AGRICULTURAL AND WATER SURVEYS

SOMALIA

FINAL REPORT

Volume I

GENERAL

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

The Final Report on Somalia consists of the following volumes:

Volume I - General

An account of the objectives, work and findings of the entire project is given in this volume. The recommendations arising from the findings of the survey are summarized, and the volume concludes with an estimate of the total returns for all the development projects proposed. A summary of the report on the FAO Livestock Development Survey of 1966 in Somalia is included in the volume as an appendix.

The following technical reports were prepared by the Lockwood Survey Corporation, which carried out the corresponding surveys under the supervision of the Food and Agriculture Organization of the United Nations:

Volume II - Water Resources

The volume deals with climate, surface water and groundwater, and investigates the potential groundwater supplies for irrigation, and for the use of livestock, herdsmen and small communities. The text of the volume is abundantly supported with figures, tables and maps and with statistical appendixes.

Volume III - Landforms and Soils

Nineteen landforms are identified, some with subdivisions, in the first part of the volume, and the soils associated with each landform are described and classified. Landforms and soils are then discussed on the basis of the natural regions. The text concludes with a summary and with recommendations. Soil profile descriptions and the methods and results of chemical and physical soil analysis are given in appendixes.

Volume IV - Livestock and Crop Production

The volume describes the surveys carried out on agricultural production and on rangeland in the project area. Details are given of regional farm practices, of present land use from region to region, and of recommendations for crop improvement. There are conclusions and recommendations on the potential of rangeland and on problems in its development. The final chapter deals with the livestock count made during the project. Species and ground cover characteristics of the ecological formations are given in an appendix.

Volume V - Engineering Aspects of Development

The volume discusses in detail the possibilities of irrigation development on the Shebelle river. It also examines briefly the possibilities on the Juba river. Surface water supplies for human and animal consumption and the possibilities of development for small streams are investigated. An account of the topographical survey and mapping work carried out and extracts from the results of reconnaissance soil survey in the Bulo Merta area are included in the volume.

Volume VI - Social and Economic Aspects of Development

The volume deals with land tenure conditions and agricultural economics in Somalia. A sample of economic returns to agriculture in the project area in 1963 is given, and the typical returns of banana plantations are included in the typical farming returns given for the various regions and sub-regions. The volume concludes with a detailed estimate of the total returns for all the development projects suggested. A revised recommendation for a rural development project for the improvement of traditional agriculture is given in an appendix.

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Agricultural and Water Surveys

S O M A L I A

FINAL REPORT

Volume I - General

Report prepared for the
Government of Somalia by the
Food and Agriculture Organization of the United Nations
acting as executing agency for the
United Nations Development Program

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

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ABSTRACT

This report describes a United Nations Special Fund* project carried out under the responsibility of FAO as Executing Agency to help the Government of Somalia to survey the land and water resources in the area between and around the lower reaches of the Shebelle and Juba rivers and to develop a general policy and plan for improved use of these resources. The Government request for assistance was approved at the fifth session of the Governing Council of the Special Fund in December 1960. A Plan of Operation was signed on behalf of the Government, the Special Fund, and F.A.O. in September 1961, and the Government nominated the Planning Department of the Council of Ministers as its counterpart agency. The project became operational in the spring of 1962 and was completed in the spring of 1966.

The final Special Fund allocation of US$ 1,000,400 included the cost of: experts to a total of 384 man-months; six fellowships of one year each, and equipment and supplies. The Government counterpart contribution of US$ 290,000 was met by: the provision of local staff, labour, certain equipment, supplies and services. A contract was let in November 1961 to Aeroexploration g.m.b.h. of Frankfurt-on-main for aerial photography and the preparation of mosaics and in December 1961 a contract was let to Hunting Survey Corporation of Toronto, later renamed Lockwood Survey Corporation, to undertake all other surveys and investigations of the project, except land tenure and livestock for which F.A.O. arranged.

The project area was finally extended northwards and encompased about 208,000 square kilometers. During the project Somali personnel received considerable "in service" training, particularly in river gauging and sampling and in air photograph interpretation, the techniques of field survey and landform and soil mapping.

During the groundwater survey three permanent wells and one temporary observation well were constructed. Chemical analyses were made of the water of 176 wells, and the location of existing wells was mapped.

The surface water survey paid most attention to the Shebelle river. Ten permanent river gauging stations were established, six of which were equipped with automatic water level recorders. The possibility of full control of the Shebelle river by means of a storage dam and the alternative of partial regulation without a storage dam and the diversion of flood flows were considered. An outline program for the construction of further artificial water catchments for human and animal needs was prepared. Three seasonal streams, Bohol Magadoi, Lak Badana and Uadi Damer were found to merit further investigation, principally for supplies of drinking water.

Under the landforms and soils studies, fourteen natural regions were mapped in detail. Seventy-seven soil typed were classified into 10 Great Soil Groups and one miscellaneous land type. Nearly two million hectares of land in the project area were found suitable for cultivation, and 5.5 million hectares of marginal suitability. Land use maps in 81 sheets at 1:100,000 scale, covering the entire project area, and a 1:500,000 generalized Natural Vegetation and Land-Use Map were also prepared.

* On 1 January 1966 the Special Fund and the Expanded Programme of Technical Assistance were merged into the United Nations Development Programme which continued to provide assistance to this project.

A survey of agricultural production for 1963 estimated the area of traditional agriculture to be roughly 1.25 million hectares, with 0.9 million hectares occupied and 0.54 million hectares under inundation irrigation and rainfed crops, chiefly sorghum, maize and cotton. Bananas, sugar cane and other crops and vegetables occupied about 14,000 hectares under controlled irrigation, mostly in commercial plantations.

The rangeland survey mapped 200,000 square kilometers, and found 25,000 hectares of this to be grass and 6,600 hectares to be unused agricultural land. Livestock surveys indicated the country is dangerously overstocked and estimated at nearly 3.5 million cattle, goats, camels and sheep. Animal husbandry, which is foremost in export value, despite the need for improvement, engages over 70 percent of the population.

The economic survey attempted to determine the gap between the value of present production from traditional agriculture and from commercial banana plantations and the value of other potential production. It was estimated that the average annual flow of 1,700 cubic meters of the Shebelle provides enough water for an annual banana crop to the value of S.Sh 630,000,000; present annual at-farm value of all crops is estimated at only S.Sh 58,000,000.

To realize the potential of the project area there is need of a long-term plan covering the development of the present lands and of new lands under rainfed cultivation, of intensified use of irrigated lands within existing plantations, and of new schemes under controlled irrigation. The rate at which development can take place, and consequently the validity of present economic forecasts, will need to be tested against the results of the first stages of development, in view of the limitations imposed by lack of finance, trained staff, and the general organization required for planning and implementation.

The items listed under recommendations to provide essential technical services are therefore of paramount importance to continue the work already begun in the setting up of the Surveys and Mapping Department, the Agricultural Development Agency and the Livestock Development Agency during the project. It is further recommended that legislation on the use of water and tenure of land and a range management plan for the north be introduced.

A follow-up project of 2½ years for the extension of irrigation and water control in the Shebelle river began in the spring of 1967, following a request made to the United Nations Development Programme by the Government early in 1966. This project includes feasibility studies of two areas on the Shebelle, one of about 3,000 hectares for controlled irrigation, the other of about 10,000 hectares of irrigation by flooding.

ACKNOWLEDGEMENTS

Throughout the course of the project a great deal of help and cooperation was extended by a large number of people and organizations.

All members of the Government of the Somali Republic who were concerned with the project gave their best efforts, without which the project could not have succeeded.

Special appreciation is due to General Mohamed Abshir and the Somali Police, and to the late General Daud and the National Army for a great deal of help beyond the call of duty.

Sincere gratitude is hereby expressed to the following persons for valuable voluntary assistance to the survey:

H.E. the Ambassador of the United Kingdom for making aerial photography available with no royalty charge.

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The Directors, Managers and members of Societa' Nazionale Agricola Industriale (S.N.A.I.), Societa' Azionaria Concessionari Agricoli di Genale (S.A.C.A.), and Societa' Agricoltori Giuba (S.A.G.) for providing valuable information and ideas.

In particular, thanks are due to Dr. Harvey T. Newton, Soil Chemist of U.S.A.I.D., for carrying out all the soil analyses and some water analyses, to Mr. F.R. Worthen, U.S.A.I.D. Water Engineer, for doing some water analyses, and to Mr. H. Campbell (U.S.A.I.D.) for his assistance and the use of the photo laboratory.

The cooperation of Engineer Ignatiuk and his colleagues of the U.S.S.R. Juba River team is also gratefully acknowledged.

CHAPTER 1

HISTORY AND OBJECTIVES OF THE AGRICULTURAL AND WATER SURVEYS

1. In September 1961 a Plan of Operations was signed by the United Nations Special Fund, the Food and Agriculture Organization of the United Nations and the Government of the Somali Republic, agreeing to the financing, activities and objectives of the Agricultural and Water Surveys in Somalia. This document forms Appendix I to this volume.

2. Under the terms of the agreement the Special Fund committed $928,800,* and the Somali Government $290,000. The project was to take four years to complete.

3. The purpose of the project was to survey the land and water resources of the "Inter-River" area of southern Somalia and to prepare a plan for its development. The original area was described as being 140,000 square kilometers in extent, (see Map 1). However, the northern limit of the survey area cut through a zone where soils and rainfall are favourable, and it became desirable to extend the studies northward to the Provisional Administrative Line that marks the present division between Somali and Ethiopian control. The final area surveyed totalled approximately 208,500 square kilometers.

4. The Plan of Operations called for aerial photography of the project area at 1:30,000 scale (see Map 2); a soil survey; a survey of present agricultural practices, rain-fed and irrigated; studies of the factors affecting livestock production, and studies of hydrology. It also included the establishment and operation of river gauging stations and investigations of groundwater and its potential uses. The irrigation possibilities of the Juba and Shebelle rivers were to be assessed and also the potential productivity of rain-fed agriculture. Studies of land tenure and agricultural economics were to be undertaken. A regional development plan for agricultural and livestock production was to be prepared based on the findings of the surveys, and costs and benefits of development projects estimated.

5. The background of the project is somewhat complex. The Juba and Shebelle rivers are the only perennial streams in the Somali Republic. Their lower valleys and the Baidoa upland that lies between the streams have the highest and best distributed rainfall of any area in the Republic. During the Italian colonial era certain areas were brought under controlled irrigation and a wide range of commercial crops tested by Italian concessionaires. Prior to 1928 cotton was the main crop, but with the collapse of the market the cultivators switched to banana production. Little attempt was made to improve or develop indigenous agriculture. The settled riverine peoples supplied needed labour for the concessionaire, for it was generally believed that the nomadic and semi-nomadic clans had no interest in permanent settlement. Between 1950 and 1960, under the Italian Trusteeship Administration, a number of minor projects were designed and completed. These included drilling over 300 wells, digging "uars" (artificial rain catchments) and constructing a number of semi-controlled flood irrigation schemes, most of them under 1,000 hectares in extent. The success ratio of these projects was very low.

6. In 1959 and 1960 the United States International Co-operation Administration carried out a study of the "Inter-River" area and issued a report entitled "Inter-River Economic Exploration". The report stated that the "Inter-River" area has

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* The final Special Fund allocation amounted to US$ 1,000,400 and covered experts' costs for 384 man-months and an expenditure of US$ 132,400 for equipment and supplies.

considerable productive potential. To realise the potential, the report recommended a concentrated effort be made to obtain the hydrological, topographical, agricultural and ecological data essential for the planning and design of major development projects.

7. The Somali Republic came into existence as an independent nation on 1st July 1960. In anticipation of this event, the United Nations, in 1959, established an aid program under the Technical Assistance Board. In accordance with the preliminary findings of the I.C.A. group, the Government applied to the United Nations Special Fund for assistance in surveying the land and water resources of the "Inter-River" area. At the request of the Special Fund, F.A.O. commissioned an engineering consultant to prepare a description of the work required, including terms of reference and estimates of cost. The Governing Council of the Special Fund approved the project at its fifth session in December 1960, and the Plan of Operation was then prepared by F.A.O., the Executing Agency for the Special Fund and signed in September 1961 by the Special Fund, F.A.O., and the Government of Somalia.

