Therefore fire alone or coupled with controlled grazing can be a most destructive influence or a very valuable tool in managing woody regrowth in the grasslands and open woodlands of Africa which form the most valuable range lands and stock producing areas of the continent.

Even as early as 1936, Swynnerton showed that in Tanganyika the exclusion of fire from a block of country for 10 years caused a thickening of the vegetation and the disappearance of the tsetse fly Glossina swynnertoni - a savanna fly related to G. morsitans which inhabits vast areas of savanna country in tropical and sub-tropical Africa, but in turn an encroachment of G. pallidipes, which is a thicket inhabitant in that area, took place.

Swynnerton's findings have been clearly confirmed many times. Another classical example was that of a forest reserve near Kaduna in Northern Nigeria where several blocks of Isoberlinia woodland received various degrees of protection from fire for a period of more than 20 years. In the section which had been completely protected, there was a general densification of the vegetation and patches of thicket with numerous creepers had formed. The block that had been burnt at the end of the dry season every year was almost completely open, tufted perennial grasses were dominant and only a few fire-resistant trees with blackened trunks remained - dead, charred stumps were numerous (Glover 1961).

Fire-tenderness - Fire-tender plants are those which have not developed a resistance to burning. In most instances the reason is that they are members of plant communities which are not normally affected by fire because of their density or lack of undergrowth, or because they belong to humid forest communities where burning can make little headway unassisted by man. The most vulnerable plants are those in the 'marginal' rainfall areas where thicket and scrub is the dominant 'climax' vegetation with low perennial grass cover of the types found in the drier bushlands of East Africa, such as those in the Tsavo National Park and the Sudan zone of Northern Nigeria

Fire-resistance - Many plants have acquired a permanent resistance to fire over periods of thousands and perhaps millions of years. Good examples of these are 'geophytes' which have developed large underground storage organs having only slender ephemeral aerial parts which are most conspicuous in fresh green growth shortly after the grass has been burnt and the ground appears to be otherwise bare or carpeted with a short fresh flush of green sprouting perennial grass.

Classical examples of geophytic fire-resistant plants are Courbonia glauca (Klotsch.) Gilg and Benedict which is common on parts of the plains of the Mara and Serengeti areas of East Africa. In the woodlands of Southern Tanzania Cryptosepalum spp. appear as perennial herbs only a few cm high but below ground there is a stout rootstock like the trunk of a small tree with widely spreading branches and only the tips of these appear above the surface. In this same woodland there are also dwarf species of Combretum, Gardenia and several plants which have taken to a geophytic habit apparently as a defence against perennial grass fires.

In addition, there are intermediate stages shewn by many savanna trees which are able to assume a geophytic form, maintaining only a small stem above the ground which can often be mistaken for a seedling but having a stout root stock beneath the surface shewing numerous fire scars. The writer has counted as many as 75 growth rings from a rootstock of this type which had no more than a small stem 6 - 10 cm high shewing above the ground in Brachystegia - Isoberlinia woodland south of Tabora in Tanzania.

There is, therefore, much evidence indicating that many savanna tree species are suppressed at ground level by perennial fires until a lapse occurs of 2 or 3 years without fire when they are able to grow tall enough to withstand being razed to the ground in subsequent years.

Glover at al (1955) doing transect counts in the Abercorn district of Northern Rhodesia in Brachystegia woodland in which the grass was burnt perennially, found that more than 75 percent of the potential tree population was between 0-3 feet (1 m) high, there were markedly fewer plants in the 3-6 ft (1-2 m) and 6-12 ft (2-4 m) height groups and little difference in the numbers in the 12-25-50 ft (4-8-16 m) height groups, indicating that plants between 3 and 12 ft (1-4 m) in height are most vulnerable to grass fires. Most of the plants less than 3 ft (1 m) high had stout root stocks at ground level or just below, shewing numerous fire scars. Very few true seedlings were found.

Later Glover (1965) working in Tanzania in the Serengeti National Park found that of 5,777 plants of various tree species counted in a series of 10 belt transects 5 miles apart in the 50 miles between Seronera and Kline's Camp, 71 percent were less than 3 ft (1 m) tall; about 8 percent were 3-6 ft (1-2 m) high; about 10 percent 6-12 ft (2-4 m) high; about 9 percent 12-25 ft (4-8 m) high and only about 2 percent were taller than 25 ft.

Here also many of the trees in the 0-3 ft (0-1 m) group had stout root stocks at ground level shewing signs of repeated burning and there were very few seedlings. Emphasising the point that most of the small plants in these areas which appear to be seedlings are not but merely regrowth from underground fire resistant stems.

These investigations indicated that although fire can have a most destructive effect upon woody vegetation, many plants have acquired a temporary geophytic phase which permits them to survive for many years in spite of having their aerial parts scorched off repeatedly until, because of drought, over-grazing or both combined, there comes a period of 2-3 years with no fierce fires when these plants are able to grow to a height of more than 6 feet and big enough to be safe from burning. Many of them also develop thick corky bark as a further protection against fire.

This ability of many woody plants to survive under ground and regenerate quickly when given respite from fire of a few years is one of the reasons why regrowth is so difficult to control in overgrazed country,tsetse control clearings and areas of grassland protected from fire.

According to the East African Rangeland Classification Committee (Pratt et al 1965) 'Rangeland can be regarded as land with natural or semi-natural vegetation which provides a habitat suitable for herds of wild or domestic ungulates. Therefore, the greater part of East Africa is rangeland. In other words, East Africa including Central and Southern Africa is mainly savanna country.

The same applies to the Northern Guinea, the Sudan and the Sahel zones of West Africa although compared with other African savanna zones, wild ungulate life is virtually extinct in West Africa.

It is therefore, from the rangeland aspect that we should consider the possibilities of further research for the conservation and development of the savanna habitat in Africa.

Suggestions for future lines of research - It has been mentioned previously that much knowledge on the management of the savanna regions of Africa has been acquired in the past 50 years - so much in fact, that if no further progress were made there is enough information available on fire control and other forms of range management to deal with any rangeland problems that might arise except for the greatest limiting factor of all which we seem less able to deal with now than we were 50 years ago, and that is the human factor.

More than 30 years' experience in Africa makes me believe that all the future research in the world will have no beneficial effect in Africa without the disciplined co-operation of the local inhabitants encouraged and supported by their politicians.

This all important matter must take precedence in any present-day plans or recommendations for further research in the savanna or any other agricultural regions of Africa. Scientific knowledge is valueless without effective administrative support. Control is the vital factor upon which the future of true development depends.

The second most important factor - again a human one - is immediate control of an exploding human population. Again, unless the present rate of increase of the peasant population of Africa and the East can be checked to a controllable pace, all innovations and modern methods of research for their welfare and the development of their natural resources will be utterly useless in terms of the destruction of the habitat and the consequent human suffering that will ensue.

At a MEETING of Experts on Trypanosomiasis in Lagos in September, 1963, the importance of these problems were fully realized and it was agreed that a MISSION should be formed consisting of experts on rural development and socio-economics to review with local experts the areas of different economic potential in Africa within the limits of the Glossina zone in relation to known techniques of trypanosomiasis control.

The MISSION would also assess the possibilities of success or failure in trypanosomiasis eradication or control schemes considered as integral parts of development plans, especially in the context of new trends resulting from the emergence of independent African nations.

No MISSION has so far been formed nor does there seem to be any likelihood that such a body will appear in the immediately foreseeable future.

Bearing these depressing facts in mind, because they are true ecological limiting factors, my suggestions (for some of the more obvious lines which require further research) in the savanna zones are:

1. Prolonged investigations on the effects of fire, grazing and browsing on all types of savanna country ranging from freshly felled forest land being prepared for cultivation to open, long-established grasslands.

L. Cook (in Phillips 1965) giving a brief description of some grassland burning experiments carried out over a period of 30 years at Frankenwald, the University of Witwatersrand experimental farm in the Transvaal in South Africa stated that after 30 years, the greatest alteration in the composition and quality of the vegetation was in the control plot which had been protected from fire. There was more bare ground between the tussocks and there were more dicotyldons present. In the plots that had been burnt annually, there was practically no change - indicating that annual burning had kept these plots in a stable condition.

Using the words of Phillips, despite the dread danger of burning when it is feckless, wanton, casual or accidental, there are great possibilities for its use as a tool in the management of the savanna regions of Africa and these possibilities require much more study in the future, particularly the timing and frequency of burning in local environments.

2. In order to gain a better understanding of the reactions of the plants themselves to the different disturbance factors mentioned above, more intensive work on their root systems is required.

A great deal has been done on the root systems of plants in America (Weaver and Clements 1938) but very little has been carried out in tropical Africa beyond the work of Glover (1950-51) in the Somaliland Protectorate and more recently in Kenya by officers of the East African Agriculture and Forestry Organization. It has been found that various plants have different types of root systems adapted to the needs of their particular niche in the environment. Some are deep-rooted, others have shallow roots with a wide lateral development and yet others have both deep roots and widely developed lateral ones.

According to Gwynne (in Davies and Skidmore 1966) a careful study into the degree of grass root activity within the top 4 feet of soil is urgently needed and into the role of the deeper roots under conditions of adequate water supply and in times of drought.

Further, the importance of variability of soil depth and the rooting habits of grassland plants in determining the species composition of these grasses is just beginning to be realized.

In addition, Gwynne says that more work on the physiology of growth of tropical grasses with particular reference to root development and the effects of water stress should be a high research priority.

Dougall and P.E. Glover (1964) made chemical analyses of Themeda triandra Forsk. and Cynodon dactylon (L) Pers. at different stages of growth after burning and mowing and demonstrated that the green leaves of Themada triandra are a better source of protein, calcium and phosphorus than either the older or bulked foliage of that plant. This is one of the reasons why both wild ungulates and stock prefer to graze freshly shooting grass after a burn than that in the taller more mature sward.

Therefore the study of the nutritive value of important grazing and browse plants is a very profitable field for further research.

3. Another aspect which requires closer investigation is the use of land for subsistence agriculture when it could be put to far better use as rangeland for the production of meat and milk especially when it lies bare and unprotected under the hot desiccating sun for months in the year followed by flash floods that result in erosion during the rains.

4. The possibilities of using all suitable parts of the savanna regions to the best advantage should be investigated in detail on the following lines:

(a) by mapping vegetation and soils;

(b) by selecting and locating grazing areas;

(c) by working out a general policy for the proper use and conservation of grazing land including wet and dry season alternation of grazing and the use of swamps for both pastoral and arable purposes. Research into the traditional tribal movements might be rewarding in this context based on trial and error experienced over countless years;

(d) by introducing methods of pasture improvement and management with special reference to stock carrying capacities in different conditions of climate and soil;

(e) to investigate and improve water resources and requirements when these are necessary;

(f) to investigate the possibilities of integrated pastoral and arable land use in areas where it seems feasible.

5. The conservation and use of wild life resources must be studied as an integral part of savanna research.

This work must include management plans for national parks and game reserves to ensure the preservation of variety in the habitat by controlling bush fires and regulating the numbers of different species of animals to the carrying capacities of the regions concerned. In some national parks, such as Tsavo in Kenya and Murchison in Uganda, overstocking of elephant coupled with uncontrolled fire is bringing about disastrous changes in the habitat. The same is starting in the Serengeti.

The causes of such situations and possible remedial measures require urgent investigation.

The control and proper use of existing wildlife resources is perhaps the most pressing problem facing Africa today apart from human overpopulation.

Before the introduction of domestic stock and the intensified agricultural activity that followed, the semi-arid areas of Africa were comparatively stable ecologically although they supported large herds of wild ungulates, but because of extreme fluctuations in rainfall distribution, high temperatures and sparse distribution of water these arid areas are vulnerable to desolation by desiccation and erosion under continued in contrast to periodic shifting stocking.

Sir Julian Huxley, writing in 1961 on Central Africa, observed that a large proportion - probably over a third of the country - consists of marginal land that constitutes an ecologically 'brittle' habitat which readily deteriorate and loses productivity under cultivation or the least degree of overgrazing.

Fraser Darling in 1960 and Ledger in 1964, have demonstrated that wild animals under 'natural' conditions are normally in a state of comparative balance with their habitat because they have a wide range of feeding and other habits, so that among the different species each one fits into its own 'niche'.