8. In November 1961 a contract was awarded to Aeroexploration g.m.b.H. of Frankfurt-on-Main, Federal Republic of Germany, to obtain the aerial photography and to prepare mosaics. In December a contract was awarded to Hunting Survey Corporation Limited* of Toronto, Canada, to undertake and to produce reports on all surveys except the land tenure studies, which F.A.O. itself would carry out.

9. Aerial photography was started in January 1962 and it was expected that it would be completed in March. Consequently the project hydrologist arrived in Mogadisoio in mid-February and the project manager early in March. Unfortunately, the air photography contractor had been able to photograph only 30% of the area in the first season.

10. At the time when the first staff arrived, working space was not immediately available and counterpart staff did not exist. However, responsibility was soon vested on the Minister of Finance, and work began.

11. Throughout the entire survey, the Government of the Somali Republic co-operated to the fullest extent. Two fine buildings with garage and storage facilities were built to house the project. Funds were provided in a special account with the Banco Credito Somalo to pay all costs of the Government contribution. The account was operated by the project manager and co-manager. Due to lack of qualified staff in Government service, the Personnel Department and the Labour Department co-operated with the management of the project in selection and employment of suitable staff. The Police, the Army, and the Local Authorities were most helpful at all times. All Ministries lent their enthusiastic support.

12. Three important concepts soon became evident and served as guiding principles throughout the survey :

(a) The project was only one of a number of development activities being undertaken. Therefore, some co-ordination of effort under these activities was required so as to avoid duplication and to obtain optimum results in the best interest of the country.

(b) The Somali Republic was virtually devoid of technical institutions, services and trained personnel. The project would have to initiate a number of services taken for granted in other countries, supervise them and attempt to provide for their continuation after its completion.

(c) Even with massive foreign aid, available financial resources would be insufficient for development needs unless a high degree of efficiency was achieved in every new sphere of technical activity.

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* Hunting Survey Corporation Limited changed its name to Lockwood Survey Corporation Limited before completion of the project.

13. Coordination of efforts in the field of land and water development involved maintaining close liaison and cooperation with a number of ministries and bilateral and United Nations aid programs. At the time the project started, the U.S.A.I.D. Mission had been assisting the Well Section of the Ministry of Public Works Transport and Communications for some years in a well drilling project. In addition, the Mission was also operating a farmer training centre at Baidoa/Bonka, where some agronomic experiments were being carried out. U.S.A.I.D. later established an experimental farm and extension worker training centre at Afgoi, where it also operated a soils laboratory.

14. In November 1962 two teams of engineers and agriculturists arrived from Technopromexport under the aegis of the Economic Counsellor of the Embassy of the U.S.S.R., one to prepare a plan for irrigation from the Juba River, and the other to design two state farms of 5,000 hectares each, also on the Juba. Under the terms of their contract, the Somali Government was committed to provide the necessary hydrological data, soils and topographical maps to the Soviet experts.

15. Particularly close relations were kept with both American and U.S.S.R. groups throughout the course of the project.

16. In the beginning, the Somali Government lacked technical services and trained people to carry out the project. Briefly, the situation was this:

Topography: The largest scale maps available were 1:500,000 of low reliability. Under both Italian and British military administrations, certain surveys had been carried out, but searches of records in Mogadiscio and appeals to both governments failed to locate any data. There were plans to establish a cartographic service.

Hydrology: Remains of staff gauges were found at Lugh Ganana on the Upper Juba River and at Belet Uen on the Upper Shebelle River. Records had been kept since 1951, and, although there were extensive gaps, these records were useable. There were no records of meterings and no hydrological service.

Although over three hundred wells had been drilled, no pumping tests had ever been carried out and no records kept. Water analysis was limited to conductivity tests.

Meteorology: A network of good stations had been established in 1954 and records had been kept reasonably accurate. Most stations were badly in need of maintenance and new instruments.

Agricultural Services: A soils laboratory had been established at Afgoi with American aid. There were, however, no soil surveyors and no soil mapping had been done.

Very limited agronomic experiments were being carried out at Baidoa/Bonka, with American assistance.

Statistical Services: Useful statistics of population, land, agricultural or livestock projection did not exist. A statistical service was being established with U.N.T.A. assistance.

17. Under these circumstances, and because the lack of technical services resulted basically from the lack of financial resources and trained manpower, it was clearly necessary for the project to obtain its own basic data, to make best use of all available resources, and to assist in establishing these essential services.

18. Establishing the project and collecting existing data occupied the period from March to November, 1962. Working space was very hard to find, but the problem was eventually solved.

19. Somali staff was recruited. Although the general level of education was very low, some secondary school graduates had moved to the capital from the Northern Regions. These young men had sufficient mathematics to learn to be survey and hydrological technicians. Three agricultural technicians were employed who had been trained at the Genale school. All personnel were selected on the basis of competitive examinations and interviews.

20. By November, ample equipment had arrived, staff was shaping up, and field reconnaissance was started.

21. In the early part of 1963 the river gauging stations were installed. They were designed by the hydrologist and senior hydrological technician and built under contract. At the same time, field work was started on the soil survey.

22. The project area lies within the influence of both North-East and South-West Monsoons. Most of the annual rainfall is associated with the Inter-Tropical Convergence Zone. During the rainy seasons, most roads are completely impassable, and consequently field work had to be planned for the periods January to mid-April and July to mid-October. Even the airfields became unusable during the rains, and these factors made some operations difficult - for example, obtaining meterings at times of peak river flow.

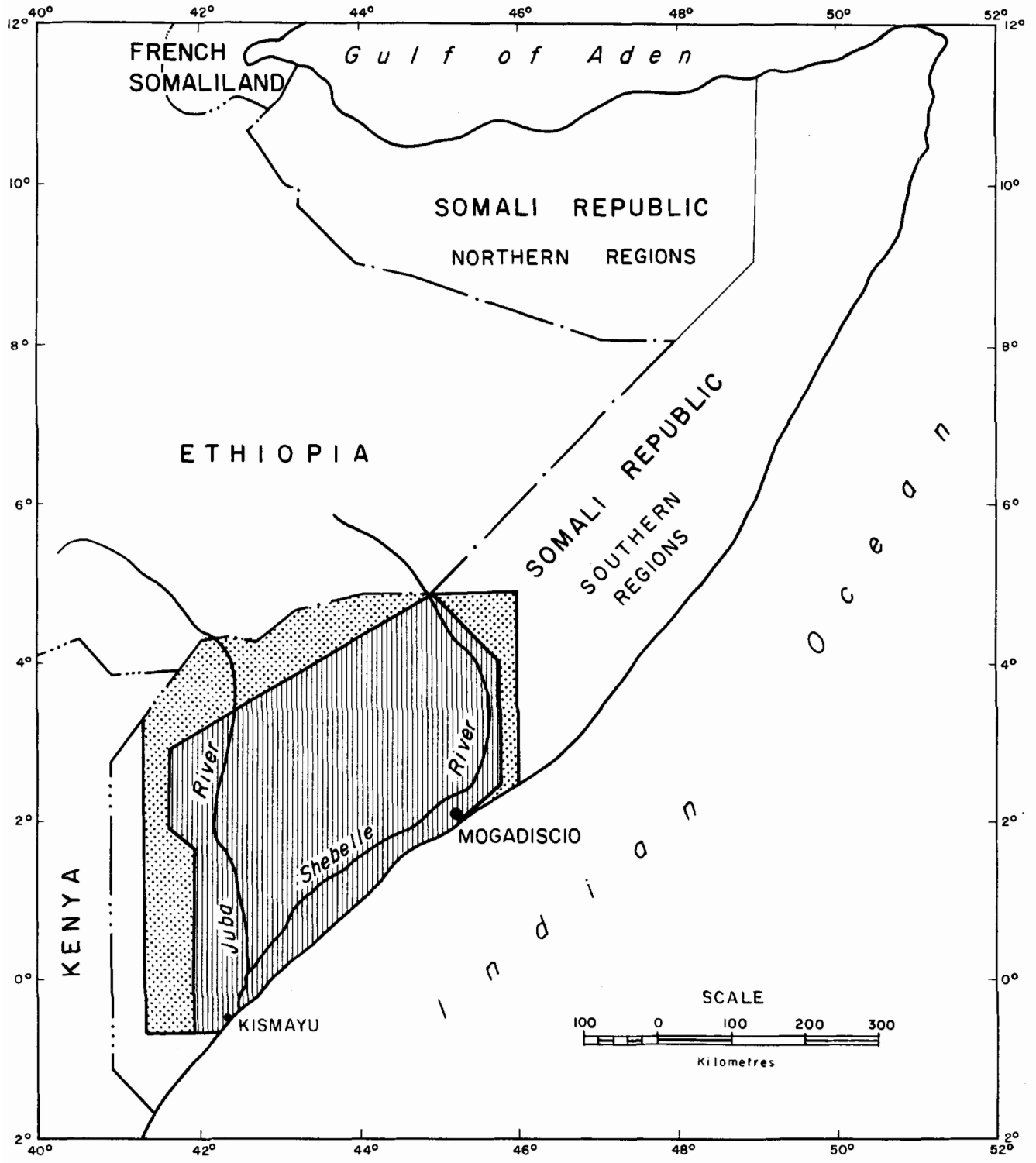
23. The project was organized as nearly as possible as the nucleus of a future governmental department for the collection of data basic to planning the development of land and water resources. In 1964 the Establishment Commission recognized the usefulness and economy of a single viable department and recommended its official recognition as the Surveys and Mapping Department.

24. As a result of these circumstances, the project became more and more the focal point for all efforts directed at raising the level of agricultural and livestock production. This resulted in a number of extra duties for members of the project staff. This led towards the ultimate objectives of the project, and, in a number of instances, responsibilities were shared in the interests of efficiency.

25. Early in the project it became clear that the lack of basic hydrological, topographic and agricultural data would delay the formulation of major irrigation schemes for a number of years, and that financial and cultural problems would have to be overcome before such projects could be built and operated successfully.

26. The solution to the regional problems seemed to lie in raising the general level of productivity of the Somali cultivators and herdsmen, turning food deficits into surpluses, and finding markets for the surpluses. Success in introducing the principle of dynamic progress, both technical and institutional, would not only feed the people but provide the Government with the financial resources required for more sophisticated, capital-intensive developments.

27. The first priority recommendation of the project was, therefore, the creation of an Agricultural Development Agency empowered to deal in seed, produce and agricultural supplies, to extend credit, to operate machinery and to offer technical assistance and advice to cultivators and herdsmen. Numbers of traditional Somali cultivators expressed enthusiasm for this idea, and indicated their eagerness to adopt new methods and form cooperatives to deal with such an authority, which was set up by decree in September 1965, during the course of project operations, with the title of "Agricultural Development Agency".



Vol. I Map 1

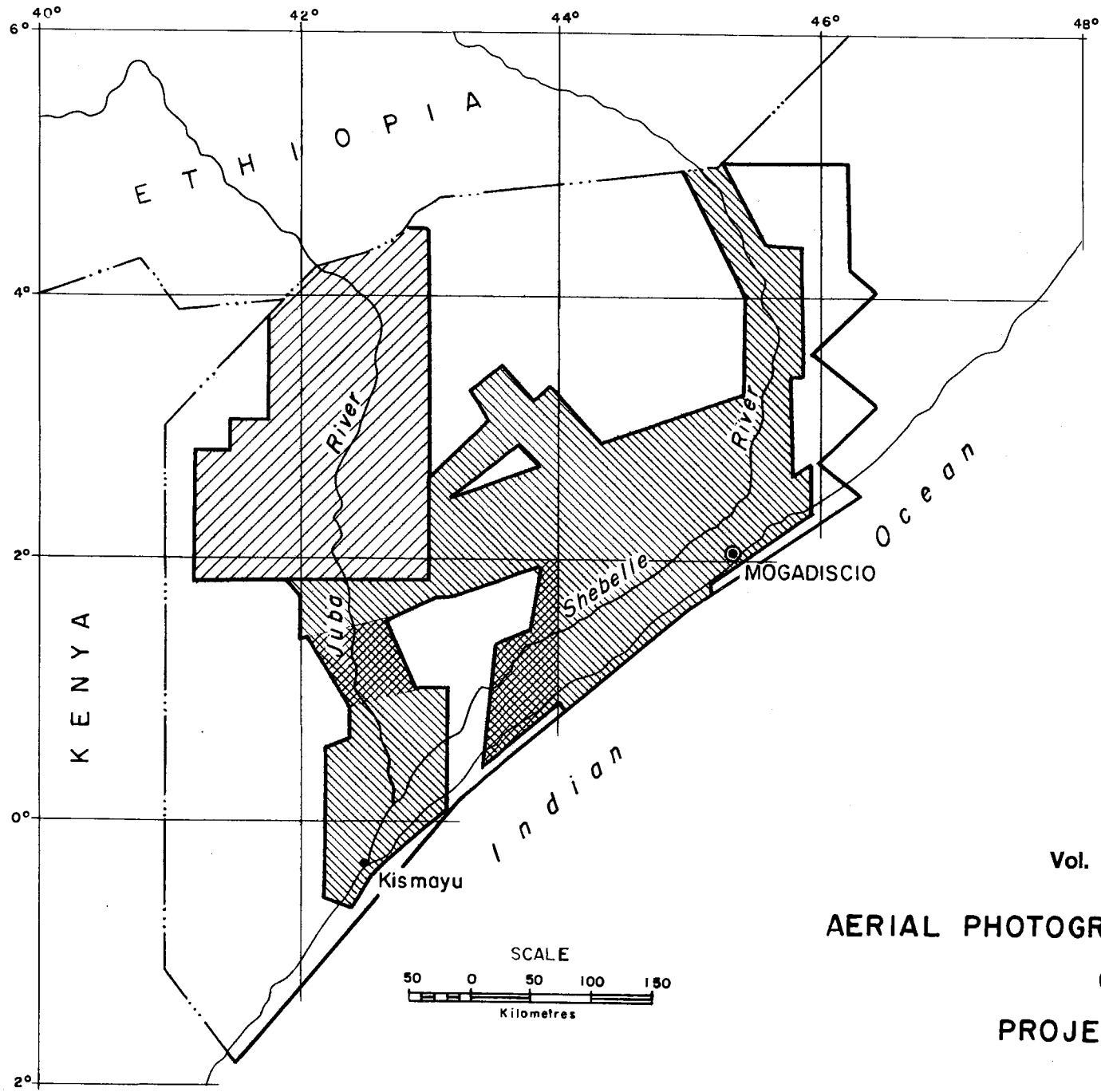
PROJECT AREA

ORIGINAL

FINAL

INTERNATIONAL BOUNDARY

PROVISIONAL ADMINISTRATIVE LINE



LEGEND

RAF
PHOTOGRAPHY DATE 1960
SCALE 1:60,000

MOSAICS
SCALE 1:60,000
1:100,000

A&WS PROJECT
PHOTOGRAPHY DATE 1962-1964
SCALE 1:30,000

MOSAICS
SCALE 1:30,000
1:60,000
1:100,000

MOSAICS
SCALE 1:100,000 ONLY

GULF SOMALIA
PHOTOGRAPHY DATE 1959
SCALE 1:30,000

MOSAICS
SCALE 1:30,000
1:60,000
1:100,000

Vol. I Map 2

AERIAL PHOTOGRAPHIC COVERAGE OF PROJECT AREA

28. Livestock production in Somalia has great potential for development. It was possible for the project team to make a preliminary analysis of only the two most obvious limiting factors, the availability of food and water and the marketing problem. However, a Livestock Development Agency was set up in Somalia by decree on 25th January 1966 and, from February to June of that year, a team of F.A.O. experts carried out a Livestock Development Survey in the country. A summary of the team's report on its findings is given at Appendix 5 of this volume.

29. Many of the recommendations for development made in this report will be the concern of the recently established Agricultural Development Agency and Livestock Development Agency. As for the work of the project in the field of controlled irrigation, it appeared that a great extension of controlled irrigation could be made and that it would be possible to finalize plans for it. Further feasibility and design studies would be required including pilot projects and more detailed soil and topographic surveys.

30. Accordingly, early in 1966, the Government of Somalia asked for further help from UNDP in the form of a follow-up project which would come within the framework of, and be consistent with, the findings and recommendations of the first project as described in the following pages.

31. This follow-up project, which was approved and which began early in 1967, is to last 2½ years and deals with the extension of irrigation and water control on the Shebelle River. Feasibility studies of two areas are to be carried out, one of about 3,000 hectares to be under controlled irrigation, from both surface and underground supplies of water, and the other of about 10,000 hectares to be irrigated by flooding. The work includes the preparation of further data, the study of cropping patterns, the preparation of designs and estimates, and of economic analyses, with also a water management plan all in accordance with the methods acceptable to an International Financing Agency.

CHAPTER 2

DESCRIPTION OF THE PROJECT AREA AND ITS COMPONENT REGIONS

GENERAL DESCRIPTION

Introduction

1. The project area comprises 208,500 square kilometers situated in the southernmost part of the Somali Republic. The location and boundaries of the area are shown on Map 1.

2. The traveller in this part of Somalia would characterize the area as a relatively featureless plain, interrupted here and there by river valleys and tracts of rougher relief. He would note the uniformity of the semi-arid, low tree and shrub vegetation, relieved only by occasional patches of rain-fed cultivation and luxuriant crop growth in the irrigated lands. He would gain the impression that the area is very sparsely settled and has a pre-eminently nomadic and pastoral economy.

3. In his conclusions, the casual traveller would be essentially correct. However, the more highly trained observer would discern that the area does exhibit variations in physiography, vegetative cover, and the use of land that are significant from the development point of view. Indeed, a major purpose of the Agricultural and Water Survey was to identify, map and evaluate these variations.

Physiography and Surface Geology

4. The project area consists of three main physiographic divisions. The first comprises a narrow strip of littoral dune formations which extend unbroken along the coastline and which reach elevations considerably higher than those of the plain immediately inland. The second division is a featureless plain covered by Tertiary lagoonal deposits and more recent alluvial materials. It occupies a broad zone extending in a northeast-southwest direction right across the project area. Its northern limit lies close to a line joining Bulo Burti and Dugiuma. The third and largest division comprising the remainder of the project area, is a plain with bedrock-controlled relief. Its southern part is underlain by crystalline Precambrian rocks and its northern part is underlain by Jurassic and Cretaceous limestones and sandstones; the boundary between these two parts is marked in the Baidoa area by a prominent scarp. This division is for the most part a gently undulating plain, but there are three tracts of greater relief in the northeasternmost corner, adjacent to the upper course of the Shebelle River and in the Bur Acaba-Dinsor area.

5. The Juba and Shebelle rivers traverse the project area. The Juba, the larger of the two, enters Somalia near Dolo and flows in a broad valley to the vicinity of Lugh Ganana, where it enters a deeply incised valley extending as far as Bardera. Throughout the remainder of its course the Juba flows in a narrow flood plain and empties into the Indian Ocean through a gap in the coastal dune ridge a few miles east of Kismayu. The Shebelle River enters Somalia at the northeast corner of the project area near Belet Uen and flows south through a broad valley to Bulo Burti. In this northern area the Shebelle has a narrow flood plain. Below Bulo Burti, the Shebelle flows in a broad flood plain until it enters the Shebelle swamp. At Balad, the river and flood plain change course and continue southwestward along the inner edge of the coastal dunes. The Shebelle has no permanent flow below the swamp and indeed in many years its flow never reaches the sea. However, at times of peak flow the Shebelle does continue beyond the swamp and reaches the Juba River below Camsuma.

Rainfall

6. The northernmost part of the project area has an arid climate, the remaining part a semi-arid climate. The rainfall occurs in two distinct seasons, termed locally the "Gu" (April, May, June) and the "Der" (October, November, December). The "Der" rains are scattered and often fail, while the "Gu" rains tend to be more reliable. The coastal lands between Merca and the eastern boundary of the project area enjoy inter-seasonal showers, known locally as the "Hagai" rains.

7. The winds blow steadily from the north and northeast between December and March and gently from the south and southeast between June and August.

Natural Vegetation

8. By far the most extensive type of vegetation in the project area can best be described as a low, arid to semi-arid shrub and tree steppe. Rainfall and soil variations are reflected by variations in the type and species composition of the shrubs and trees.

9. In the northern part of the project area, along the Somalia-Ethiopia border, the natural vegetation is a dwarf shrub steppe and farther south there is a zone of arid tree and shrub steppe. Both types of steppe occur in the arid rainfall zone. Over the rest of the project area the natural vegetation is a semi-arid tree and shrub steppe, including also some areas of grassland and dense shrub. Along the Juba and the Shebelle, riverine forest is the natural vegetation. However, much of it has been cleared for cultivation.

10. The steppe vegetation is important in the economy of the project area, since it supports the pastoral activities pursued by a large proportion of the area's population.

Agriculture

11. Dryland or rain-fed cropping has been and remains the traditional form of agricultural activity in the project area. Primitive irrigation based on seasonal high flows is practised in certain areas along the Juba and Shebelle rivers. The Italians introduced controlled and pump type irrigation during the period of their colonization.

12. The dryland cultivation is most extensive around the centres of Mahaddei Uen, Uanle Uen, Bur Acaba, Baidoa, Bardera, Saoo and along the Juba River below Fanole. In all these areas the soils and climate are favourable for this type of cultivation. This system of cultivation is also practised in less well endowed areas near Lugh Ganana, Oddur, Bulo Burti and Belet Uen. In the coastal area near Mogadiscio, a form of rain-fed land rotation is practised on the sandy dune soils. The main crops grown under dryland cultivation are sorghum and maize.

13. The inundation irrigation systems along the Juba River have developed in the "desoeks" or slackwater depressions of the flood plain. Along the Shebelle, canals were constructed to take water from the river to low-lying tracts of land. Maize, sorghum, sesame, cotton and vegetables are the main crops grown under this system of cultivation.

14. The controlled gravity flow irrigation system at Johar was established to provide assured water to a sugar cane plantation. At Genale a controlled gravity flow irrigation system was developed for the growing of bananas. Pump irrigation from the Juba and Shebelle rivers provides a controlled water supply to plantations growing bananas, vegetables and maize.

15. The raising of livestock, which can be considered the foundation of the traditional tribal agricultural economy, is carried out by both the settled cultivators and the nomadic herdsmen in the project area. In general, cattle are kept by the cultivators, while camels, sheep and goats are tended by nomadic herdsmen except west of the Juba River. Grazing rights are governed by tribal custom.

Population

16. The people of Somalia possess a common religion and a common language and culture, and their economic and social activities are tied to traditional tribal custom. They are however a nationalistic and forward looking people. The present population of Somalia is composed of six families of clans, namely the Dir, Isaq, Hawiye, Darod, Digil and Rahanwin. Within the project area the Rahanwin and the Digil are numerically the most important. Another important element in the population of the project area consists of the riverine peoples, who are culturally associated either with the Hawiye or with the Digil and Rahanwin. The clan families tend to be concentrated in geographical areas. The Rahanwin, Digil, Dir and Hawiye are cultivators and pastoralists. The riverine tribes are traditionally bound to the land and cultivate along the rivers, while the Darod are mainly pastoralists.

17. Based on the sample study carried out in the project area, the population is estimated to be approximately 1,285,000. Of this estimated population, 38 per cent or 485,000 people are classified as partly agriculturist and stockraisers, 39 per cent or 500,000 as nomadic stockraisers, and 23 per cent as urban dwellers.