Further, Ledger shewed in 1963 that the carcase composition of wild animals has advantages over that of domestic stock because wild animals have a larger proportion of red meat per unit of carcase.

Dassman in 1961, studied the commercial production of game meat and income in Rhodesia and elsewhere and found it both feasible and profitable.

This information indicates that wild animals must be studied not only in relation to their scientific and aesthetic interest and their impact on agricultural activities, but from the point of view of red meat production as an economic asset to the community.

I reiterate, the conservation and management of wildlife presents two of the most pressing problems facing Africa today. Indeed they are inextricably linked, because the equilibrium of the habitat is fundamentally dependent on the natural fauna and flora - they must be preserved at all costs even in the face of increasing human population pressure and the continuous economic competition caused by so-called 'development' including the introduction of 'better' breeds of domestic stock.

To recapitulate - the lines upon which future research must be based must enable administrators to enforce the knowledge available, supported by propaganda and education to convince the people concerned of the evils of mismanagement.

In the new approach to proper land use, education will have to be on three levels: 1) that of the people of the land; 2) that of the upper administrative echelons, and 3) that of the leading politicians.

To be effective, this new approach will have to be carried out by example and demonstration in the field as well as in the classroom and strict discipline will have to be enforced.

The time is now long past for the continuance of repeated minor research projects, because there is a great volume of information available for constructive action to be taken in the conservation of the fast vanishing natural habitats of Africa with their unique flora, fauna and stock producing potential.

Finally, a more enlightened understanding of game/stock management is urgently necessary and a new veterinary approach is needed to recognise the great potential that lies at hand if it is properly used - despite the protests of the 'old guard' of veterinarians, some of whom still claim that the only good wild animal is a dead one and if wild ungulates have to be preserved, they must be kept behind a barbed wire entanglement with a ditch in front of it.

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GRASSLAND ECOLOGY IN RELATION TO CONSERVATION AND DEVELOPMENT OF THE SAVANNA HABITAT

PROBLEMS IN THE DEVELOPMENT OF SAVANNAS OF EASTERN AFRICA

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A greater part of Eastern Africa can be grouped under the broad term "savanna" which includes a cover of varying density of woody vegetation ranging from dense woodland through many types of wooded grassland to semi-desert dry bush. Talbot (1964) estimates that three-quarters of central and eastern Africa are covered by savanna.

At the outset, it may be mentioned that pasture research workers in East Africa do not accept terms like "savanna" and "steppe" as defined at the Yangambi Conference. As early as 1943, Greenway observed that the word "savannah" as commonly used was only to denote grassiness, and rejected the term as a South American one, seldom correctly applied in East Africa and too much abused to be any longer of service for exact purposes. At the Second Conference on Raising the Productivity of East African Rangelands (1965) it was proposed that the term "savanna" as defined by the Yangambi Conference should usually be replaced by "Wooded tall grassland" or "Wooded medium grassland" and "grass savanna" by "tall grassland" or "medium grassland." However, several earlier workers such as P. Sermolli (1957) and Langdale Brown (1964) have distinguished savanna types of vegetation in East Africa. In this paper, the term savanna is employed in a broad sense, as a "tropical formation where the grass stratum is continous and important but occasionally interrupted by trees and shrubs; normally burnt from time to time; main growth period correlated with the rainy season" (FAO staff, 1965)

Basic research in various fields of development and conservation of savanna lands of Eastern and Central Africa has been in progress for more than three decades. Studies on the various aspects of savanna environment have made substantial progress. Considerable scientific studies and field work in game and range ecology have been accomplished by visiting scientists from various international agencies. A brief review of the problems and the progress so far achieved is presented here.

In general the balance between grasses and woody vegetation in the savannas of Eastern Africa can be described as being unstable. The main modifying factors which affect the grasslands are fire, grazing and browsing by domestic livestock and wild ungulates, and the encroachment of bush. The balance is sufficiently delicate to pose a major problem of range management of both livestock and wild game populations.

Although a wealth of material is available on livestock, its production and growth, grazing habits, food and water requirements, very little data is available on vegetation, range condition, carrying capacity of the rangelands and the importance of shrubs and trees in maintaining soil fertility and animal productivity.

The removal of vegetative cover by fire, grazing and trampling exposes the soil surface to desiccation and erosion. Favourable patterns of surface infiltration, subsoil percolation and perennial stream flow from the catchment areas are replaced by surface run-off, flash flows, and reduction of dry season flow. This destruction is already widespread in East Africa and is worsening as a result of increase in human and livestock populations.

Fire as an ecological factor

Fire is the major ecological factor in East Africa, where there is hardly any vegetation below an altitude of 6,000 ft. that is not affected by it. Practically all savanna types of vegetation in East Africa are subject to frequent grass fires, the severity being proportional to the height of grass.

Many of the woody components in the savannas are fire-tolerant. Trapnell and Langdale Brown (1962) divide them into two classes: (1) those which, allowing for the obvious opening effects of repeated burning, appear at the same time to be original in the sense that they show no evidence of having replaced a previous vegetation of different composition, and (2) various secondary or derived types of savanna which are shown by remnant species to have replaced a previous closed type such as forest and thicket. At present this distinction can be drawn between some of the savanna types in Uganda and Kenya but there is shortage of evidence on the various savanna areas of Tanganyika.

Fire is an excellent tool for bush control, if it is possible to burn only when desired. It is extremely difficult to prevent accidental or incendiary fires. In East Africa, most grassland areas are burned over annually and it is reported that Africans burn range land for a number of reasons and sometimes for no reason at all. Heady (1960) has summarised the various reasons for burning in East Africa.

1. Burning prevents the encroachment of bush species into grassland as demonstrated by several experiments in East Africa, under varied climatic conditions. According to Enlow (1961) burning is practised as a bush control measure, the intervening period being three to four years. The numerous grazing schemes suggested for Kenya stipulate the burning of pastures in rotation every fourth year. Brown (1959) who conducted a survey of the various grazing schemes in Kenya has emphasised the need for a burn every three years, particularly in the *Themeda* grassland areas. He found that in the absence of fire, the bush problem increased enormously on Esageri. Of the 2,000 acres of bush ringbarked and a further 1,500 acres bulldozed between 1946 and 1949, no trace was found at the time of the survey, that the work was ever carried out.

2. Burning is practised to obtain a more desirable species composition of forage plants. Edwards (1942) found that *Themeda triandra* disappeared with complete protection from fire, and also that it was eliminated by overgrazing without fire. If fires and grazing are prevented, the grasses soon lose vigour because they have to compete with an increase of herbaceous species, the growth of which is no longer checked by burning. Succession then proceeds until eventually, a bush association is formed from which the palatable grasses are practically entirely excluded. With heavy uncontrolled grazing, the successional trend is similar except that erosion is generally more severe due to the destruction of the grass cover.

3. Burning is also resorted to improve the quality of forage because grass burning stimulates growth out of season. In Ankole (Uganda) grasslands are sometimes burned twice a year, to induce a flush of young growth, highly valued by herdsmen, and frequently grazed bare. It is well known that foraging animals are attracted to newly burned areas and they utilize that part of a pasture which is burned and leave the unburnt part ungrazed.

4. Fire is also employed to drive game and to control undesirable animals such as tsetse, rats, snakes and nests of harmful birds.

5. Ash produced by a fire is considered to have a fertilizer effect which produces vigorous growth and greater forage production. The dangers of uncontrolled bush fires stem from the fact that the soil is often left in a highly erodible state immediately before the rains, which may wash away the ash, before it can be incorporated in the soil or absorbed by the plants. Besides, fire has other far-reaching effects on the soil by excessive heating of surface layers and reducing the moisture and humus content.

However, there are several bush species that are not killed by fire. There are also several coarse tussock grasses which cannot be eliminated by burning and mowing and their control can be assured only with cultivation for one to three years. Studies are essential to determine the role of these tussock grasses in the course of plant succession and of the factors that lead to their increase and means of their control.

Edwards (1942) points out that where an area of tall grass is protected from both fire and grazing for any length of time, a hot burn may destroy valuable grasses and result in a stand of undesirable vegetation. Thornton (1960) has demonstrated that fierce grass fires, if carried out at the end of the dry season, just before the rains break, can be useful in bush control, although such fires reduce grass production in the subsequent year. Experiments in Uganda have shown that burning early in the dry season encourages bush encroachment as do cool burns where insufficient burnable grass material is present. It is conceded by many workers that burning does have a place in the control of bush. But the fact remains that burning only "controls" bush encroachment and does not eliminate the fire-resistant species, which are continued to be maintained at low levels, and which increase when there is no further burning. Therefore, the use of fire has to be continuous and has to employed with care and knowledge. It has also been observed that wide-scale burning partially accounts for the paucity of leguminous species in savanna lands. <u>Desmodium</u>, <u>Indigofera</u>, <u>Tephrosia</u>, <u>Teramnus</u>, <u>Glycine</u>, <u>Crotalaria</u>, <u>Alysicarpus</u>, <u>Rhyncosia</u> and other legumes occur more frequently after protection from burning for several seasons.

Much remains to be learned about the use of fire in the management of grasslands. The effects of fire on vegetation are determined by intensity, frequency and time of burning. Experimental data on burning in East Africa are lacking and more data should be gathered before definite burning practices can either be condemned or recommended. Work is also needed as to how frequently an area has to be burned to control the different bush species, before grazing schemes incorporating burning are designed. Such data is needed for long-term effectiveness, because the grazing schemes have to provide not only for grazing, but for continued grass vigour and for control of the pernicious species. It is also necessary to determine grazing intensities and patterns where grasslands can be maintained in good condition under light or moderate grazing without forage being destroyed and wasted by burning, as it has been pointed out that burning is expensive, due to loss of any returns from grazing, because it is generally necessary to accumulate a full year's growth of grass in order to have a fire hot enough to kill bush, so that period plus the time for regrowth after burning represents a loss of revenue from the rangeland. Suitable techniques for handling fires have to be ascertained as also the cost and returns of burning in comparison with alternative procedures.

Pratt (1966) has emphasised the resistance and tolerance of bush species to fire and the importance of recording fire temperatures at various heights. For the present, one has to reluctantly agree that under the existing conditions, some use of fire is probably desirable in grassland management. In principle, however, one has to oppose burning, as over the years, it may do more harm than good by the destruction of vegetative cover and setting the stage for loss of soil fertility.

Bush Problem

Thick and regenerating stands of bush constitute the major problem of the savanna lands of East Africa. Forage and livestock production are greatly limited by bush, particularly in the semi-arid zones. There are several pernicious shrub and tree species that are in general resistant to fire and drought, put on exceptional regrowth after breaking, spread rapidly by rhizome or seed or both and are very persistent. The list of such troublesome species is fairly long, but the worst ones are Acacia brevispica, A. drepanolobium, A. hockii, A. senegal, A. seyal, A. mellifera, A. pennata, A. orfota, species of Combretum, Commiphora, Lantana, Solanum, Dicrostachys glomerata, Euclea divinorum and Tarchonanthus camphoratus.

Bush control has been attempted for various purposes such as controlling the tsetse fly, preparing land for cultivation, increasing production of indigenous grasses and to improve the habitat for certain game species. The problems of bush and its control have been thoroughly reviewed by Heady (1960) and Bentley (1963). Africans eradicate bush by hand slashing with panga or axe and hand stumping. Mechanical control of bush has been attempted by bull-dozer, chaining, the Holt-Breaker and the Gyro-mower. In general, mechanical bush eradication is too expensive for general use. Hand clearing followed by burning appears to be the most practical and economical control measure. However, the labour involved in hand clearing of bush is considerable. Trials among the Suk are reported to have shown that one man working 4 to 5 hours per day could clear two acres per week or 100 acres per year, in a manner sufficient to permit regeneration of grass cover. The area thus cleared might be capable of carrying 10 to 15 stock units which in turn might support 2 to 3 people. In the Yattas (Kenya) it is reported that as many as 20 to 25 mandays are required to clear an acre of bushland (IBRD, 1966)

Bentley (1963) considers Holting to be an ineffective removal method. Pratt (1965) however, states that in Kenya, the Holt IX bush breaker has proved useful to provide the initial knock-down. It was, however, found essential to sow grass on to the corrugations and to burn subsequently in order to control the increase in seedling trees which follows Holting. If sufficient grass still existed under the bush canopy, it was possible to use fire at the outset, without mechanical pre-treatment.