Administration

18. The project area is divided into four major units or provinces, each under the control of a Governor. (Map 3) The provinces are further subdivided into districts, each under the jurisdiction of a District Commissioner.

Cities and Towns

19. Mogadiscio is the capital of Somalia. It is one of the major ports for import and export trade. Kismayu in the southwest corner of the project area is gaining in importance as a port because of the development of new harbour facilities. The town of Merca exports the bananas grown in the Genale area. Gelib and Giamama are significant administrative and agricultural centres in the lower Juba area. In the Shebelle area, Genale, Afgoi and Johar are important centres serving nearby irrigation developments. Baidoa, Bur Acaba, Bardera and Uanle Uen are service centres in the heart of the dryland cultivation areas. Lugh Ganana, Uegit, Oddur, Belet Uen and Bulo Burti are also important administratively.

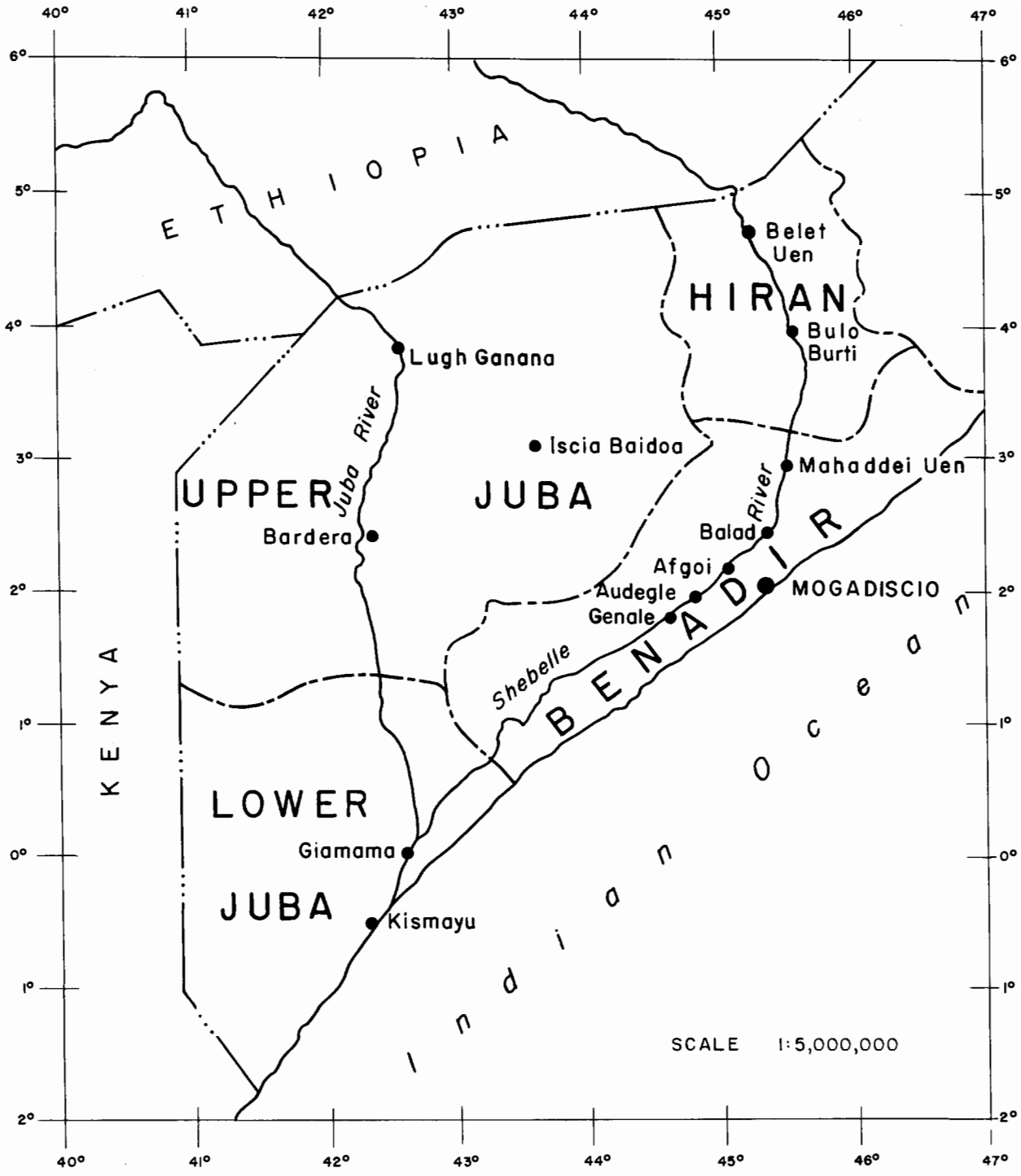
Transportation

20. All the administrative centres are linked by roads of varying quality. An all-weather road connects Kismayu and Gelib; another links Mogadiscio, Afgoi, Genale and Merca; the "Strada Imperiale", built by the Italians, serves the communities along the Shebelle River between Mogadiscio and Belet Uen. Elsewhere the roads are clay or gravel surfaced and are often closed during the rainy periods.

NATURAL REGIONS OF THE PROJECT AREA

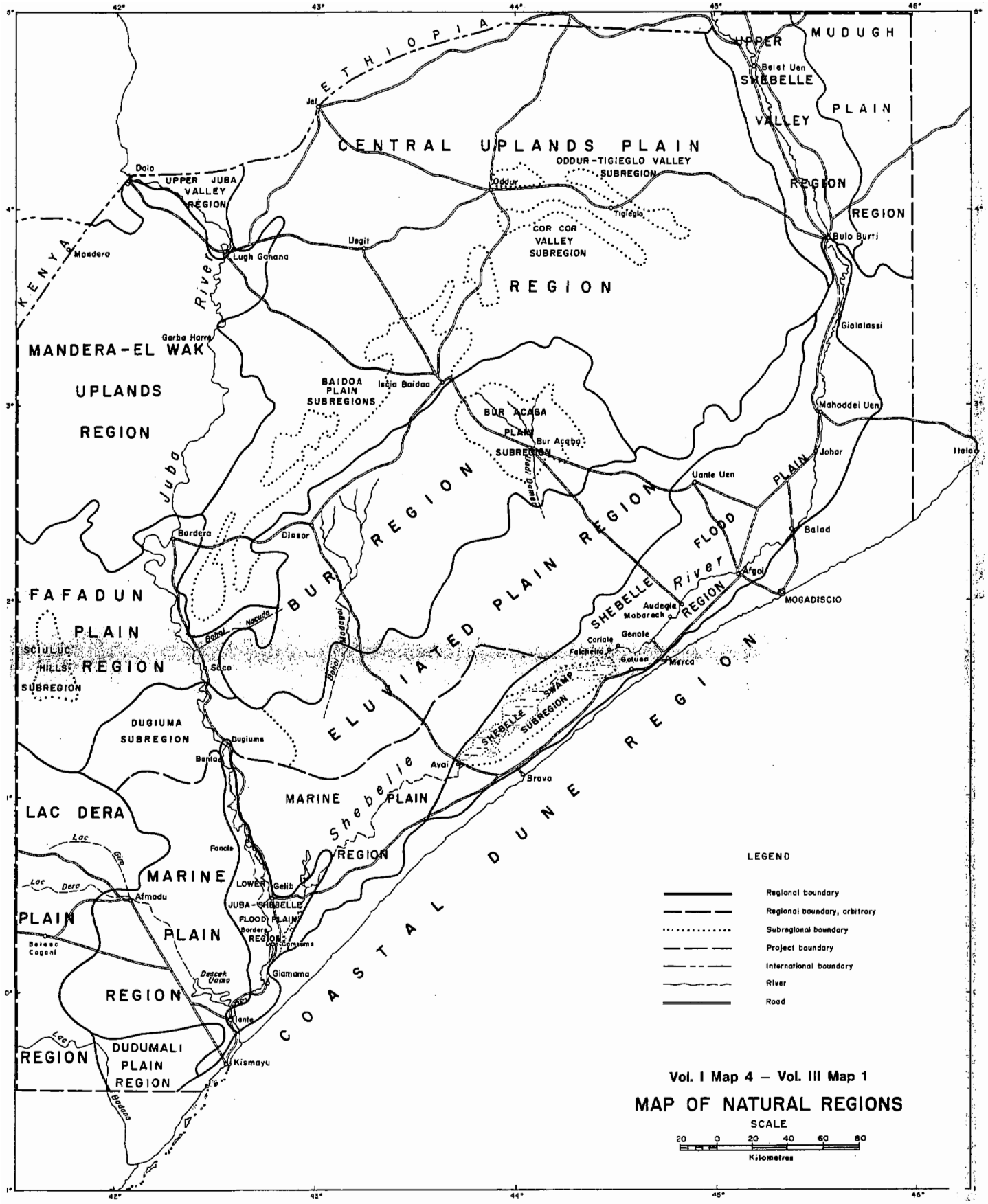
Regional Approach

21. The project area exhibits significant variations in physiography, climate, natural vegetation, hydrology, land use and human activity. Because of these variations, the potentialities for development vary from one part of the project area to the next. For these reasons many of the results of the survey are more effectively



Vol. I Map 3 — Vol. IV Map 1

ADMINISTRATIVE PROVINCES OF PROJECT AREA



Vol. I Map 4 – Vol. III Map 1

MAP OF NATURAL REGIONS

SCALE

20 0 20 40 60 80

Kilometres

presented under regional headings than for the project area as a whole. The regions described in the following pages may be termed "operation units for planning and development purposes".

22. Fourteen regions have been identified and delimited, as shown on Map 4. In a few cases, subregions too have been delineated in order to facilitate the text discussion. In all instances the regional boundaries are based on physiographic criteria.

Mandera-El Wak Uplands Region

23. The Mander-El Wak Uplands region comprises 20,735 square kilometers of land lying west of the Juba River in the northwestern corner of the project area. This region contains the most rugged and complex relief of the project area. Access is very difficult, although there is a very rough road extending south from Lugh Ganana to Garba Harre and Bardera. The main centre of the region is Garba Harre.

Upper Juba Valley Region

24. The Upper Juba Valley region comprises 1,799 square kilometers occupying the main valley of the Juba River north of Lugh Ganana. It consists of a narrow flood plain and the low gentle slopes flanking it. The only access through the region is by way of the main road from Lugh Ganana to Dolo. The main centres of the region are Lugh Ganana and the border post of Dolo.

Central Uplands Plains Region

25. The Central Uplands Plains region is the largest region in the project area. It occupies 64,954 square kilometers in the north between the Juba and Shebelle rivers. The region is a gently sloping featureless limestone plain, composed mainly of very shallow-soiled areas broken by areas of deeper soils which are cultivated in places. Three subregions have been delimited within the region. These are the Baidoa, the Oddur-Tigieglo and Cor-Cor subregions. These subregions contain most of the cultivated lands.

Upper Shebelle Valley Region

26. The Upper Shebelle Valley region occupies 6,878 square kilometers situated along the Shebelle River north of Bulo Burti. The region consists of the valley proper and the flanking hills. The Shebelle Flood Plain is narrow throughout most of its extent. The main centres of the region are Belet Uen and Bulo Burti. The "Strada Imperiale" joins the two main centres with Mogadiscio.

Mudugh Plain

27. The Mudugh Plain region comprises 6,107 square kilometers of land in the north-eastern corner of the project area. It is a featureless sandy plain which slopes gently down to the south. There are no major centres in this region. Access is provided by two roads, one in the north extending east from Belet Uen, the other in the south extending east from Bulo Burti, through Jesomona.

Fafadun Plain Region

28. The Fafadun Plain region comprises 13,625 square kilometers in the western part of the project area. With the exception of the Juba valley and the Sciuluc hills north of Afmadu, the region is a gently sloping plain. There are two roads, one extending west from Bardera, the other following the Juba River from Bardera to Gelib. Access within other parts of the region is almost non-existent, except for some trails and out lines. The major centres are Bardera and Saco.

Bur Region

29. The Bur region, located in the central part of the project area, emcompasses 17,253 square kilometers. It is composed of two distinct parts: the Bur Acaba sub-region in the east, which is a livestock and cropping area, and the natural vegetative cover of the remainder of the region, which is used for grazing. The landscape is an undulating plain with numerous bare inselbergs rising above it.

30. Bur Acaba on the main road from Mogadiscio to Baidoa serves as administrative centre for the subregion. Smaller roads and tracks radiate from Bur Acaba to the surrounding areas. Elsewhere in the region access in the north is provided by the road from Baidoa to Dinsor and Bardera. A poor road extends south from Dinsor to Avai on the lower Shebelle River.

Eluviated Plain Region

31. The Eluviated Plain region comprises 18,408 square kilometers along the southern limit of the Bur region. Its western extension crosses the Juba River and merges with the Fafadun Plain and the Lac Dera Plain. The eastern extension forms a narrow band between the flood plain of the Shebelle River and the Central Uplands Plain region. Two intermittent streams, the Bohol Madagoi and the Iscia Baidoa, enter the region from the north but spread out, evaporate and infiltrate, and do not reach the Shebelle.

32. The eastern part of the region is crossed by the Mogadiscio-Baidoa road and a road from Audegle to Bur Acaba. The central part has virtually no access other than footpaths and camel trails. The road from Avai to Dinsor does cross the region, but it is barely traversable by vehicle traffic. In the western part the road from Gelib to Bardera on the right bank of the Juba provides the only access.

Shebelle Flood Plain Region

33. The Shebelle Flood Plain region comprises 16,080 square kilometers on both sides of the Shebelle River, between Gialalassi and Avai. The present course of the Shebelle River is incised in the flood plain and bounded by a low levee formation. On the lands flanking the existing course, there are many old river channels which were once former courses.

34. This region is the most highly populated region in the project area and has undergone the greatest agricultural development. Besides extensive areas of dry farming, the region contains two irrigation developments, the sugar plantation at Johar and the banana plantations at Genale. The region also contains several experimental stations and research farms, most notably the Government research station at Genale, the AID/SR experimental farm at Afgoi, and the pasture experimental farm at Uar Mahan.

35. Access within the region is good. The upper part of the region is served by an all-weather road from Mogadiscio to Balad, Johar, Mahaddei Uen and Gialalassi. The lower part of the region is served by a recently built all-weather road from Mogadiscio to Afgoi and Genale. Centres of importance in the region are Gialalassi, Mahaddei Uen, Johar, Balad, Afgoi, Uanle Uen, Audegle, Genale, Shalambot, Goluen, Coriole, Mundun and Avai.

Marine Plain Region

36. The Marine Plain region comprises 16,446 square kilometers adjacent to the lower courses of the Juba and Shebelle rivers. It is a broad featureless plain covered with a dense tree and shrub steppe. Adjacent to the narrow Shebelle flood plain are several "desceks" or depressions which extend well into the plain and are included in the region. These depressions become filled with water when the rivers are high and are cultivated as the water recedes.

37. Large areas within this region are inaccessible. The southwestern part is served by the main road from Kismayu to Beles Cogani and Afmadu. The southeastern part is served by the main road from Mogadiscio to Kismayu. Afmadu is the only major population centre in the region.

Lower Juba - Shebelle Flood Plain Region

38. The Lower Juba - Shebelle Flood Plain region comprises 2,952 square kilometers of flood plain land along the lower courses of the Juba and Shebelle rivers. The region contains fairly extensive croplands. Below Gelib there are banana plantations irrigated by pumps from the Juba. Most of the remaining cultivation takes place in the desceks, but there are also several areas of true rain-fed farming.

39. The region is served by the main all-weather road from Kismayu to Gelib and by part of the main road from Gelib to Mogadiscio. Centres of importance are Giamama, Gelib, Ionte and Camsuma.

Lac Dera Plain Region

40. The Lac Dera Plain region comprises 11,180 square kilometers situated in the southwestern corner of the project area. It is a gently sloping plain composed of outwash materials from the Lac Dera and Lac Gira channels. The aerial photographs reveal a marked scrolled pattern representing old meanders, sandy outwash, and channel and levee remnants.

41. Access in the region is provided by the main road extending from Kismayu, via Beles Cogani to Kenya. Another road extends from Beles Cogani to Afmadu. Northwest from Afmadu, access is provided by the "Dif Trail". The only centre of importance in the region is Beles Cogani, a police and customs post between Somalia and Kenya.

Dudumali Plain Region

42. The Dudumali Plain region located in the southernmost corner of the project area comprises 2,344 square kilometers and is the smallest of all the regions mapped. It has little existing development and is covered with a semi-arid tree and shrub steppe, utilized mainly for grazing and browsing livestock. Access within the region is limited. The main road from Kismayu to Beles Cogani crosses the eastern section. A second road extends west from Kismayu.

Coastal Dune Region

43. The Coastal Dune region comprises 9,720 square kilometers of land in a long, narrow strip extending along the entire coast of the project area. The region can be divided into two parts: the western part extends westward from near Merca to beyond the Juba River and the town of Kismayu, and the eastern part extends from near Merca in a narrow tract to Balad and Mogadiscio, whence it broadens and extends north. The western part is narrow and consists of a pronounced ridge formation, while the eastern part is broader, lacks a definite ridge, and instead constitutes a rolling plain. The western part is mainly covered by natural vegetation, while the eastern part is extensively cultivated, particularly near Mogadiscio and to the northeast.

44. Access across the western part of the region is by roads connecting the towns of Merca, Brava and Kismayu. Access in the eastern section is provided by the main roads from Mogadiscio to Afgoi and Balad. One road penetrates the area, from Mahaddei Uen to Itala, and there is a coastal road from Mogadiscio to Uar Schek. The major regional centres are Mogadiscio, Merca, Brava and Kismayu.

CHAPTER 3

SUMMARY OF RECOMMENDATIONS

GENERAL CONSIDERATIONS

1. Recommendations for development in the project area may be grouped and presented in three different ways.

2. First, there are programs of action designed to improve one sector of the economy or another, for example animal husbandry, irrigation or rain-fed farming.

3. Second, there are recommendations for regional development, covering a number of diverse activities impinging on all sectors of the regional economy. Thus development in the Shebelle Flood Plain involves extension of controlled irrigation, improvement of inundation irrigation and rain-fed agriculture, provision of watering points for livestock, control of tse-tse fly and the provision of facilities including marketing, credit and technical guidance.

4. Third, there are recommendations for improvement in each line of technical endeavour. These come from the individual experts in line with their respective terms of reference.

5. As the timing of assignment of individual experts varied, and some individuals had completed their reports before the final planning phase could be undertaken, most of the recommendations put forward by this project are grouped by subject, the third way described, and are detailed in the appropriate volume of the report.

6. It is most important to note that this is a regional project and that the studies were carried out to measure the opportunities for development by first measuring present production, and then projecting potential production under improved management. The costs of improvements and values of anticipated benefits have been estimated wherever possible.

CONCLUSIONS

Development by Economic Sector

7. Development projects should be directed towards one or more sectors of the economy and efforts should be concentrated in those natural regions which have the highest concentration of population. These regions possess not only the labour needed for development, but also the population to share in the benefits to be derived.

8. An important criterion for according priorities to various development projects is the quantity and timing of input required in comparison with anticipated gains. Another is the number of people who can benefit directly. These considerations point to the traditional sectors of the economy, both agricultural and pastoral, as offering the best prospects for early and optimum returns on minimum investment.

9. The key factors that delay growth in these economic sectors have been identified as primarily institutional - lack of credit, organized marketing, technical guidance and good seed and implements. Certainly natural hazards play a major part, but we

believe that their effect can be more than offset by the introduction of technical improvement and economic stabilizers. It has been recommended that this be accomplished through the Agricultural Development Agency.

10. Approximately 40 per cent of the cattle in the project area are owned by cultivators. Consequently the Agricultural Development Agency can and should have a very significant effect on the livestock industry. Other programs directed specifically to this industry are also needed and are recommended.

11. New irrigation development will require a much larger investment than the Agricultural Development Agency and will take longer before economic benefits begin to accrue. However, feasibility and preliminary design studies for irrigation projects should be carried out concurrently with the initiation of improvement to the traditional sectors. The economic strength and also the advances in technical knowledge to be achieved through the operation of the Agricultural Development Agency will be needed for successful irrigation development.

12. Development of the commercial agricultural sector is of high importance to the overall economy because about half of the total Government revenue is derived from the banana industry. It would be disastrous for the nation if government policy killed, or even wounded, this goose that lays the golden eggs. The Government would probably not be required to invest heavily in this economic sector as capital is already available, but encouragement from the Government would be most necessary.

Regional Development

13. Regionally, the greatest potential for economic growth is in the Shebelle Flood Plain, where a great increase in production can be achieved from rain-fed agriculture, livestock (especially cattle), and both controlled and inundation irrigation.

14. The Bur Acaba subregion and the Baidoa Plain subregion offer considerable possibilities for further development of rain-fed agriculture and animal husbandry.

15. The Dudumali Plain, Lak Dera Plain and adjacent parts of the Marine Plain are capable of supporting a significant growth in the livestock industry.

16. The Lower Juba-Shebelle Flood Plain and parts of the Fafadun Plain region adjacent to the river are suitable for controlled irrigation.

17. The potential of the remaining regions is limited to improvements of animal husbandry and minor developments in the riverine areas. However, there is little doubt that the pastoralists using the interior regions will benefit, through a multiplier effect, from the developments that take place in the areas that offer better opportunities. Also, the advantages of settlement will undoubtedly attract many nomads when present insecurities are reduced or eliminated.

RECOMMENDATIONS

TECHNICAL DEVELOPMENT PROJECTS

GROUNDWATER DEVELOPMENT

Water Resources Inventory

18. The collection of hydrogeological information should continue and be expanded to include:

(a) Observation wells drilled and equipped to record the fluctuation in water levels in well fields.

(b) Records of water levels and pumpage at all producing wells.

(c) Test pumping of existing wells before installation of pumps or when a well is rehabilitated. All new wells should be test pumped.

(d) Survey of the elevations of wells, particularly observation wells.

Shebelle Flood Plain and Coastal Region

19. A detailed study of the Shebelle Flood Plain and adjacent Coastal region should be carried out. (This could take the form of a project). Specifically the investigation should determine the following:

(a) Infiltration from the river.

(b) Recharge from the infiltration of precipitation.

(c) Thickness of the fresh water zone.

(d) Areas with favourable aquifer conditions.

(e) Favourable areas for artificial recharge.

(f) The design of well fields that will permit the optimum use of waters and avoid contamination of the fresh water zone.

These investigations would involve test drilling, test pumping, geophysical studies, topographic mapping, an observation well program and a detailed study of the rainfall.

Reconnaissance Test Drilling

20. Reconnaissance test drilling should be carried out in areas about which little is known, as detailed in Chapter 6, para. 93.

Rangelands

21. More wells should be drilled where water quality is suitable. In the Bur Province a seismic survey would be a method of establishing areas of saturated drifts.

Municipal Water Supplies

22. Test drilling should be carried out and observation wells set up at main towns and villages to establish the amount of groundwater available for future use.

Well Construction

23. More attention should be paid to the sanitary construction of wells and the selection of materials and equipment to suit local conditions, as described in Chapter 6, para. 97.

Water Law

24. The water law prepared for Somalia with the assistance of F.A.O. should be passed by Parliament.

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* Drilling and test pumping carried out under the Government in the neighbourhood of Johar since this report was drafted indicate there are prospects in the area of groundwater supplies suitable for supplementary other supplies for irrigation. The indication is subject to full examination and confirmation.