However, little experimental data are available on the relative effectiveness of different mechanical control techniques in eradicating different bush species, nor have any follow-up procedures been devised to maintain a grass cover free of bush, periodic burning still being generally resorted to, to keep the woody plants from growing tall. Where lands have to be cleared solely for forage production, high costs and quick regeneration of bush exclude the large scale use of mechanical control. It has been suggested that re-encroachment could be prevented by reseeding of the cleared areas (Naveh, 1965).

Chemical control of bush has been attempted in East Africa since 1936, with the principal objective of changing the habitat and thereby eliminating the tsetse, the common chemicals employed being Arsenic compounds. Arboricides have been attempted since the Second World War, the most common ones being 2,4-D and 2,4,5-T. Results have not so far been encouraging in East Africa, except in a few isolated cases. Much more basic work is needed with different arboricides on different species. One of the important factors governing the use of arboricides is that there are only few days in a year, when conditions are optimum for the application of arboricides, when kills over 95 per cent can be expected. Applications of arboricides have so far been mainly by hand to the bole of the plant, either frilled or unprepared and to stumps, frilling generally giving better results. Much more experimental work needs to done on the application of arboricides to the foliage, particularly to young growth of seedlings and sprouts. The economics of aerial spraying have also to be worked out, especially when large areas have to be cleared of bush. Chemical control will not be successful unless the environmental requirements and growth characteristics of the various species are first determined. It is also important that complete and detailed life-history studies should be conducted on the important bush species, particularly to determine the critical periods in their life-cycle, which are suitable for destruction, whether it be by fire, chemicals or other means.

Value of Browse

East Africa has a wealth of indigenous trees and shrubs, chiefly of the genus *Acacia*, which plays an important role in maintaining the plane of nutrition of wildlife and domestic stock. In some cases, the foliage has good browse value. Others produce valuable pods and seeds while some are prized by Africans for the value of bark as animal feed. Dougall and Bogdan (1958) and Dougall, Drysdale and Glover (1964) have provided adequate evidence of the wealth of indigenous vegetation that is at present a potential source of food for wildlife and/or domestic ruminants.

Observations have also been conducted on the browse habits of cattle and goats. Some of the browse species contain as much as 30 per cent crude protein and a small intake of these, can contribute considerably to the total protein intake, particularly when the grass cover is low or absent. Payne and MacFarlane(1963) found in Tanganyika that during the dry season, browse can comprise a significant part of total intake and that when browse is plentiful, cattle eat it readily. Payne (1963) further observed that when cattle have a limited amount of time available and browse is not plentiful, they will spend a larger proportion of their available grazing time filling themselves with what grass is available, rather than searching for browse; whereas when browse is plentiful, they will eat it readily as they do not have to spend time looking for it.

In a survey of the grazing schemes operating in Kenya, Brown (1959) has, however criticized the view that where browse feed is available in quantities greater than fodder, browse might be utilized in place of grasses. It was noted on the grazing schemes that cattle ceased to browse as soon as a minimum quantity of grazing was available, and did not do so from choice, in spite of the excellent feeding value of most browse species. He concludes that it would be both uneconomic and unnatural to attempt to utilize browse alone except when starvation point has been reached.

In several areas in East Africa, the present day herbaceous cover provides little by way of fodder, whereas the indigenous fodder trees provide considerable feed, particularly in periods of drought. It should be emphasised that grass is pivotal and fodder trees could only form an essential supplement. Better knowledge of the utilization of browse species and their contribution to the nutrition of wildlife and domestic animals will be of considerable help to range management workers. It has been recently proposed that studies should be undertaken to establish the relationship between intake of shrubs and grasses by animals in the semi-arid areas of East Africa, to evaluate the edible shrubs as a source of feed to animals at various times of the year, to determine the potentialities of various animals to subsist on browse and to assess their ability to control bush.

Grazing Problems

Payne (1963) has drawn attention to the very large increase in livestock population in East Africa, particularly in Kenya, where the livestock population has increased far more rapidly than the human population. Due to the unequal distribution of livestock population, problems of both undergrazing and overgrazing are reported. In Uganda, the natural grasslands over large areas of the country are understocked for most of the year and so deteriorate in feed quality resulting in much wastage. On the other hand, overgrazing of some plant communities acts both directly by repressing herbaceous growth and denuding perennial grasses and indirectly by the consequent reduction in the intensity of annual grass fires. As a result, there is an increase in fire-susceptible shrubs which appears to have a drying effect on the soil and causes further reduction in ground cover, soil compaction, increase in run-off and sheet erosion. Thus the development of bush from savanna reflects the onset of more arid conditions.

In Uganda, due to overgrazing, species of low grazing value invade the grasslands. One of them is Cymbopogon afronardus, a fire-resistant, unpalatable species which forms the first step in a secondary succession towards thicket. Work in Uganda to date has shown that C.afronardus cannot be economically controlled by the use of available herbicides such as dalapon, paraquat, and amino-triazole and that there are serious difficulties of application as the chemicals are at least equally effective against desirable grass species.

Large grazing schemes have been in operation in Kenya, covering 11,850 sq.miles or 7,589,000 acres on which different systems of range management, grazing control or grassland rehabilitation have been applied. The three principal schemes are (i) one herd, four paddocks, and three grazing periods, (ii) one herd, five paddocks and four grazing periods, and (iii) three herds, four paddocks and yearlong grazing. In fact, for improving impoverished grasslands, any deferred rotational system would be suitable (Pratt, 1964). The preservation of over 10,000 sq.miles of grazing land with limited staff, often dealing with a recalcitrant and reactionary population, a minimum of capital and in hard country with indifferent communications is, in itself a gigantic task and even if the problems of overstocking and marketing have not yet been overcome, in nearly all cases, erosion has been halted and denudation of vegetation prevented.

The majority of these schemes were on land which had been badly used and therefore, land rehabilitation measures took precedence over livestock management, which itself received very little attention. Most of the schemes have had to adhere to a rigid pattern. Carrying capacities were laid down arbitrarily. Encroachment by unlicensed people resulted in considerable overgrazing, with perennial grasses in many localities being replaced by coarse annual grasses, and some areas almost completely denuded of grass. Lack of grass, which serves as a tinder for fires made it difficult to carry out the necessary burning to keep down the bush. Attempts to combat bush by settling people who were allowed to keep only small stock that were expected to browse on bush also seemed to have failed. Bush infested by tsetse fly has made steady encroachments (Brown, 1959; IBRD, 1966).

Naveh (1964) feels that in many grazing and development schemes in East Africa, much effort was spent on attempting to superimpose modern concepts of animal husbandry, range management, and improvement on disrupted pastoral subsistence economies, and that these attempts usually failed because they were not combined with a parallel effort for a basic change in the whole socio-economic set up.

The principal difficulties in the grazing schemes are: (1) Graziers find it difficult to accept the idea that livestock numbers should be kept fixed irrespective of annual fluctuations in climatic and grazing conditions; (2) A tendency to sell a disproportionately large male stock and to keep as many cows as possible to maintain the supply of milk and to assist in a rapid reconstitution of the herds, resulting in an increase in immatures, for which no ready market can be found; (3) A tendency to become sedentary without having to move the stock over vast grazing schemes, from one paddock to another and a growing demand for replacement of grazing schemes by individual holdings;and (4) A general resistance to destocking and grazing controls.

It has to be demonstrated that a lower ratio of cattle to grazing land will actually produce a higher income per acre. The number of cattle must presumably be allowed to fluctuate from year to year, so as to enable people to save cattle for sale during years of harvest failure. People need to be convinced with the help of their own political leaders that control over livestock is necessary to prevent overgrazing. In order to enforce a sound destocking plan, accurate data should be collected on the number and composition of livestock herds and flocks, on the rate of increase and mortality and on the annual take-off.

Crop Production

Unfortunately, there is very little data available on crops and cropping patterns of the savanna lands. The savanna lands of East Africa, of which the Themeda-Hyparhenia community is a typical and extensive example, are best suited for grazing, with the exception of local situations near the upper rainfall limits, with favourable soil and moisture conditions, where crops are successful.

The short cropping season, imposed by the variable rainfall patterns makes it imperative to adopt early-maturing food crops and early planting and timely weeding practices. Originally, the Africans had grown mostly sorghum and millet which mature more quickly than maize, but these have now largely gone out of cultivation because they were particularly susceptible to bird damage, were rather low-yielding and had to be laboriously pounded into flour (rather than mechanically ground) before they could be used for food.

Crops are planted in pure stands only on about 25 per cent of the cultivated land. On the rest of the land, generally mixtures of two or more crops are grown. By far the most popular of the crop mixtures is maize and pulses, principally beans and pigeon peas. This mixed farming is probably due to the African's belief that mixed cropping yields a higher output per acre than planting in pure stands. Mixed cropping is beneficial to a certain extent in that it produces a dense vegetative cover, and apparently reduces somewhat the burden of weeding and the loss of soil moisture by evaporation. Above all, the mixing of crops is designed to reduce the risks in the lower rainfall areas.

Except in the high potential areas, yields are generally very low. Moreover, they vary markedly from season the season and in accordance with climatic conditions. Thus the average yields of maize, which occupies about half the cropped area, may range from less than one bag per acre in a poor year to five bags or more in a good year. For instance, in the Machakos district of Kenya, during the period 1943-1963, maize had to be imported for 15 years, 7 of which were considered severe famine years.

Since the longer-maturing maize is more susceptible to droughts, efforts were made by the Department of Agriculture to introduce quicker maturing varieties such as "Taboran" and "Katumani synthetic". However, these varieties have characteristics which have prevented their ready popularization. While they give yields superior to that of local maize, when the rainfall is poor, the local maize varieties showed greater yields in seasons of higher rainfall. Taking good years and bad years over a sufficiently long period, the improved varieties do give a greater output. Unfortunately this was difficult to demonstrate to farmers because the introduction of improved varieties coincided with a time of abnormally good rainfall. It was also difficult to prevent the admixture of new seed with that of indigenous maize.

Time of planting also influences crop production. Experiments in Kenya in 1960 showed that sorghum yields were 1,500 lbs. per acre when planted in the dry season before rains, but only 1,100 lbs. and 700 lbs. respectively when sown 4 days and 7 days after rains. Similar work by Bennison at Katumani research station showed that yields of Taboran maize fell from 1,761 lbs. and 1,362 lbs. when sown in the dry season, prior to rains to 1,049 lbs. and 851 lbs. respectively, when sown 6 days after the first heavy rains. The African farmer is often unable to resort to early planting, because of the hardness of the ground, weakness of the oxen owing to poor available grazing, and the necessity for replanting, if rains failed, requiring more seed. The use of implements like hoe makes it more difficult for the farmer to plant all his crops in time. The period of arduous land preparation often tends to run into or even overlap with the subsequent period of weeding, both of them constituting a bottle-neck resulting in poor standards of cultivation.

Lack of proper crop rotations is another factor limiting crop production. Fallow land is much harder to break up than cropped land. Moreover, wherever land is cropped twice a year, the selection of a proper crop sequence is important in avoiding the overlap of agricultural operations. For instance, the harvesting of late crops such as pigeon peas, of one season can and does delay the preparation of land for the next season's crops.

In general, the integration of agriculture and animal husbandry has not attained the ideal state. While the importance of fertilizers is realized by the African farmers their cost generally precludes their use.

Role of Wildlife in Savannas

In any study pertaining to the conservation and development of savanna lands of East Africa, the role of wildlife is of great importance and has to be considered in relation to the problems of domestic livestock. Forage, water and cover are basic requirements for both wildlife and domestic animals. In East Africa, almost all the National Parks and Game Reserves are situated on range lands, and, therefore, game ecology - the consumption of forage by wild animals, the effect of grazing both by wildlife and domestic animals on the existing vegetation are important factors, to be considered in savanna development.

Wildlife is always a potential source of revenue from tourism and hunting. Initial short-term studies have revealed a high meat production potential of wildlife and the extensive possibilities of its commercial exploitation as an important protein source.