RANGELAND DEVELOPMENT

25. Studies should be undertaken to determine the production of grass in relation to rainfall in the Shebelle Flood Plain region, the Lower Juba-Shebelle Flood Plain region and the Baidoa subregion. These production figures, when related to rainfall probability, should indicate the degree of hazard in establishing large herds on areas recommended for development.

26. The curing and haying qualities of the natural Somali grasses should be more thoroughly investigated and the knowledge put to practical use.

27. Range management should be started through the farming communities of villages. Range and grazing management practices should be included in the program of the Agricultural Development Agency.

28. Future development of the livestock industry in the project area should concentrate on the raising of cattle, primarily for an export market.

29. The quality of the cattle to be marketed should be improved. This could best be done through the establishment of finishing farms where the animals can obtain proper feeding and veterinary care. Finishing farms can be located in the Shebelle Flood Plain region, Lower Juba-Shebelle Flood Plain region and possibly in the Baidoa subregion. Finishing farms should come under strict range management. Range management could then be gradually extended to the surrounding open rangelands.

30. Consideration should be given to increasing the production of sheep and goats in the Baidoa subregion and the Central Uplands region. Goat hides from this area are of good quality. The hides from the Somali sheep are highly valued in the luxury leather trade.

SURFACE WATER DEVELOPMENT

Shebelle River Irrigation Development

31. Without the construction of a storage dam and reservoir it is possible to extend the irrigation system along the Shebelle River to irrigate an extra 20,000 hectares of annual crops plus the 5,000 hectares proposed for development in 1964.

32. The area of first priority for this extra development should be the idle farm land in the areas occupied by the members of the Societa Azionaria Concessionari Agricoli (S.A.C.A.) in the vicinity of Genale. The area of second priority should be the Bulo Mererta project area.

33. A feasibility study of a proposed storage dam and reservoir sited upstream from Bulo Burti would prove a valuable undertaking for the future. The various unfavourable and uncertain features of this site, including heavy losses of water in comparison with its storage capacity, prospect of limited life because of siltation, and considerable cost, are discussed in Chapter 13, paras. 24-34, and Chapter 15, para. 63. If, however, such a project was to prove technically and economically feasible, it would provide water on a year round basis so that the areas developed under the proposal in paras. 31 and 32 could be replanted to higher value crops as markets for these crops become available

34. The establishment of new irrigated land will require an overall plan of phased development covering the next 20 years. Discussions regarding the selection of farmers, land tenure, organization, and the aquisition and testing of competent management must be made. A Shebelle and Juba River Board Authority should eventually be set up to control the development of irrigation in the best interest of Somalia. This board should be a semi-autonomous body financed by charges levied for water use.

35. It is apparent that some expatriates will be required in the initial organization of irrigation projects. There are four alternative approaches to the problem of obtaining administrative and agricultural specialists:

(a) A partnership could be arranged between the Government and S.A.C.A.

(b) One or more large cooperatives might be established by the Ministry of Agriculture, or preferably by the Shebelle and Juba River Board Proposed above.

(c) A large private company might be set up with combined Somali and foreign capital. With proper contractual arrangements the long term interests of Somalia could be guaranteed.

(d) A variation on the private company approach would be for the Government to enter an agreement with an existing large and experienced international company for a pre-determined period. This method was successful on the Gezira Scheme in the Sudan.

36. The following steps are recommended:

(a) A Shebelle and Juba River Board Authority with full powers to plan and implement development should be established following the results of the follow-up project now approved for the Shebelle River and the results of the first stage of the U.S.S.R. missions development plan for the Juba River.

(b) Land tenure and water use legislation should be formulated and passed. Until this is done, no development can properly proceed.

(c) A feasibility study should be carried out on the possibility of diverting flood waters of the Shebelle to obtain the maximum possible benefits therefrom.

(d) The existing irrigation development centred on Genale and certain portions of the contiguous land farmed with inundation irrigation should be mapped.

(e) Immediate steps should be taken to stop the proliferation of farms along the Shebelle River which make inefficient use of its waters.

(f) Maximum possible use should be made of the organizational, administrative and technical advisory services which may be provided by such agricultural organizations as now exist.

(g) The farmers now growing bananas in the Genale area should be pressed, by suitable systems of taxation or by legislation, into growing crops on all cultivable land on their farms to which water is now, or can easily be, provided.

Surface Water Supplies for Human and Animal Consumption

Surface Storage Ponds or "Uars" (See Glossary)

37. "Uars" are technically feasible on the Shebelle Flood Plain, the Lac Dera Plain, the Marine Plain and the Central Uplands.

38. Until more data on ground-water supplies is available, no action on "uar" construction should be taken on the Marine Plain (East) and action on the Shebelle Flood Plain should await consideration of the possibilities of flood diversion.

39. The "uar" location survey required for the Lac Dera Plain and the western section of the Marine Plain should be carried out as soon as funds are available, and construction should follow as soon as possible.

40. The program for the Central Uplands is of low priority, but a very modest construction programme for the immediate future might be justified.

Small Streams

41. There are three small seasonally flowing streams in the project area which might be developed to provide water supplies on a small scale. These are the Lac Badana, the Bohal Madogoi and the Uadi Damer. The first might be dammed, suitable sites for ground water dams and seepage galleries might be found on the second, and the last might be dammed at one point or have sub-surface dams constructed at a number of points.

42. All these possibilities warrant detailed study in due course. This could best be done by combining a feasibility study of these projects with the proposed flood water diversion study of the Shebelle River.

SOCIO-ECONOMIC DEVELOPMENT-LAND TENURE

43. Cultivators have expressed a strong desire to expand and increase production and there is a wide public demand for tractors and modern farm methodology.

44. In the project area, the village is a natural unit on which all development operations should be based. Given facilities and marketing opportunities, everything suggests that a wide extension of village cooperatives would follow.

45. Land registration is a pre-requisite to credit availability and should be carried out on a village basis in which villages, or clusters of contiguous villages, are taken as cooperative units. Individual parcels need not be registered in the first instance.

46. Whether village land is registered or not, it would be desirable to proceed at once on a registration of all company and plantation land holdings irrespective of whether these are engaged in the banana trade.

47. This registration should be accompanied by the extension of direct taxation on all such enterprises which, whether they participate in the banana export trades or not, are in many cases sufficiently profitable to yield revenue.

48. Taxation should also eventually be extended to include village lands, but this should be delayed until a number of effective village cooperatives have been established. Such revenues would presumably accrue to local municipalities rather than to the central government.

49. There is nothing in the existing tenure conditions to impede the establishment of further state-owned farms which may prove an effective form of exploitation in irrigation areas. But it will no doubt be best to await indications from the results of the state farms at Gelib.

50. Anything which makes cultivation and cattle rearing more obviously profitable is likely to encourage the trend, already apparent, away from camel herding, and thus to reduce wide-ranging nomadism.

DEVELOPMENT OF AGRICULTURAL POTENTIAL OF THE PROJECT AREA

51. Development of the agricultural resources of the project area must be based on a long-term plan and involve four main phases. These are:

(a) Development of lands presently under rain-fed cultivation.

(b) Development of new lands under rain-fed cultivation.

(c) Intensified use of irrigated land within existing plantations.

(d) Development of new controlled irrigation projects.

Rain-fed cultivation should be developed based on extension using the development agency principle and village cooperatives.

If during the next five years the existing banana plantations improve yields and maintain their market position in Europe, plantations may expand total plantation crops considerably.

During the next ten years considerable effort should be expended in increasing the area of land under controlled irrigation.

Improvement of Rain-fed Agriculture

Marketing

52. A grain storage and marketing program should be started without delay so that seasonal price fluctuations are reduced to a normal range. Organized auctions should be set up for livestock so that raising, feeding and fattening of livestock can be concentrated in areas suitable for these activities. A well-developed marketing structure can then be provided for the livestock owners.

Research

53. Research must be carried out on varieties, fertilization, crop rotations, disease, insect control and tillage methods on the following rain-fed crops - sorghum, maize beans, groundnuts, cotton and forage crops.

Extension

54. The Government should organize its extension effort for rain-fed farms on a project basis. This should be started by concentrating first on a limited number of villages which are already organized unofficially into village cooperatives.

Principles of Extension

55. (a) The Government should recognize the existence of village cooperatives, grant them legal status and give advice on their internal organization and operation.

(b) The Government should establish an Agricultural Development Agency entitled to deal in cooperative produce, seed and farm supplies, and to extend credit and operate machinery.

(c) This agency should initially deal with cooperatives and thus offer the principal vehicle for agricultural extension within the country.

(d) The village cooperatives should agree to farm according to the direction of Agency employees who will be assigned to each village. Eventually, staff members of the Agency will revert to advisory status.

(e) The cooperatives must be organized internally so that effective control is exercised over the use of the land. Also, they should be encouraged to engage in community development projects such as construction of storage and water facilities. Individual farmers will, however, work their own lands and own the crops produced.

Improvement of Irrigated Agriculture

Shebelle River

56. (a) Development of the villages contingent upon inundation irrigation should be part of the program of the Agricultural Development Agency.

(b) The area under perennial crops can only be expanded beyond present plans if storage is provided. Controlled irrigation, therefore, must first be extended to seasonal crops including cotton, rice, groundnuts, vegetables and high-yield forage crops.

(c) Plantations can put 5,000 hectares of idle land at present under irrigation command into production and thus reduce their cost of banana production.

(d) In addition, an area probably amounting to 20,000 hectares can be irrigated under settlement schemes in such a development. It is recommended that holdings initially be established at 5 hectares per family.and that development in the later stages be dependent on the results in the earlier stages. Good returns from the irrigation scheme are anticipated.

(e) At present no duties are paid for irrigation water. This must be rectified in order that the irrigation systems and the River Board can be self-supporting financially. In addition, changes made for water used give an incentive to production and promote economy in water use.

(f) A main effort in the Shebelle area should be towards increasing average yields of banana and changing the variety grown to the Poyo.

Juba River

57. (a) The settlement scheme developed to exploit the waters of the Shebelle River should be adapted to the Juba River, once the two state farms are operating. Settlements should first use the land adjacent to the state farm.

(b) In the Juba area, schemes can be developed to increase perennial crops. This can be achieved by extending as vigorously as possible existing production organization, marketing groups and the market for bananas.

(c) Strenuous efforts should be directed towards retaining and extending the export market for bananas.

(d) Expansion of banana production in the Juba area could follow the present commercial plantation systems, and, in addition, village cooperatives of Somali agriculturalists could be encouraged.

Banana Industry Development in Somalia

58. The next five years will be a period of readjustment to changing price and market conditions in the Somali banana industry. Existing plantations will have to increase production per hectare. There may be instances of consolidation and re-organization to improve efficiencies. The plantations will probably have to use idle land to diversify crops in order to maintain profits. Plans for development of the project area assume this will be done by the existing plantation operations and marketing organizations.

ESSENTIAL TECHNICAL SERVICES

59. The Somali Republic is extremely short of qualified professional and technical men, in all fields of endeavour. Faced with a large number of problems, political, juridical, administrative and technical, the civil service tends to grow administratively rather than technically. It is more important for the Government to realise that its very income will depend upon the efforts of its scientists. Encouragement must be given to students to study scientific subjects - engineering, geology, agriculture and surveying in particular. Professional and technical men must not be wasted. They must be employed and salaries and allowances established on a scale commensurate with the efforts they have put into their education and the great responsibilities that they are required to bear.

60. The Meteorological Service and the Hydrological Service both need strengthening. Meteorology now comes under Civil Aviation, stations are located mainly at airports and recording is of the synoptic type, for forecasting. Stations must also be established for agricultural purposes in all natural regions. The Ministry of Agriculture should advise the Meteorological Service of its requirements and, if these are not met, should establish its own network. Each village cooperative established under the Agricultural Development Agency should have at least a recording rain gauge and some plantations, and all Government farms should have full stations. The hydrological observation program initiated under this project should be continued and some new stations established. All stations must be visited at least quarterly for equipment maintenance and supervision of the observers.