The problem of grazing large herds of livestock and the management of wild animal populations differ considerably in the two broad ecological zones found in East Africa. In the open grass plains, there exist very large migratory herds of wild grazing animals which share the forage and water with innumerable herds of livestock owned by pastoral tribes. In the second and more extensive area, dominated by varying densities of woody vegetation, loosely defined as "bush", the greater part of which is infested with tsetse fly, there are large populations of wild animals, which for the most part are less migratory, than the game in the open plains. Whereas the wild herbivores are adapted to their environment and make highly efficient use of it, the overstocking of the the plains with domestic stock constitutes the most serious and wide-spread land-use problem, that affects much of the tsetse free savanna areas. Overgrazing by domestic livestock has also lowered the carrying capacity of some of the savanna lands, hitherto exclusively occupied by wild animals.

Preliminary studies of wildlife habits have shown that various species of wild ungulates have different and complementary diets. Where several species of wild ungulates feed together, they utilize the available mixed vegetation in a very efficient manner. It has been suggested that a study of the ecology of game animals may show that some may be beneficial to the maintenance of pasture and also that some are capable of utilizing the scanty rainfall and offer a source of meat in areas unsuited to the development of domestic animals. For instance, animals such as giraffe survive mainly on shrubs and trees and compete but little with domestic stock in the utilization of herbaceous vegetation.

Present knowledge indicates that combinations of wild ungulates or of wild ungulates and domestic stock will make far more efficient use of savanna lands than will cattle alone. Sustained productivity of the savanna lands can, therefore, be achieved, by the proper management of wildlife and domestic stock together, and this productivity may often be higher than which can be obtained with domestic livestock alone.

The rapidly accelerating human and livestock populations in East Africa have led to a progressive restriction of wildlife habitats through increased land being brought under cultivation and grazing resulting in the restriction of wildlife into restricted areas such as Parks and Game Reserves. On the other hand, due to the elimination of predators and reduction in poaching and other depradatory activities, there has also been considerable local increases in the numbers of wildlife, resulting in a severe competition for feed and fodder and occasionally their encroachment on agricultural lands. There is thus an urgent need to control the numbers of wildlife as an essential part of game management, wherever overpopulation and habitat depletion have occurred. In fact, it is because of this explosion in wildlife population, that game cropping and wildlife harvesting have been initiated in the countries of East Africa, to achieve some sort of control in the numbers of wild animals. Rational long-term utilization of the natural resources of savanna lands has to be based on the sustained yield of a population which is in balance with its habitat.

Research work is needed to define population dynamics, food habits - preferred and second choice diets, movement patterns, and management techniques of the economically important ungulates of Eastern Africa, as a basis for determining management policies and methods for National Parks, Game and Forest Reserves and for game cropping schemes. Studies are also needed on the diseases of wildlife with particular reference to transmission between wildlife and domestic stock, because preliminary studies conducted so far indicate that the wild herbivores suffer from a number of diseases of viral, protozoal and bacterial origin, some of which are capable of inter-transmission to domestic livestock.

Sociological Problems

It will not be out of place to dwell briefly on the human problems. Africans have been grazing cattle, sheep and other animals for generations without regard to the condition of the grasslands, erosion or the gradual disappearance of water supplies through rapid run-off. It is also difficult for them to understand the advantages of any "system" of handling livestock. Other factors which come in the way of planned management are traditional ownership and land usage, failure or lack of incentive to turn cattle into an economic asset, holding of livestock for purposes of prestige and for bride price, lack of permanent water sources, insufficient land, remoteness from markets and lack of marketing systems, resistance to destocking, lack of knowledge to conserve fodder or prepare silage for dry season use, a general disregard for animal welfare and promiscuous and unregulated burning of grasslands. Some of these are deep seated difficulties which have their roots in tradition and for which there appears to be no immediate solution in sight, as in general the Africans' customs, traditions and beliefs resist change.

The encouraging feature of the grazing schemes in Kenya is that in general, the Africans who have participated do recognize the fact that cattle make better growth when there is ample grass. There seems to be little doubt that with patient and understanding leadership, a knowledge of tribal psychology, and administrative backing, the African tribes can be eventually won over, although it may take much time and effort.

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THE ROLE OF FORESTRY IN SAVANNA DEVELOPMENT

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I. INTRODUCTION

Sources of information on Savanna Forestry

The area of Savanna in Africa is about one half of the total area of the continent, and it supports rather less than half the population of the continent south of the Sahara. By contrast it may be remarked that the area of high forest is about one twelfth of the total area, and it, too, supports one half of the population.

Future economic development, rising standards of living and increasing population will generate increasing demands for forest produce of all kinds. At the same time they will create increasing pressure on the land for agriculture and stock raising and on water resources. The combined effect will, therefore, be a need to increase the production of forest produce from a static or dwindling area of land, without reducing the protective function of the forest. In this the African savanna, if only because of its vast size, must play its full part.

The need for the development of the savanna was recognised by the FAO African Forestry Commission at its first session held in Nigeria in 1960. Because of the low productivity of the natural savanna, it was also recognised that any appreciable increase in its productivity must in the main be effected by means of planting. A Working Party was set up, and the Forestry and Forest Products Division of FAO (a) compiled a bibliography on savanna forestry with particular emphasis on savanna afforestation;

(b) requested reports from the members of the Working Party on methods of savanna afforestation;

(c) prepared a draft report on savanna afforestation in Africa.

The last forms the basis of the present statement.

II. CHARACTERISTICS OF FORESTRY IN NATURAL SAVANNA WOODLANDS

The environmental characteristics of savanna have been discussed under preceding items. The conditions which most affect tree growth are the long dry season and accompanying soil moisture deficit which may persist for much of the year, the desiccating wind and low atmospheric humidity, which is particularly marked near the Sahara, the low fertility of many of the soils and the limitations on rooting depth caused by laterite formation, the gently rolling topography which gives rise to the "catena" or recurring series of soil and vegetation types dependent on the position on the slope, the practice of shifting cultivation and the widespread occurrence of annual grass fires. The tree growth, which results from these conditions, has the following main characteristics :

(1) Even in the best types of "Open Forest", such as Miombo, tree heights of over 15 m (50 ft) and utilisable bole lengths of over 6 m (20 ft) are uncommon.

(2) Stocking is low in comparison with both high forest and plantations. A basal area of 16 m^2/ha (70 sq ft/acre) has been recorded from the best sites in Zambia (Endean 1966), but over much of the area stocking is only a fraction of this.

(3) Increment is low. Girth increments of 0,6 - 0,8 cm (1/4 - 1/3") a year are common for a number of species. Gross timber volume increment of 1,4 - 2,1 m^3/ha/an. (20 - 30 cu ft/ac/an.) has been recorded on the very best sites (Endean 1966), but this is exceptional and over most of the savanna gross increment is much less.

(4) Harvestable increment is a small fraction of gross increment. The majority of timbers occurring naturally in the savanna are hard, heavy, difficult to season and work, perishable and often of indifferent form. The few really good savanna timbers, of which Pterocarpus angolensis is an outstanding example, are scattered very sparsely through the savanna woodland; in Tanzania, for example, the harvestable increment of this species has been calculated at about two trees or 60 cu ft per square mile per year (Parry 1959) an increment of about 0,1 cu ft/ac/an. or .007 m^3/ha/an. In these conditions logging becomes dispersed over large areas and hence expensive. In a few areas, specialised markets allow fuller utilisation of the commoner species of indifferent quality (e.g. the use of the Brachystegia and Isoberlinia spp. on the copper belt in Zambia), but this is exceptional. Another exception is the relatively pure stands of Gum Arabic or Acacia senegal in the Sudan.

(5) Under natural conditions, many tree species spend a variable period of ten years or more in the suffrutex stage, during which the root system slowly expands, while the stem dies or is burnt back annually. Only when the root system has reached a certain size does it send up a shoot large and vigorous enough to survive the dry season. Natural regeneration is therefore slow and uneven.

III. PAST AND PRESENT PRODUCTION FROM SAVANNA FORESTRY

(a) Wood Products

Current production from savanna follows the traditional pattern of the past, and a rough estimate of current requirements has been made in the draft report on savanna afforestation in Africa as follows :

(1)	Fuelwood	66 million m^3	(2,300 million solid cu ft)	a year
(2)	Poles	7 " "	(245 " " ")	"
(3)	Timber	1 " "	35 " " "	"
(4)	Pulpwood	Nil		
(5)	Total	74 million m^3	(2,580 " " ")	"

On an estimated savanna population of 100 million and an estimated area of 5 million square miles (13 million km^2), these figures become (rounded) :

Average Annual

	Consumption per head		Production per unit area	
	m^3	cu ft (solid)	m^3/ha	cu ft (solid)/acre
(1) Fuelwood	0.66	23.1	0.053	0.69
(2) Poles	0.07	2.4	0.006	0.08
(3) Timber	0.01	0.4	0.001	0.01
(4) Pulpwood	Nil		Nil	
(5) Total	0.74	25.9	0.06	0.78

It must be emphasised that these estimates are only rough average ones, but they do demonstrate the current predominance of fuelwood utilisation. Where populations or industries are concentrated, local consumption and production figures are very much higher than the average and the proportion of timber and poles to fuelwood may be increased appreciably e.g. in the copper belt in Zambia.

(b) Other Products

A number of other products are produced locally from within the savanna region, including thatching grass, binding material from tree bark, fruits and nuts. More important products are gum arabic, which is a very important crop in the Sudan, and beeswax and honey, which are important over a wide area of the savanna. Tanzania is the world's largest exporter of beeswax, which is produced mainly from its "Miombo" open forest. Beehives are traditionally constructed from the bark stripped from *Brachystegia* species, and this involves the death of a large number of trees every year.

IV. POSSIBILITIES FOR FUTURE DEVELOPMENT

It has been estimated that as a result of rising population and living standards within the savanna region, consumption of fuelwood and poles may double by the end of the century, while consumption of timber may be increased fourfold. The means of meeting the anticipated increase in consumption are discussed below :

(a) Extensive Forestry

The large areas of sparsely populated savanna are likely to be able to continue to supply the needs of the population in fuelwood and poles for some time to come. Natural regeneration can be relied on to replace the cut and, if combined with fire control, may theoretically increase it. In some regions it may also be possible to continue the supply of timber of a particular species, e.g. in Tanzania the young poles of *Pterocarpus angolensis* far exceed in numbers the mature trees and a simple form of yield control, based on large-scale enumerations and estimates of growth rate based on tree increment plots, should be capable of maintaining the current yield indefinitely.

Though simple forms of extensive management may be capable of maintaining present supplies of produce, the prospects of increasing yields of indigenous savanna several times over are very slim. Experiments in Zambia showed an increase of about 50% in production of the best treatment over the control, after 25 years (Endean 1962). This order of improvement is entirely inadequate to meet the increased needs of wood products near future concentrations of population and industry. Proposals have been made for improving the yield per acre of *Pterocarpus* (Boaler 1966) which include the thinning of well-stocked young pole stands and the transplanting of suffrutices, but a considerable period of successful experimentation will be needed before any techniques of this type can be applied on a wide scale. For any worthwhile increase in production, afforestation will be necessary.

(b) Intensive Forestry including Afforestation and the Use of Exotics

Intensive forestry implies the use of plantations, which will rely heavily on exotics. Plantations have a number of advantages :

(1) By correct choice of species for a given site, yield per unit area may be many times that of the indigenous savanna. Approximate estimates of mean annual increment of timber from various tree crops are :

(i) <u>*Pterocarpus* alone in Tanzania.</u> 0.1 cu ft/ac/an. (.007 m^3/ha/an.)

(ii) <u>The best Miombo in Zambia, with full utilisation</u> 20 - 30 cu ft/ac/an. (1.4 - 2.1 m^3/ha/an.)

(iii) <u>Pine plantations for timber</u> 100 - 200 cu ft/ac/an. (7 - 14 m^3/ha/an.)

(iv) <u>Eucalyptus plantations for fuel or poles or timber</u> 200 - 300 cu ft/ac/an. (14 - 21 m^3/ha/an.)