61. The soil survey section established under the project and also the soils laboratory at Afgoi should both be strengthened by adding graduates and technicians. Detailed soil surveys will be required for irrigation and rain-fed development schemes; reconnaissance soil surveys are needed elsewhere in the Republic.

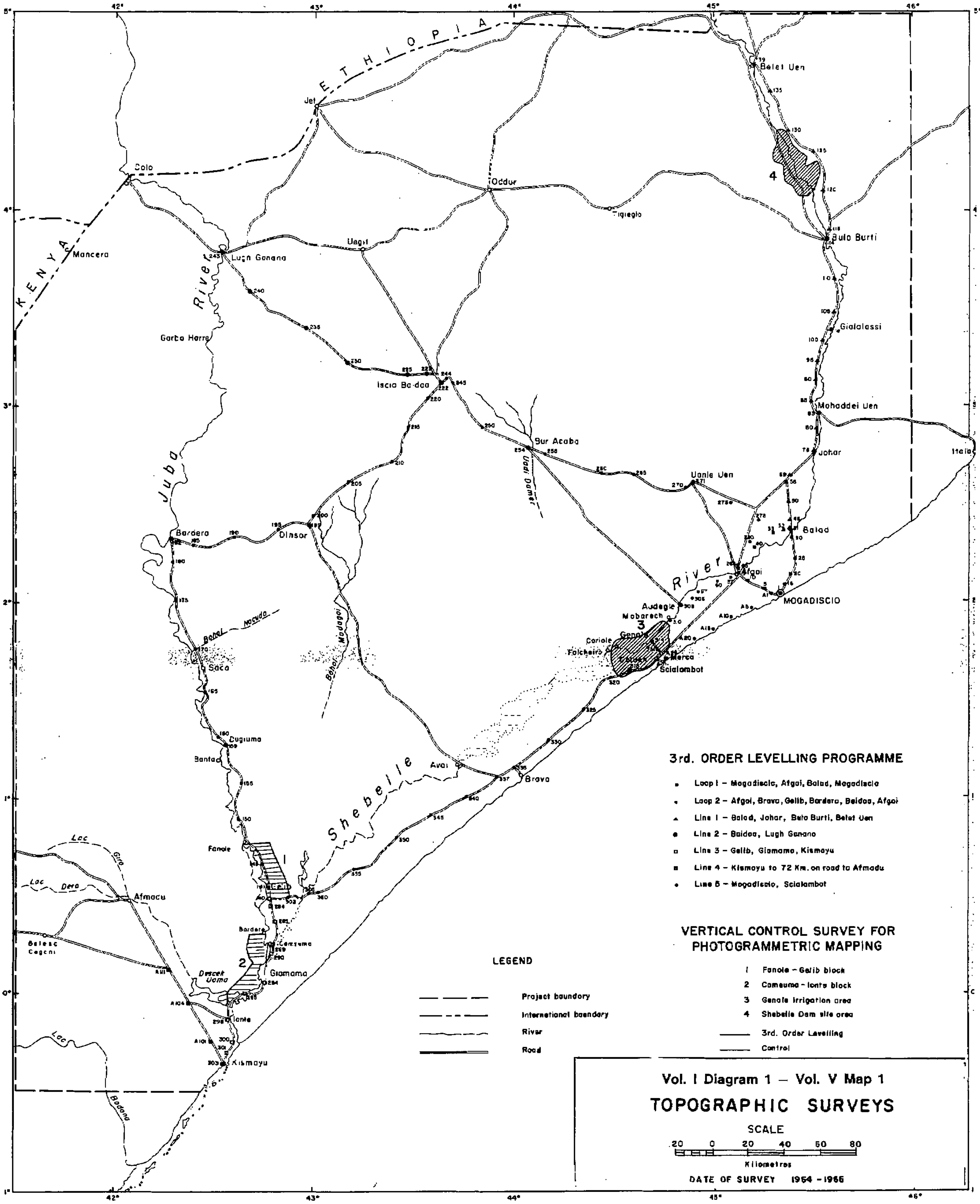
62. Agronomic research should be continued at Afgoi and Baidoa, initiated on the State Farms, and encouraged on the plantations areas under S.A.G. and S.A.C.A. The main emphasis initially should be on variety and management trials on crops presently grown. Attention should also be given to disease and pest control. The problem of controlling damage from birds (Quelea quelea) should be investigated.

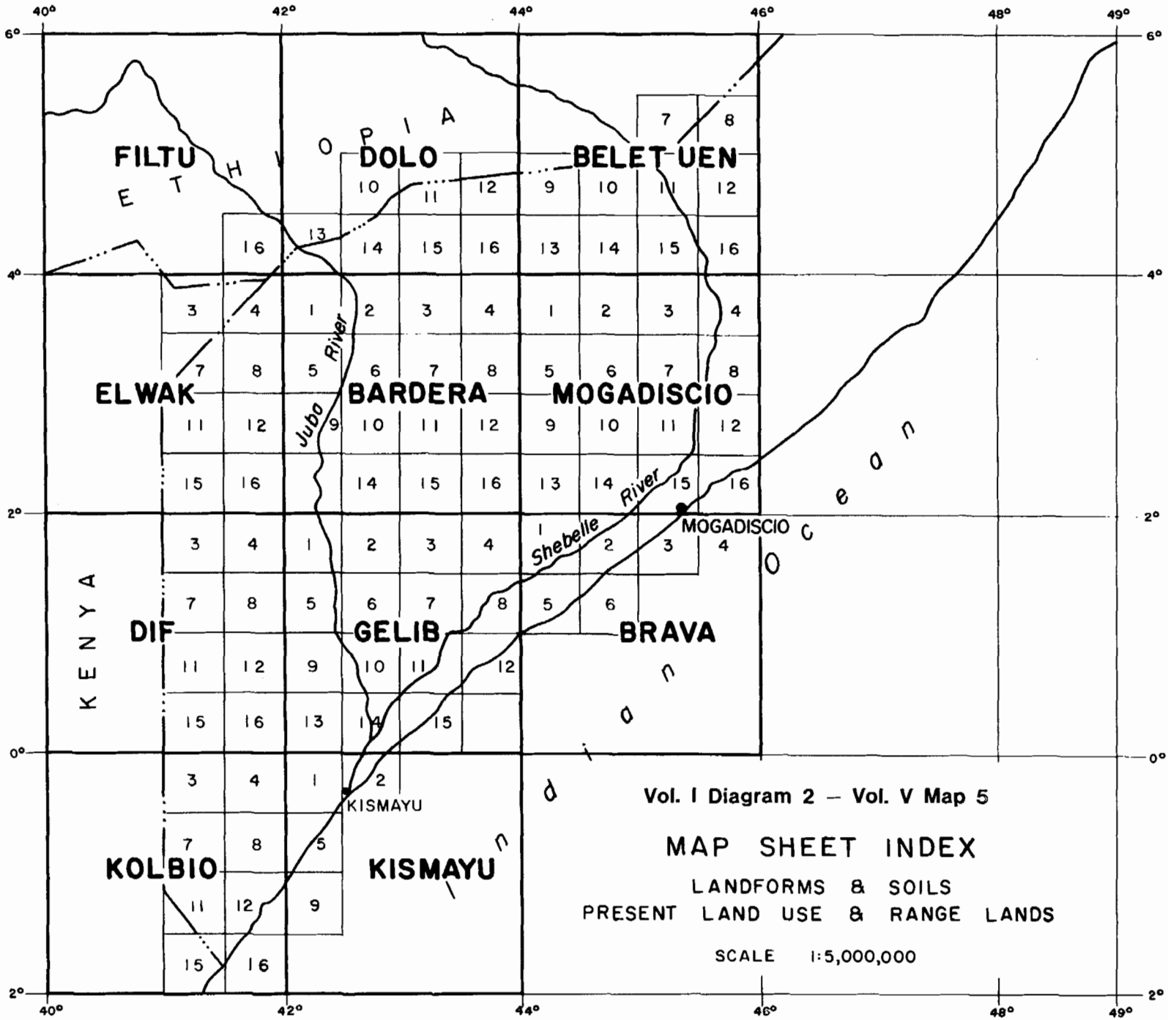
63. Under the recently formed Livestock Development Agency, rangeland production surveys should be continued on a sampling basis in every season and the data correlated with weather records. Aerial livestock counts should be done periodically. (See also Appendix 5 - Summary of the report on the F.A.O. Livestock Development Survey in Somalia, 1966).

64. The topographical service of the Surveys and Mapping Department must be given every encouragement. Detailed elevation surveys will be required for all irrigation projects and surveys for land registration are essential for the progress of the work of the Agricultural Development Agency.

65. During the field operations of the project, a Survey and Mapping Department was formed, comprising a Water Resources Service, an Agricultural Survey Service and a Topographical Survey Service. This proved a most efficient and economical way to organize the technical services that are essential to economic development projects.

66. Finally, it is important to note that these essential services can only be conducted in the field, and consequently the transport and facilities needed for field operations must be provided.


E T H I O P I A
K E N Y A
Belet Uen
Bulo Burti
Gialalassi
Mohaddei Uen
Johar
Italia
Balad
Afgoi
MOGADISCIO
Audegle
Mobarech
Genale
Coriole
Falcheiro
Merca
Scialambot
Brava
Avai
Uanle Uen
Bur Acaba
Uadi Damer
Iscia Baidoa
Oddur
Tigieglo
Uegit
Jet
Dolo
Mancera
Lugh Ganana
Garba Harre
Bardera
Dinsor
Saco
Bohol Nacuda
Bohol Madagoi
Cugiuma
Bantao
Fanole
Afmadu
Lac Dera
Lac Giro
Camsuma
Giamama
Descek Uama
Bardera
Ionte
Kismayu
Badana
Juba River
Shebelle River
3rd. ORDER LEVELLING PROGRAMME
Loop 1 – Mogadiscio, Afgoi, Balad, Mogadiscio
Loop 2 – Afgoi, Brava, Gelib, Bardera, Baidoa, Afgoi
Line 1 – Balad, Johar, Bulo Burti, Belet Uen
Line 2 – Baidoa, Lugh Ganana
Line 3 – Gelib, Giamama, Kismayu
Line 4 – Kismayu to 72 Km. on road to Afmadu
Line 5 – Mogadiscio, Scialambot
VERTICAL CONTROL SURVEY FOR PHOTOGRAMMETRIC MAPPING
1 Fanole – Gelib block
2 Camsuma – Ionte block
3 Genale irrigation area
4 Shebelle Dam site area
3rd. Order Levelling
Control
LEGEND
Project boundary
International boundary
River
Road
Vol. I Diagram 1 – Vol. V Map 1
TOPOGRAPHIC SURVEYS
SCALE
20 0 20 40 60 80
Kilometres
DATE OF SURVEY 1964 – 1966


40°
42°
44°
46°
48°
49°
6°
4°
2°
0°
FILTU
DOLO
BELET UEN
ELWAK
BARDERA
MOGADISCIO
DIF
GELIB
BRAVA
KOLBIO
KISMAYU
ETHIOPIA
KENYA
Jubo River
Shebelle River
MOGADISCIO
KISMAYU
Indian Ocean
Vol. I Diagram 2 — Vol. V Map 5
MAP SHEET INDEX
LANDFORMS & SOILS
PRESENT LAND USE & RANGE LANDS
SCALE 1:5,000,000

CHAPTER 4

TOPOGRAPHICAL SURVEY AND MAPPING

PURPOSE AND SCOPE

1. The Plan of Operation allowed for the services of a survey engineer for 24 months and a sum of $ 30,000 for photogrammetric mapping. At the time that the Plan of Operation was prepared U.N.T.A. had provided the services of three advisors (in topographical survey, photogrammetry and cartography) to assist the Somali Government in forming a national cartographic office. It was assumed, therefore, that most of the mapping needs of the project, and all of the draughting, would be undertaken by this new office.