(2) By correct choice of species, a more uniform and more useful type of wood can be produced than is possible from the indigenous savanna, with its multitude of different species. Softwood plantations can make a specially valuable contribution to the production of general purpose, easily worked timber for construction and light joinery which is likely to be in most demand in the future and for which most of the indigenous species are unsuited.

(3) By virtue of their higher yield per unit area, plantations can be concentrated on a smaller area than would be needed for the same yield from indigenous forest. Concentration reduces costs of management, protection and harvesting.

(4) Plantations, being a more labour intensive form of land use than management of indigenous savanna, can make a much greater contribution to full employment. In the case of large projects, where processing is an integral part of the operations, e.g. a pulpmill, the economic, social and recreational conditions of the surrounding population may benefit greatly.

Plantations for production of fuel and poles are usually to supply a local market, and the produce is not valuable enough to justify transport over long distances. Hence this type of plantation is likely to be made on a small-scale local basis, either by a communal effort, the village woodlot, or by private woodlots. Timber production, on the other hand, is more economical in larger units and the more valuable converted lumber will bear transporting for some distance. The degree of practicable concentration, however, will often be affected by the lack of homogeneity in savanna soil conditions. Owing to the long dry season and the difficult growing conditions in much of the savanna, it is essential that only the better soils should be used, if plantations are to be successful. Very careful soil survey therefore needs to be carried out in advance of large-scale planting, as is the standard practice in Zambia (Sanders 1966) and variation in site quality may sometimes require planting in units smaller than the most economical (in theory).

Production of short-rotation pulpwood from savanna plantations is a future possibility, but detailed investigation would be needed in each individual case to justify the economics of the large investment needed. The fact that large areas of sparsely populated land are available from the savanna makes it attractive at first sight for pulpwood production, but the maintaining of fast and uniform growth over large areas would be an even greater problem than in timber plantations.

The effort put into afforestation in savanna is often of inverse proportion to the availability of alternative, higher quality sites elsewhere. Thus Kenya and Tanzania, with large areas of land over 5,000 ft, have confined research in savanna afforestation to trial plot programs of fairly modest dimensions. In Uganda and Northern Nigeria there are numerous species trials in the savanna (for example the 1965-66 Annual Report for the latter region records nearly 250 species elimination trials and over 150 species growth trials). In Zambia results from some invaluable earlier trials have enabled savanna afforestation to be started on a considerable scale and an annual program of 2,500 acres of Pinus khasya and 2,500 acres of Euc. grandis is planned (Cumming 1966).

(c) Combination of Intensive and Extensive Forestry

In some areas afforestation with exotics may, paradoxically, contribute towards the management of indigenous savanna. Once an afforestation project has been started, the project facilities in the form of staff, buildings, transport etc. may also be available for research into the silviculture of the surrounding savanna. Research into the silviculture of Pterocarpus angolensis, one of the few savanna species the intrinsic qualities of which can justify expenditure on research, would benefit greatly by being based on an active and well sited afforestation station.

(d) Possibilities of Co-ordinating Forestry Development with other Forms of Land Use.

The combination of forestry with other forms of land use has in the past been coincidental rather than planned. The traditional preservation of "standards" of the more valuable species by shifting cultivators and the effect of the fiercer fires, which often follow cultivation for a few years and which can favour, for example the fire-resistant Pterocarpus against some of its more aggressive but less fire-resistant competitors, is a case in point. Conversely, the Miombo tree species are essential to agriculture both for their direct contribution to honey manufacture and for the suitability of their bark to the manufacture of primitive hives; at the same time they provide the fuelwood and poles for house construction which are essential to the life of the shifting cultivator. An example of planned integration of forestry and agriculture has been the preservation as "hill-top forest reserves" of protective caps of forest/thicket on granite lopjes in the intensely cultivated areas of Sukumaland, Tanzania. Savanna woodland also provides a habitat for a large variety of wildlife; the more spectacular concentrations of animals usually occur in the more open acacia grasslands and the thornbush areas rather than in the open forests.

The combination of agriculture and forestry may be expected to expend, at least in the form of small woodlots of quick-growing fuel species within farming communities. The possibility of large-scale multi-purpose projects is dependant on much more intensive research than has been possible in the past. Basically the problem is to combine land usage forms, the site requirements of which are complementary. An example might be the use of pines for afforestation on the ridges and upper slopes in rolling country, while growing rice and ranching cattle in the low-lying grassy, seasonally waterlogged valleys.

Integration of forestry and agriculture may be assisted by the radical modification of climatic conditions which may be effected by irrigation. An outstanding example of this is in the Gezira in the Sudan.

(e) Protective Functions

Owing to the overall gentle topography of the savanna areas, the protective value of forestry is less marked than in the more mountainous areas. In general, it is likely that indigenous woodland is as good for the protection of minor catchment areas as plantations, but that plantations, provided they are properly managed, need not be considered harmful from the protective point of view. It is fair to say, however, that research on the protective aspects of forestry and of alternative forms of land use in the savanna has scarcely begun.

One protective function which may be fulfilled more efficiently by exotics than by indigenous forest is that of shelterbelts and windbreaks. A properly designed windbreak of several complementary species may be extremely valuable to agriculture where wind is a problem, and fast-growing species such as eucalyptus can modify wind effects more quickly than indigenous species, especially if a second species of bushy form is planted as well.

V. MAJOR PROBLEMS, GAPS IN KNOWLEDGE, OBJECTS FOR RESEARCH

Research on savanna forestry has been spasmodic and local in the past, and evidence on many problems is conspicuous by its absence. Knowledge of the best species and methods for afforestation is still inadequate in most countries, and the more complex ecological studies of indigenous species have been developed still less. The main items which need study are :

A. The Environment

(i) Better distributed meteorological stations and the continuance of observations over a longer period are of fundamental importance. Hydrological observations need to be added to existing meteorological ones.

(ii) Particular attention to be paid to soil moisture relations throughout the year and especially in the dry season, since this may well be the most important single factor affecting tree growth.

(iii) The study of site factors and their affect on species success. The method of Principal Component Analysis used by Boaler (1966) for *Pterocarpus angolensis* is a useful model, but it would be highly desirable to devise a method applicable not only to indigenous trees but to exotic trees and agricultural and pasture crops also.

B. The Trees

(i) Extension of the range of species, provenances and sites being tested.

(ii) Further research on the cost/benefit ratio of various afforestation methods. For the difficult conditions of the savanna intensive site preparation and weeding seem essential, but for certain favoured local sites a simpler and cheaper method may be acceptable.

(iii) Long-term effects of fast-growing plantations in savanna on

(a) soil moisture relations
(b) soil fertility

and the possibilities of field-scale fertilisation

(iv) Further information on growth rate, yield and ages of the few valuable indigenous species and on the possibilities of concentrating these species in pure stands. Further information on the variability in growth rate within the same species on the same site and the possibility of distinguishing between the inherently fast and slow growers is of particular importance.

VI. CONCLUSIONS

The vast area of savanna is in itself a challenge to solving the problems of increased production. Treatment of the low-yielding indigenous vegetation does not promise any substantial increases in yield, but judicious afforestation projects, based on adequate results from trial plots in the same locality, are likely to yield bigger and quicker results. Integration of forestry with other forms of land usage is in its infancy. Research adapted to local conditions will need greater expenditure in the future; among the subjects needing most emphasis is the correct evaluation of site quality not only for forestry, but for all forms of land use.

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THE ROLE OF WILDLIFE MANAGEMENT IN SAVANNA DEVELOPMENT

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I. INTRODUCTION

The process of proper development of wild lands is far from uncomplicated. Development without direction or unconsidered use of technically advanced tools achieves only limited objectives at the expense of a loss of overall potential productivity of the land. The fauna represents a factor in the ecology of wild lands which both has its function in the maintenance of the ecosystem and also which, under suitable management, can yield a high economic return.

II. DEFINITION AND SCOPE

For the purposes of this paper, the term "Savanna" is taken to include :

a) Open Savanna, being sub-climax grassland dominated to a greater or lesser extent by *Acacia* and *Commiphora* spp. and which, in certain limited areas of low rainfall (from 6 - 10 inches per year), may merge into semi-desert.

b) *Brachystegia/Isoberlinia* Woodland ("Miombo"), being open fire-climax forest dominated by *Brachystegia* and, to a lesser and variable extent, *Isoberlinia* spp., within which are valley grasslands whose type is conditioned by the character of the soil and the efficiency of the drainage. These woodlands merge into undifferentiated woodland to the north and to the south of the main intertropical forest belt. At the interzones *Isoberlinia* dominance is replaced by other species.

Wild fauna is distributed throughout the Savanna according to specific habitat requirements. It has been shown by Petrides *et alia* that, providing these requirements are met, it is possible for a given area to sustain a much higher weight of wild herbivores than of domestic stock due not only to the full use made of the environment by a wide spectrum of wild herbivorous species with differing food preferences, but

also to their more efficient forage conversion. Moreover, wild animals have a r
tively high naturally induced immunity to endemic disease.

The optimum condition of energy exchange is found in a naturally regulated
tem. This ideal is now hardly ever achieved owing to the direct or indirect inf
of human activity and the ecosystems are consequently either vulnerable or in a
of actual instability. Some degree of compensatory management is therefore nece
coincidentally with any management system directed towards a particular form of
zation of the wildlife resource.

III. METHODS OF UTILIZATION OF THE WILDLIFE RESOURCE

In planning the development of wild lands the potential economic productivi
wildlife should be taken into account, to be made use of either during a transit
period towards some other intensive form, or as a main objective in a sole or a
tiple form, of land utilization. The degree of management necessary to achieve
utilization of the wildlife resource as a main objective may be considerable.

If proposed development is such as to exclude the feasability of utilizing
wildlife resource, the problems arising from remnant or invading wild animals sh
be recognized, as should the effects of denial of the development area to wildli
already under some form of management in neighbouring areas.

The potential economic productivity of wildlife may be realised in a variety
ways :

a) Tourism and Recreation :

Cheap and quick air communication brings the continent of Africa withi
of industrially developed countries whose crowded populations have the mean
the desire to seek the recreation and aesthetic refreshment offered by Afri
wildlife. As the African countries themselves develop, so are their own po
tions also beginning to appreciate this human search for psychological tran
lity and satisfaction.

National Parks are suitably chosen areas whose management is directed
the maintenance in perpetuity of a viable ecosystem of natural fauna and fl
played for public enjoyment by the discreet provision of tracks and where a
dation facilities are made available. Although seldom economically self-su
they are the magnets which attract increasingly large numbers of foreign vi
to the countries in which they are situated, from whom a very substantial r
is derived during their stay.

Some of these visitors are prepared to pay heavily for the privilege o
ting particular animals. This demand may be sufficiently great as to justi
reservation of certain suitable areas where management can be applied to pr
a sustained yield of trophy animals for wealthy sportsmen. Apart from indi
revenue accruing to safari outfitters and from other incidental expenditure
comparatively high cash return from licence and hunting fees can be obtaine

b) Controlled Hunting :

Wild animals are present throughout the undeveloped and semi-developed
na. The controlled hunting of them on a sustained yield basis by the indig
population for meat and hides represents a locally profitable use of the wi
resource where wild animals densities are too low to allow of a more intens
utilization. In large areas of tse-tse fly infested Brachystegia woodland
populations are comparatively small. Excepting in very limited localities,

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The optimum condition of energy exchange is found in a naturally regulated ecosystem. This ideal is now hardly ever achieved owing to the direct or indirect influence of human activity and the ecosystems are consequently either vulnerable or in a state of actual instability. Some degree of compensatory management is therefore necessary coincidentally with any management system directed towards a particular form of utilization of the wildlife resource.

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In planning the development of wild lands the potential economic productivity of wildlife should be taken into account, to be made use of either during a transitory period towards some other intensive form, or as a main objective in a sole or a multiple form, of land utilization. The degree of management necessary to achieve the utilization of the wildlife resource as a main objective may be considerable.

If proposed development is such as to exclude the feasability of utilizing the wildlife resource, the problems arising from remnant or invading wild animals should be recognized, as should the effects of denial of the development area to wildlife alalready under some form of management in neighbouring areas.

The potential economic productivity of wildlife may be realised in a variety of ways :

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Cheap and quick air communication brings the continent of Africa within reach of industrially developed countries whose crowded populations have the means and the desire to seek the recreation and aesthetic refreshment offered by African wildlife. As the African countries themselves develop, so are their own populations also beginning to appreciate this human search for psychological tranquillity and satisfaction.

National Parks are suitably chosen areas whose management is directed towards the maintenance in perpetuity of a viable ecosystem of natural fauna and flora displayed for public enjoyment by the discreet provision of tracks and where accommodation facilities are made available. Although seldom economically self-supporting, they are the magnets which attract increasingly large numbers of foreign visitors to the countries in which they are situated, from whom a very substantial revenue is derived during their stay.

Some of these visitors are prepared to pay heavily for the privilege of hunting particular animals. This demand may be sufficiently great as to justify the reservation of certain suitable areas where management can be applied to provide a sustained yield of trophy animals for wealthy sportsmen. Apart from indirect revenue accruing to safari outfitters and from other incidental expenditure, a comparatively high cash return from licence and hunting fees can be obtained.

b) Controlled Hunting :

Wild animals are present throughout the undeveloped and semi-developed savanna. The controlled hunting of them on a sustained yield basis by the indigenous population for meat and hides represents a locally profitable use of the wildlife resource where wild animals densities are too low to allow of a more intensive utilization. In large areas of tse-tse fly infested Brachystegia woodland human populations are comparatively small. Excepting in very limited localities, domestic stock can only be kept under conditions of strict prophylactic treatment, and wild animals, although their densities are fairly low, assume an important role in the provision of protein and animal products for the local people. The degree of management necessary is limited to the establishment of realistic offtake quotas for each species, a mechanism to enforce the regulatory legislation, particularly when wild animals are concentrated on the valley grasslands at the driest season of the year, and to improvement of grassland condition and water supplies. An organized system of distribution and sale of game meat and products can also be introduced, through, for example, a co-operative system.

c) Game Cropping :

A development of controlled hunting by much more intensive management is the use of suitable wildlife populations to produce the maximum possible sustained yield. To achieve this requires considerable prior research, refinement of hunting and processing techniques, and the exercise of strict control over other land uses. Game cropping is already profitably practised in grassland areas of Rhodesia and South Africa, and has proved that the higher potential productivity of wild animals can actually be realised. Such cropping can be applied both to completely wild areas and to areas where domestic stock are also ranched, then giving a dual crop. A proper understanding of the dynamics of the wild populations in question is necessary in order to induce a population explosion in the species and then to maintain explosion point, when the maximum possible offtake may be obtained. Intensive management is obviously essential and must include full control over incidental human activities. The main reason why game cropping is not more widely practised is due largely to the political and social difficulties of applying this type of control to public lands, for unless such control is guaranteed, the comparatively high capital investment necessary in a cropping scheme will not be forthcoming.

Methods of processing and marketing the products of game cropping depend upon local circumstances, but it is in these that the greatest expense lies. It is thus of advantage to have a ready market near at hand, when processing and transport costs are minimal. There is however a considerable potential export market for game meat in a canned or deep-frozen form both for human consumption and for the pet-food trade. The latter could also absorb powdered or dehydrated meat. In these cases capital investment in the necessary plant is very high and the successful implementation of management must be assured to the investors, be they Governments, contractors or private companies. Game cropping in a modified form is practised in many parts of Africa where use is made of the products of animals necessarily killed in population reduction operations of, for example, hippo and elephant.

d) Ranching of indigenous Animal Species :

This represents an extension of game cropping where indigenous animal species are ranched in substitution for domestic stock by methods which approximate to conventional cattle range management practices. This makes use of the more efficient environmental adaptation of indigenous species and those used for this purpose should therefore be those whose natural habitat is represented by the range upon which they are to be managed. Such species must also be capable of becoming amenable to some degree of control, handling and confinement. Eland and buffalo are already ranched with success in some southern parts of Africa. Again, this type of management demands the strict range control which can only be achieved through some system of tenure of the land by the operator.

IV. CONCLUSION

While the directions in which the utilization of wildlife may be developed to economic advantage have been indicated, the feasability or desirability of this type of development can only be assessed in the local context of the prevailing circumstances of each particular area. This assessment has to be made by local planners, who should, however, be aware of the possible ways in which the wildlife resource could be utilized. They should also be aware of the full implications of the necessary management practices, and should realise, insofar as information is available, the relationship of wildlife to human beings and their domestic stock with regard to disease and general use of pastures and water.

In the preparation of any development plan for savanna areas, international organizations can assist in several ways. Firstly, advisors can be made available to the planners to recommend how the wildlife resource could be used and to explain the problems likely to be encountered from the presence of wildlife in that area; secondly, research workers can be provided to obtain information necessary for a management plan involving wildlife, thirdly pilot experiments for large scale projected wildlife utilization schemes can be set up; and fourthly capital injection for such large scale schemes can be provided.

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HUMAN AND INSTITUTIONAL FACTORS: SOCIOLOGICAL AND RELATIVE PROBLEMS OF SHIFTING CULTIVATION, NOMADS AND SETTLEMENTS

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There is a tendency, in projects and schemes of all kinds which involve both technical and human factors, to concentrate on the technical aspects. This tendency is particularly apparent in projects like building a dam or organising a settlement, but exists also in big area development schemes and national plans. The reason for this is not far to seek. When we build a dam we are dealing with something tangible, we know that, if we follow the specifications and take the necessary precautions, our dam will serve its purpose and show results for the expenditure of our money, skill, effort and time. When we deal with human and institutional factors, there is no exact mathematical or scientific formula to follow in order to ensure success. We cannot apply experience gained in one set of circumstances directly to another set of circumstances and we can rarely say with confidence that the project is finished and is a success.

Everyone who has worked with rural people and farmers knows that they cannot be changed quickly from one mode of life to another, from nomads to settled farmers, from shifting cultivators to settled homesteaders, from pastoralists to crop husbandmen or from dryland farmers to irrigation farmers. It is perfectly natural that the habits ingrained by tradition and the security engendered by known forms of agriculture are reluctantly abandoned for new and strange methods, even though the benefits of these have been shown by demonstration. In my experience it took a minimum of three years for the majority of farmers to accept a new practice, even the most obviously beneficial, after the leading farmers had accepted it. Often it takes ten years and more to have a new form of agriculture accepted by the farming community.

With the present urgent need for greater production of food crops and the desire for increasing national incomes and improving standards of living, it is tempting for Governments to use administrative pressures and to replace the long and slow process of teaching and demonstration by quicker and apparently more effective methods. Sometimes, the hope is expressed that after the farmers have been pressed to use a new practice they see the benefit of the change and adopt it as a habit, so that the pressure can be relaxed. Nevertheless when administrative pressures are withdrawn, the people usually revert to their former ways and nothing can, in the long term, effectively replace patient explanation, teaching and demonstration to persuade farmers to adopt a new practice.

It follows that if a project involves both technical factors and human factors, progress in both must be encouraged simultaneously, after the initial exploration, survey and investigation establish that a project is physically, agriculturally and economically feasible. It is timewasting and inefficient economically to complete a dam and irrigation layout and then begin work on providing the research, extension and other services that are necessary to enable the farmer to make full and economic use of the water provided. Such human and institutional aspects must be studied and work begun on them at the earliest possible moment, even though it may be possible to treat some aspects on a small scale only, e.g., teaching irrigation farming before a large irrigation dam is built.

The human and institutional factors and the sociological problems of projects such as settling of nomads and stabilising of shifting cultivators, vary in relative importance with every project, but normally the following aspects must be considered and those which are absent or weak must be strengthened, otherwise the project will be a failure. This is not exhaustive and is merely a brief summary of factors to be considered as a basis for further discussion.

1. Research - Normally for the purpose of a project, it is not necessary to do basic agricultural research, but merely to do adaptive experiments which apply to the local conditions research done elsewhere. Even such simple adaptive research takes time and should begin early so that the agricultural questions of the extension workers and in turn of the farmers can be answered.

2. Extension - Agricultural research, where results are not made known to the farmers, is pointless. A well-informed and dedicated extension service is essential to pass on to the farmers the results of research and to make the farmers' problems known to the research workers. It is important that the farmers not only accept, but enthusiastically support the project and this can only be achieved by government plans being explained to their leaders in advance and accepted by them.

3. Credit - All the advice of extensionists has little impact if farmers lack the means to obtain credit for the necessary purchases of implements, equipment, fertilisers and insecticides, planting material and sometimes labour to put the advice into action.

4. Farm Supplies and Services - These include the provision and hire of implements, contract ploughing, fertilising, pruning and spraying services, vermin control, etc. These may be provided by Governments, Marketing Boards, Cooperatives, or private enterprise. In many developing countries there is need to increase such services and provide the farm supplies at least in the pioneering stage if development of farmers from subsistence to profitable farming is to be achieved.

5. Marketing Facilities - An attractive, stable price for his produce is the best incentive a farmer can have for increasing his crop production. The establishment of satisfactory market facilities is necessary to ensure the success of a project involving increase in production of crops or stock, yet this aspect is sometimes neglected. In many developing countries this is provided through cooperatives, so that farmers feel that they share in the profits of marketing in addition to the production of the raw product.

6. Land Tenure and Tenancy Arrangements - There must be secure and equitable landholding arrangements to permit the optimum production from a project. There are many ways in which this can be achieved : - individual, cooperative or communal ownership or enlightened and secure tenancy arrangements. It may be necessary in a project, such as an irrigation scheme, for the Authority to have land rights over the area so as to have the power to evict individuals whose activities harm the rest of the tenants. Many irrigation schemes have failed because there was no clear-cut understanding among the tenants what their agricultural and financial obligations were and no control by the authority over the actions of the tenants.

7. Training of Field Staff and Farmers - An essential feature of most agricultural development and settlement is the training of field staff which are usually inadequate in numbers and ability to undertake the greatly increased duties that such developments involve. The greatest need is usually for the middle grade field worker and technician, and the training of these should have high priority. It is also important to supplement extension work among farmers by short-term courses of a highly practical nature for farmers themselves.

8. Organisational Arrangements - The Government body responsible for agricultural development involving settlements, stabilisation of agriculture and irrigation schemes may be the Ministry of Agriculture, or of Agrarian Reform, or of Lands and Natural Resources. Alternatively, such developments may be supervised by some autonomous or semi-autonomous authority responsible for the specific region or type of development. Whatever the responsible body or bodies may be, it is essential that coordination of all associated authorities is achieved, both in agricultural aspects and the aspects which are the responsibility of other Ministries and Departments such as Public Works, Health, Education, Local Government. This can be achieved by an inter-ministry authority under the Chief Minister or some other Senior Minister and at field project level by regular team meetings of the local officials and authorities concerned. To make coordination at field or project level effective, there should be as much delegation of authority as possible to the local officials on the spot. Only by such coordination can duplication of work be avoided and a uniform policy put into practice. If an authority is set up to be responsible for developing settlements, it is important for the normal Government departments to take over responsibility once the development stage is over. At field level, it is important that officials should have as little as possible of administrative and financial burden to carry and that they should have every possible facility such as transport and equipment to carry out the duties for which they are talented and trained.

Conclusion

This is a highly simplified summary of some of the human and institutional factors which must be considered when planning and implementing a project or settlement scheme. In most countries in the Savannah region, there is a shortage of trained and experienced men in the various agricultural and associated disciplines to undertake all the tasks which the increasing tempo of development demands. It therefore is of paramount importance to step up the speed of education and training of agriculturalists of all grades and, secondly, by careful planning and coordination to utilise the existing skilled manpower in the best possible way.

All of you must have experience of the ways in which human and institutional factors can make or mar a project or a regional or national development plan. This brief introductory paper merely serves as a basis for discussion and interchange of experience to assist in the preparation of better balanced plans for projects, settlement and development schemes in the future.

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ORGANIZATION OF REGIONAL AGRICULTURAL RESEARCH PROGRAMS FOR AGRICULTURAL DEVELOPMENT WITHIN THE FRAMEWORK OF ECOLOGICAL ZONES

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1. INTRODUCTION

The development of agricultural research and the improvement of cooperation and conditions of technical and financial aid in this field are problems of primary importance for agricultural development in Africa. Rapid agricultural progress, involving sizeable increases in the productivity of land, labour and capital, is essential for the economic development of theAfrican countries. In the more advanced countries, such progress has been facilitated by the results of substantial and continuing efforts in research, and similar steps must be taken by governments of developing countries and bilateral and international technical assistance programmes.

There is an increasing need for research covering a wide range of natural and social science as they relate to agriculture and rural development, a problem so vast that if it is to be solved there must be an appreciable improvement in efficiency through better organization and cooperation between all parties involved.

There is a growing awareness in some countries that these activities and technical aid to support them are becoming more and more necessary in all scientific, economic and social fields of agricultural research in the tropics. This paper considers ways and means of developing closer cooperation between the various countries and organizations in their efforts to improve agricultural research and development in Africa.

The research undertaken in Africa and the different forms of technical assistance which are offered are numerous and vary to a considerable degree both in policy and in organization. It appears also that efforts made and aids given do not sufficiently cover the subject matter fields involved. It can be stated that the various research institutions and sources of assistance are usually insufficiently coordinated and that where coordination does exist it is established only during the implementation of a programme or project, by which time it is often too late to avoid duplication. Nevertheless, there is a certain amount of experience in inter-governmental cooperation (regional projects) and liaison between different sources of technical aid which could provide a basis for closer cooperation in the future.

II. MAJOR PROBLEMS ENCOUNTERED

The development of agricultural research is faced with two main problems. One is concerned with the availability of trained and experienced manpower and the other with the organisation and implementation of research programmes, including measures for ensuring that the results of research get into the hands of the field services in a form in which they can be put to practical use.

1). Manpower.

Lack of qualified personnel is certainly of major concern. Even if funds and material allocated to research were tripled, this would not alter the fact that there are not enough research workers available. With the increasing number of new states, demographic expansion, progress in science and technology, the development of research organizations and the competition to provide or receive aid and assistance, there has been a considerable increase in the number of institutions and the amount of technical assistance aid in various forms during the last five years without so far having improved their efficiency.

Financial and physical aspects (infrastructure) appear to be other main barriers to the expansion of research activity, but it is mainly the lack of qualified personnel which limits the development of research. It is much easier to build and equip a research station than to find the necessary research staff. The demand for qualified research workers far surpasses the available supply, particularly for those possessing tropical research experience.

The volume of current requests for personnel under bi-lateral and international technical assistance programmes and the difficulty experienced in filling posts, re-emphasises the seriousness of this problem. From the difficulties experienced by industrialised countries in training and recruiting sufficient numbers of agricultural research staff, it is apparent that one of the crucial obstacles to development in Africa may well be the inadequacy of the number of people choosing careers in agricultural science. The situation is further complicated by the increased demand for research staff within many of the developed countries where the possibilities for employment in other fields of work are immense and the conditions of life and professional work are more satisfactory, offering security, chances of a continuing career, intellectual environment and social amenities.

Research workers who are capable of integrating several scientific disciplines, of comprehending technical as well as social and economic aspects of a research project, and who are interested not only in making new discoveries but also in their practical application, are very difficult to find. Yet it is this type of research worker, possessing a wide range of experience who is best suited and most urgently needed to lead and conduct agricultural research programmes in developing countries.

2). Organization and Implementation of Research Programmes.

In organizing and implementing research programmes, the need for an inter-disciplinary approach and for relating research to the requirements of agricultural development plans are factors of prime importance.

Much of the agricultural research undertaken in developing countries does not fully reflect the multi-disciplinary nature of the problems involved. Development projects are often embarked upon without the necessary basic studies having been carried out, while in other cases, studies and surveys already completed and published are ignored. There is a tendency to concentrate on the purely technical aspects of research, without regard to the integrated aspects, which include attention to basic problems as well as the economic and social side of agricultural development.

There is a pressing need to avoid competition and duplication through closer cooperation between developing countries, between developing and developed countries and between bilateral and international aid to agricultural research. Developing countries in many cases eagerly accept any offer of technical assistance even if it does not conform exactly to the priority needs of the country. Agricultural research in developing countries should be concerned primarily with the solution of their most urgent problems relating to national and regional development plans.

There are in existence numerous studies, inquiries or pre-investment surveys which merely end up in the archives; far too much research which stops upon its publication; an enormous number of small specialised projects carried out in isolation and too many so-called research stations conducted by one research worker only. Multi-purpose projects led by teams of research workers at multi-disciplinary research centres which also take into account problems involved in the application of research results, are to be found only in limited numbers.

Political boundaries in Africa today are rarely related to ecological regions. One ecological zone will extend over several countries. As the basic agricultural problems of a given ecological zone are similar, it is highly desirable that regional cooperation in research should be established on an ecological basis.

III. SUGGESTIONS FOR IMPROVING COOPERATION AND RESEARCH EFFICIENCY.

There is much to be done to increase the efficiency of agricultural research, but it is suggested that the first steps should be to make better use of the trained and experienced personnel already available and to reorganize existing activities as much as possible in the form of multi-disciplinary projects at national institutes and as part of regional research programmes, through inter-governmental agreements. Even without an increase in funds and personnel, it should be possible in this way to double or even treble the effectiveness of the research and assistance already provided.

The proposed solution for strengthening agricultural research and intensifying methods of co-operation is to establish Regional Agricultural Research Programmes in Ecological Zones, supported by bi-lateral and multi-lateral assistance as the basic frame for inter-governmental activities in the field of research and development. The primary objectives in organizing inter-country research on an ecological basis are to avoid duplication and to make more effective use of available funds, trained manpower and facilities for agricultural research, to investigate the common problems of the participating countries and to obtain research results readily applicable throughout the zone.

The interdependent nature of agricultural research problems in some African countries is well known. Ecological zone research programming is, therefore, an effective and rational way of isolating and selecting the research priorities of the greatest scientific and practical significance to all countries situated in the same ecólogical zone. Joint facilities, research results and their implementation would be shared and experiences could be exchanged, resulting in effectiveness and economy.

Perhaps the most forceful justification for the concept lies in the rationalisation which could be made in the strengthening of national institutes and the use of international funds and personnel. Aid offered to such programs would strengthen national institutes working on both national and regional agricultural research programs. In the implementation of regional research programs, the aim would be to approach the multi-disciplinary aspects of agricultural problems on the basis of the whole ecological area involved.

By grouping several countries together with their own network of research stations within one ecological zone, it would be possible, by examining their national research programmes, to define the overriding priorities and common problems and to agree on regional projects which call for intensive co-operation and co-ordinated action.

Problems common to a variety of countries are more likely to be solved through close liaison and efficient working relationships between all the countries concerned, rather than by each country attempting to solve these problems alone. Isolated and understaffed institutes and stations cannot carry out research which is likely to make an impact on a given large area or solve complex agricultural problems.

As opposed to Regional Institutes, the concept of Regional Programs favours developing countries which are generally unwilling to contribute to the long-term financing of an institution situated in a single country. Individual countries, despite high cost in financial and human resources, prefer to have their own national research institution well established before contributing to the joint financing of regional institutes, which are outside their immediate control. Nevertheless, this does not apply to Regional Institutes created and provided with long-term financial support entirely by private groups or foundations (i.e. Ford-Rockefeller). On the contrary, such institutions could form bases of operations for the establishment and the organisation of regional programs to be implemented by a regional network of selected existing national research stations.

The organization of research on the basis of ecological zone programs would not affect bi-lateral or multi-lateral assistance arrangements in any given country, as each of them would continue to carry out its own national research program; but there is no doubt that it would facilitate better use of the assistance provided through overcoming the shortage of manpower and would avoid wasteful duplication and unprofitable competition. It would not only strengthen closer co-operation between countries confronted with similar problems but would also foster and increase the contribution of external aids, facilitate the transfer of technical knowledge to developing countries and partnership arrangements between institutes and associateship schemes with international organizations.

Before launching such programs, it is essential to have a complete inventory of existing knowledge and research findings ready for application or adaptation, as well as to know the needs and priorities for new knowledge and the requirements of agricultural development programs of each country involved. This is of great importance as a regional program of this type would consist of research projects which are an integral part of the national programs concerned.

It is brought to the attention of the meeting that during the second half of 1967 FAO will hold a "First Conference on Agricultural Research Programmes on an Ecological Basis" in the Sudanian Zone of Africa (see attached map). The Conference intends to discuss the concept and principles of agricultural research organization on an ecological basis, to compare the different national research programs and to study. and draw up plans and measures in order to set up a workable and sound regional program on the main problems facing agricultural development in that ecological zone of Africa.

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ECONOMIC ASPECTS OF SAVANNA DEVELOPMENT PROJECTS INCLUDING ELIGIBILITY OF PROJECTS FOR INTERNATIONAL FINANCING

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In opening a discussion of the economic aspects of Savanna development projects one should probably begin by re-stating an essential principle of economics - that we are concerned with a problem of choice. We have to decide which specific projects merit priority in investment.

In Savanna regions water is a scarce factor virtually by definition. Land is plentiful and so is unskilled labor in relation to factors of production other than land. Investment capital and management resources may, however, be almost as scarce as water. So while we recognize that putting water onto arid lands can achieve a striking increase in agricultural output, we have to examine carefully where this would be most advantageous. Consideration not only of relative cost is involved, but of relative benefits and with how long a waiting period.

A. Choice of areas for pre-investment projects

Certain criteria stand out clearly as regards the initial choice of area to study. 1/

1. Lack of foreign exchange to pay for indispensable imports of capital goods is a basic handicap to the development efforts of the Savanna countries. This means that in long-term development plans high priority must be given to the regions which can develop exports most rapidly, i.e. areas with a production potential of beef, citrus, long staple cotton, or other products in international demand. Production to replace imports of rice and sugar, for example, would achieve the same goal. Such production for export or import substitution would be most successful where there is easy transport to the main shipping and/or population centers. Past experience shows that areas open to external trade have generally developed most rapidly and contributed correspondingly to overall progress.

2. In a developing economy capital is extremely scarce and great care is needed in allocating it. In particular, general infrastructure costs should be kept at a minimum. Interrelationships with other investments have therefore always to be taken into account. There have been deliberate attempts to develop a particular region without considering

1/ See FAO Agricultural Planning Course 1963, Rome, 1964 the national framework, but the advantage has rarely been manifest. Since the location of general infrastructure investments may be largely determined by non-agricultural factors, attention should be given to the possibility of locating agricultural infrastructure investment in areas that will aso have the benefit of transport, power supplies and industries. The returns from both types of investment are then likely to be larger per unit of capital outlay and to come more quickly. The Juba and Shebelli project, for example, would certainly seem central to the economy of its country, perhaps also the Volta flood plain; some of the other Savanna development projects are less so.

3. Increasing employment upon productive enterprises is a sound investment goal. Thus the Gezireh cotton crop attracts labor from Kordofan after the local harvest has been completed. But this does not necessarily mean investment to create employment on the spot. Particularly where resources are limited, it is important to invest where the returns are greatest and let labor move to the opportunities created, as has been the tendency towards the tropical zones of Ghana from the drier areas to the north. Developing countries cannot spare much capital for areas where incomes would still remain so low as to leave little possibility for saving, reinvestment and sustained development.

4. Keeping people in the rural areas is an oft quoted policy objective; but the reversal of an established trend should not alone be a basis for investment.

5. We all know that social and political factors may in practice play a major part in the choice of region to study. There can be some economics behind these too. The cost of relief, and perhaps more urgent measures needed in face of political discontent, can run very high on a national basis. While such considerations may inspire a project, economic experience should still play its part in the consideration of solutions.

While these points all merit attention, decisions on particular pre-investment studies must always be taken within the context of the development policies of the country concerned. Of the Savanna countries, Senegal, Niger, Nigeria, Chad, Sudan and Somalia have current development plans.

B. Factors to consider in pre-investment studies

It is now recognized that institutional factors such as land tenure, access to credit, educational and extension services, pricing and marketing systems, etc. bearing upon incentives to individual producers, play a vital role in the successful implementation of development projects. In this paper, only a brief treatment of difficulties on the marketing side will be attempted. 1/

1. (a) Cash returns to producers depend on their goods reaching a consumer. Therefore, the success of a project to change a physical production pattern depends on an effective organization to bridge the gap between producer and consumer. This gap may be of varying width and complexity.

(b) Detailed research on markets, on consumer preferences, etc. - where not already available as for standard export products - may be needed to determine which products to grow and which varieties of these products. Other marketing factors - ease of handling, durability in transport, suitability for processing, etc. - have also to be taken into account.

1/ J.C. Abbott: "Marketing Studies, Organization, Methods and Service for Development and Settlement Areas" - Montly Bulletin of Agricultural Economics and Statistics - Vol. 13, No. 5, May 1964.

(c) The cost of marketing can cancel out efficiency in production. No matter how suitable an area may be for production and how acceptable the product in consumer markets, if the cost of getting it to those markets takes too high a share of the final price, then production may be uneconomic except on a subsistence basis.

(d) Greatly improved marketing organization may be essential if full advantage is to be taken of favorable production opportunities. In many situations there is a need not so much to reduce the cost of marketing as performed at present, but for much more elaborate and comprehensively organized marketing systems. This would be needed, for example, to make worthwhile growing fresh tomatoes or strawberries in the Jebel Marra, and generally where produce has to be sold on competitive export markets. For fresh fruit and vegetable marketing over long distances, uniform and precise grading, packing, temperature control in transit, timing and adjustment of total quantities delivered to particular markets, and consistent and thorough sales promotion are vital. The successful entry of Gezireh cotton onto European markets was also due in large part to the particular marketing organization selected.

2. Distributive organization to furnish production supplies and consumption requirements is also needed. If fertilizer, insecticides, farm machinery and tools, etc. are not readily available at low cost, the agricultural production targets on which a project is based may never be attained. If a suitable range of consumer goods is not obtainable conveniently and inexpensively, there may be little incentive for farmers to obtain income beyond that needed for subsistence. Perhaps this has been taken too much for granted in the Savanna project studies available to-date.

3. Pre-investment studies for a particular area are generally best carried out on an integrated economic basis even though its resources seem to be primarily agricultural in character. Means of transport that would not be economic for agriculture alone might become available if there was a profitable return load or out of season use based on other demands. Mining, industrial, military or other non-agricultural activities can change radically the market picture. The development of tourism based on game parks, archaeological or historical associations, etc. can in some situations pay off better in foreign exchange earnings than agriculture alone. This could be highly relevant in a country like Chad.

C. Appraisal procedures

With these aspects taken into consideration we can move to an appraisal of a project pre-investment study or of recommendations and projects arising from such a study.

Strategic investment criteria are:

(a) Economic benefits - the additional income produced (in the whole project area or by the establishment of a particular enterprise or service within that area); the additional employment created; the increase in income per person employed (particularly if previously incomes were considered to be below acceptable levels); the net contribution via taxes to the costs of local and central government; contributions to social services; additional rents paid; and the accumulation of money for future investment through amortization provisions should also be counted.

Indirect benefits such as payments to transport and other services, and induced benefits due to the spread of new money through the economy, the so-called multiplier effect of earning created by a project should also be considered, likewise the economic surplus, i.e. if internal prices of some foods, etc. are lower as a result of the additional output created by the project then consumers are left with more money to spend on other things.

In practice indirect and induced benefits often receive only descriptive mention because of the difficulty of quantification. Generally they are regarded as providing additional justification for an otherwise sound project.

(b) Investment cost - total cost in relation to the finance available from outside including provision from within the country for continuing services including maintenance of roads, etc.; the cost per employment unit created; the cost per hectare of agricultural land improved.

(c) Scarcity of specific resources - e.g. land, water, foreign exchange, special skills, managerial and administrative capacity. Their relative scarcity in a particular country or region may set limits to the scale or nature of an investment independent of the probable return. Such scarcities can be taken into account in economic calculations by the use of "shadow prices" as opposed to market prices. Thus the rate for foreign exchange may be set above that used officially. The wage rate for labor may be adjusted to reflect previous under-employment, e.g. if there was only 40 percent employment then one might value labor at 40 percent of the standard wage. Wages for peasants working on their own land should reflect alternative earning opportunities open to them, and might be set at zero. Scarce trained government administrative and service staff, however, should probably be valued at more than the official salary scale because of the high economic cost of keeping them off other work. Products that will replace imports can be valued at the price of the imported produce even though the substitute may actually be sold at a different price. Though assignment of "shadow prices" will often be a matter of judgment their use is likely to result in a more realistic economic appraisal. Once adopted, they should be used uniformly to calculate current production and investment costs as well as net value added.

(d) The time factor - i.e. the delay until the benefits foreseen from investment are realized and the duration of such benefits. From a financial point of view, the rate of interest payable on the capital required is important here; usually a long wait for the eventual benefits is only feasible if the rate of interest charged is low.

(e) Rates of return - One should distinguish carefully between: (i) the financial (or private) rate of return, i.e. the return to the entrepreneur on the capital he invested; (ii) the economic (or social) rate of return, i.e. the return to society as a whole on all development efforts made in terms of net increases in gross national product. In making such return calculations, the "internal rate of return" which avoids the choice of an interest rate and takes time effects fully into account should be preferred. Internal rates of return are better and more precise criteria than the traditional cost/benefit ratios. Particularly when used with shadow prices, they are the most comprehensive possible criteria incorporating all other criteria mentioned above.

The internal rate of return is the discount rate at which the total present value of all expected future net annual returns exactly cover the present value of total corresponding investment. 1/ If this rate is well above the going rate of interest on long-term loans, e.g. 15 percent as against 6 or 8 percent, then the project offers substantial investment appeal. However, a delay of say 10 years until a project comes into the phase of full returns can reduce this rate of return substantially because of the heavy weighting of interest charges during the early unproductive period. See the following examples:

	Discount rate 6%	Discount rate 10%
	......$......	
Present value of $100 to be received in 10 year's time	55.80	38.60
Present value of $100 to be received in 20 year's time	31.20	14.90

1/ For further illustrations of procedure, etc. see F. Rosenfeld: Techniques d'Analyse et d'Evaluation des Projets d'Investissements - Etudes Tiers Monde, Presses Universitaires de France, Paris, 1966.

In practice a long delay before returns come in is only acceptable, especially in developing countries where capital is scarce and the going rate of interest therefore usually high, if the eventual benefit is very great indeed. Thus recognition of an economic interest rate of at least 6 percent in these days bears hard on the recommendation of a 40 year project for the Volta Flood Plain based on an interest rate of 2-1/2 percent. The annual cost is increased by more than 50 percent.

Commonly used preliminary and incomplete measure for comparison of alternative projects is the capital ratio, that is the total amount invested divided by the average annual value added when the project is in full operation. The ratio for large-scale agricultural investments is usually between 3 and 5. A higher ratio would imply above normal investment costs in relation to the return.

Comparative measures for Savanna projects on which reports are available are:

Project	Cost per hectare $	Capital ratios
Shebelli River Control Dam	300	3
Volta River Flood Plain	1450-1770	8.3

The level of investment cost per hectare likely to find easiest acceptance by the IBRD, for example, would depend on the type of crops to be grown. $1,000 per hectare might be acceptable for citrus with access to export markets but would be too high for rice.

Calculation of internal rates of return has not been attempted. Clearly it is difficult for complex area development projects involving a range of costs and benefits not easily susceptible to measurement, but it is quite feasible and indeed necessary for specific projects within a more general development plan.

Training projects are more difficult to appraise in economic terms. However it should be possible to quantify the social benefits from investment in providing training facilities in the developing countries and so attain a measure for use in assigning priorities as between projects in different fields. 1/ It may be thought that the need for trained men is obvious. We have still to consider the appropriate allocation of resources between general and specialized education, and training at different levels, and the cost of training under a specific project with that of obtaining comparable training elsewhere. Comparison on this last level is fairly easy and this is the minimum of economic appraisal that we could expect in the projects under discussion. Some relevant data are:

Project	Cost per trainee month (excl. fixed investment) $
University of Khartoum 2/	130
University College, Ibadan 2/	320
Ecole Supérieure d'Agriculture, 2/ Tunis	206

1/ D.G. Mc Clelland has estimated the economic return on investment in university education in the developing countries at about 12 percent. "Does education accelerate economic growth?" - Economic Development and Cultural Change - Vol. XIV (3), pp. 257-278, April 1966.

2/ Assuming 9 months attendance.

Project	Cost per trainee month (excl. fixed investment) $
Agricultural Training Center, 1/ Bobo-Dioulasso, Upper-Volta	173 + 30
Forestry Research and Education Center, 1/ 2/ Sudan	90 + 30
FAO Fellowship in Europe 3/	330

D. Financial eligibility

So far as international lending is concerned the eligibility of a project can hardly be dissociated from the credit worthiness of the country in which it is situated. The main economic criteria for credit worthiness are the manner in which savings and other resources are invested to increase production, the rate of growth of the population, and the past record of repayment of outside loans.

Coming to the project level, a speaker for the FAO/IBRD Co-operative Program at a comparable meeting in Latin America stressed the need for clear information on the following points: 4/

(a) the action implications of projects i.e. the specific steps involved in bringing the project into execution, e.g. the establishment of farms, housing, roads;

(b) the project costs, with its fixed costs for a period of time, operating cost etc., broken down by foreign and local costs;

(c) the benefits to the economy of the country, in terms of added value of production, foreign exchange earnings and other criteria discussed earlier in the paper;

(d) the returns at the level of the beneficiary. The return to an irrigation authority set up to operate a project is needed, also estimates of income streams and cash flows at the farm level. The returns to the project beneficiaries indicate whether the beneficiary is capable of repayment;

(e) who will manage a project? what are the responsibilities of all the agencies of parties who would be involved in this. Staffing can be a great limiting factor so that from the very beginning project managers should face the problem of who is going to get it off the ground, and how will it operate;

(f) an indication from the country of what domestic resources could be mobilized for the project; it is preferable that the direct beneficiary of the project also makes the maximum contribution, because his interest will be only as strong as his financial commitment.

1/ Initial costs with UNDP/SF support internation staff and estimate $30 for board.
2/ On the basis of 15 percent of resources devoted to training.
3/ On one year basis including travel.
4/ FAO, Report of Latin American Meeting of UNSF/FAO Project Managers and Co-Managers, Santiago, Chile, Oct.1965.

Questions of the following order must be answered: How would repayment of the costs of the project be made? Is there provision for revenues, e.g. from taxation, water charges, etc.? Are there separate provisions for repayment of capital and interest costs and for repayment of operation and maintenance costs? Is the cost of civil works to be allocated to individual farms and, if so, how? What is the cost of on-farm works and on what terms will they be met? What is the expected annual payment per hectare or other unit? What is the total and per hectare charge for operations and maintenance? When would charges become applicable? How would payment be secured? Supposing a loan were obtained how would it be repaid? How would local costs be financed?

It appeared from the Santiago meeting that the most difficult projects to finance by an international banking institution were those involving a high element of local costs and a long waiting period. This was particularly true of afforestation and re-forestation projects.

These points reflect the requirements of a potential lending agency. From the point of view of the sponsors of a particular project the relative likelihood of its appealing to different sources of finance is an important consideration. They will be well advised to take into account in their presentation the requirements and interests of different potential lending agencies.

Under IBRD procedures, two types of agricultural programs could be financed; first, irrigation or other capital intensive public works, and secondly, farm equipment and requisites, mostly through intermediate institutions. Its approach to agricultural lending is now more flexible and finance for area development schemes and the strengthening of agricultural institutions, including credit agencies is now more readily available. Moreover, certain current expenditures are now eligible for financing during the project development period. However, the interest rate and time of repayment reflect the Bank's dependence on fund-raising in the open market.

The International Development Association can make loans for up to fifty years, at a nominal interest rate, primarily to meet requirements in the financing of "social infrastructure" - education, environmental hygiene and housing.

The Development Fund of the Six Common Market Countries for Associated Countries is prepared to finance social and economic development projects. Bilateral financing terms may be still more favorable for projects of specific interest to the lending country. Such assistance will probably be more readily available if there are suitable national financing institutions to help administer it.

The scope for using food aid to remunerate local labor engaged on improvement operations and to maintain settlers while awaiting crops from new holdings should also be taken into account.