2. Unfortunately, this organization was not in a position to offer any significant amount of concrete help until mid 1964. Two other factors also affected the topographic program. First, the only survey data that could be found, either in Mogadiscio or as a result of appeals to the Governments of Italy and the United Kingdom, amounted to a single benchmark (fortunately originally the top of a tide gauge) in the Mogadiscio harbour. Second, the aerial photography carried out for the project was only suitable for mapping with a 4 metre contour, whereas the very low slopes required a much smaller interval for irrigation planning.

3. In consequence it was agreed to re-define the topographic requirements as follows:

(a) First priority was accorded to a level control survey of the rivers, to be done to 3rd order standards of accuracy and monumented.

(b) Second priority was to establish ground control surveys for photogrammetric mapping of irrigation project areas. This mapping could then be done under a follow-up project. The contour interval would be 1 metre.

SURVEY WORK

4. Permission was granted to employ a second survey engineer, and Somali secondary school graduates were hired and trained as instrument men and survey technicians.

5. Attached is an index diagram of the elevation surveys accomplished under this program (see diagram 1). The U.S. Corps of Engineers under U.S.A.I.D. had established a tide gauge at Kismayu, and a mean sea level datum was established by computing 13 months' records from this gauge. The level line from the tidal datum at Mogadiscio closed to within 10 centimeters of the Kismayu datum, and the loop from Afgoi to Gelib to Bardera to Bardoa to Afgoi also closed to about 10 centimeters. There is no check on the lines to Lugh Ganana and Belet Uen, but it is estimated that the maximum error at Lugh Ganana would be 15 centimeters and at Belet Uen 20 centimeters, considering the specifications of accuracy employed.

6. All the river gauging stations were surveyed and tied into the sea level datum, in view of the low slopes and the low elevations in the Juba Flood Plain.

7. In two areas on the Juba river, cut lines were bulldozed at 2 kilometers intervals and level surveys were carried out for photogrammetric mapping control. It was possible to contour the location maps at a 5 metre interval.

8. Wherever possible and practical benchmarks were established at wells. These relatively permanent benchmarks will be useful for groundwater studies.

9. After the departure of the project surveyors, further surveys were conducted by the same staff under the guidance of the U.N.T.A. topographical engineer. The work included completion of levelling of the Camsuma Ionte block in the lower Juba, full control of the dam site and elevation control of the reservoir area north of Bulo Burti, and full control of the Genale irrigation area.

MAPPING AND DRAUGHTING

10. Two series of maps at 1:100,000 scale were produced, one showing Landforms and Soils and the other Present Land Use and Range Ecology. There are 81 sheets in each series (see diagram 2).

11. The map of the potential dam site north of Bulo Burti was prepared by photogrammetric methods by the U.N.T.A. Photogrammetric Advisor.

12. During the survey draughtsmen were trained and draughting supervised by the U.N.T.A. cartographer.

13. All original survey records and the Landforms and Soils and Present Land Use and Range Ecology maps are kept in the offices of the Surveys and Mapping Department, Ministry of Public Works, Mogadiscio.

CHAPTER 5

CLIMATE OF THE SURVEY AREA

1. The climate of the survey area is tropical, semi-arid to arid, with a seasonal rainfall pattern influenced by the monsoon winds.

2. The rains occur during April, May, June and September, October, November. The first rainy period of the year is termed the "Gu" season. The latter rainy period is called the "Der" season.

3. Three broad climatic zones may be recognized. These are characterized by a difference in rainfall pattern. In the coastal zone significant amounts of rain occur during July and August. These are called the "Hagi" rains, and they effectively lengthen the "Gu" season. The semi-arid zone has two strongly defined rainy seasons; light rains may occur during July and August. The arid zone has a lower annual rainfall than the other two zones with dry periods in July and August.

4. The rainfall tends to be variable and unreliable, and failure of the rains is not uncommon, particularly in the arid areas. The amount of rain can vary considerably from the averages presented in the bar charts at the end of this section. This is an important factor to consider in assessing the value of the seasonal rains in terms of agriculture.

5. The temperature is fairly uniform throughout the year, averaging from 25° to 30° centigrade. Based on average figures, the coolest month is August and the warmest is April, the difference in temperatures averaging 2° to 4° centigrade (see Table 1).

6. Relative humidity varies between 70 and 80 per cent in areas near the coast, and between 40 to 60 per cent in the more arid regions of the interior. Deviations from the yearly mean values are negligible.

7. The monsoon winds are the important factor affecting the climate and the time of the rainy periods. The southwest monsoon winds prevail during June, July and August. The northeast monsoon winds prevail during December, January and February. The seasonal rains are associated with the directional changes of these winds. Although the statistics show a moderate wind velocity, personal observations would indicate that the monsoon winds are remarkably steady with velocities sufficient to cause damage to banana plantations. Wind velocity and direction is an important factor to be considered in agronomic planning.

8. The tables and diagrams in the following pages were compiled from data obtained from Government departmental records as well as data collected during the project. The period of basic data is short, 5 to 12 years, except for the station at Johar, where records for 27 years were available. Climatic data are presented as follows:

Figure 1: Mean Monthly Rainfall - Coastal Zone

Figure 2: Mean Monthly Rainfall - Semi-Arid Zone

Figure 3: Mean Monthly Rainfall - Arid Zone

The observation stations will be found on Map 10.

TABLE 1

AVERAGE MONTHLY TEMPERATURES
DEGREES CENTIGRADE

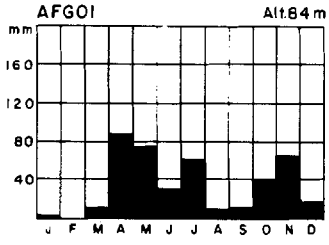
A - Monthly Mean Temperatures
B - Monthly Max. Temperatures

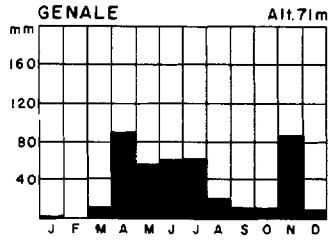
STATION		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
Kismayu	A	27.4	27.6	28.2	28.6	27.2	26.4	25.5	25.5	26.1	27.1	27.7	27.6
	B	30.7	31.0	31.5	31.8	30.2	29.2	28.1	28.5	29.1	30.3	31.3	30.9
Ionte	A	28.2	28.1	28.7	28.9	27.8	26.3	25.6	25.8	26.1	27.3	27.3	27.9
	B	32.7	32.8	33.2	33.3	31.7	29.9	28.9	29.9	29.9	31.3	31.8	32.5
Genale	A	27.1	27.5	28.4	28.3	26.7	25.4	24.8	24.8	25.5	26.0	26.4	26.9
	B	33.0	33.2	34.2	33.7	31.6	30.3	28.9	29.3	30.0	30.6	31.5	32.5
Afgoi	A	27.3	27.7	28.7	28.6	27.1	25.9	24.9	25.5	26.0	26.6	26.4	26.8
	B	33.7	34.4	34.8	34.1	31.7	30.5	28.4	30.1	31.1	32.0	31.9	32.5
Mogadiscio	A	26.3	26.5	28.0	28.9	28.1	26.6	25.6	25.5	26.1	26.8	26.9	26.6
	B	29.6	29.7	31.0	32.0	30.9	29.3	27.8	28.0	28.7	29.4	29.9	29.7
Balad	A	26.9	27.6	28.3	27.6	26.6	25.6	24.7	24.8	25.6	26.0	26.1	26.4
	B	36.7	34.9	35.5	34.2	32.0	30.9	29.3	29.6	30.6	31.5	31.6	32.2
Afmadu	A	29.4	29.7	30.1	28.9	28.5	26.6	24.7	26.3	27.6	28.3	27.8	28.3
	B	36.8	37.2	37.3	35.6	35.2	31.4	32.0	33.3	34.5	35.5	34.2	34.5
Baidoa Bonka	A	27.1	27.6	28.4	27.3	26.0	25.3	24.5	25.0	28.8	26.0	26.0	26.1
	B	35.2	35.7	35.8	33.1	30.6	30.4	29.1	30.2	31.5	31.7	31.3	32.8
Bur Acaba	A	28.8	29.5	29.8	29.3	28.3	27.1	25.8	26.7	27.8	28.2	27.9	28.2
	B	35.9	36.6	36.7	35.4	33.2	32.5	30.8	32.4	34.1	34.2	33.6	34.8
Bulo Burti	A	28.3	28.7	29.9	29.5	28.8	28.3	27.2	27.5	28.6	28.5	28.2	28.3
	B	34.6	35.4	36.6	35.9	34.4	33.5	32.3	32.8	34.5	34.5	33.8	34.1
Lugh Ganana	A	29.9	30.7	32.0	30.6	29.0	28.2	27.1	27.7	28.7	28.8	28.5	29.3
	B	37.6	38.7	39.8	37.2	34.2	33.7	32.2	33.5	34.6	35.2	35.0	36.4

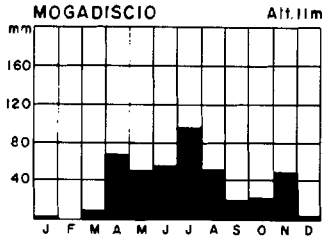
MEAN MONTHLY RAINFALL DIAGRAMS

COASTAL ZONE

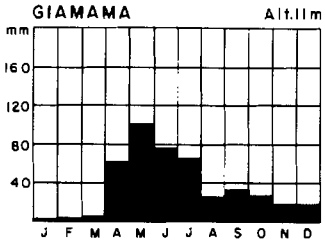
SHEBELLE RIVER

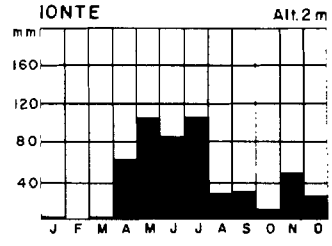


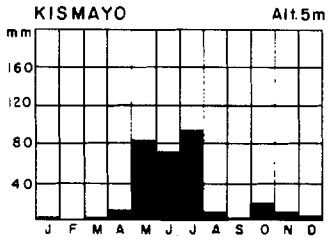




JUBA RIVER





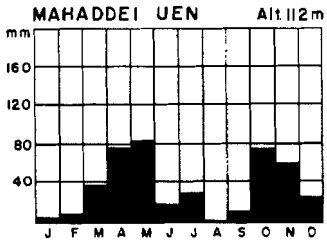


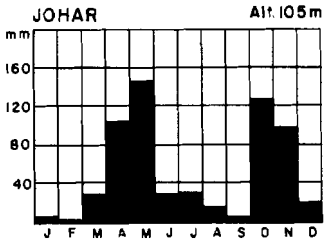
Vol. I Fig. 1 – Vol. II Fig. 1

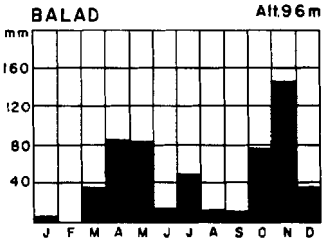
MEAN MONTHLY RAINFALL DIAGRAMS

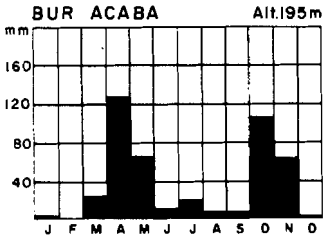
SEMI-ARID ZONE

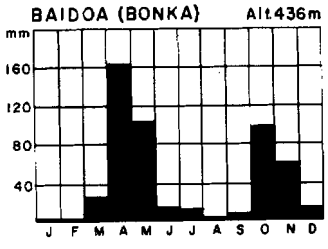
SHEBELLE RIVER



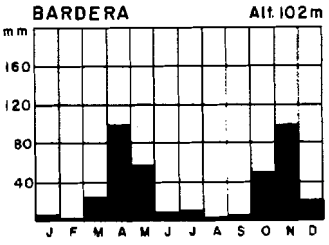


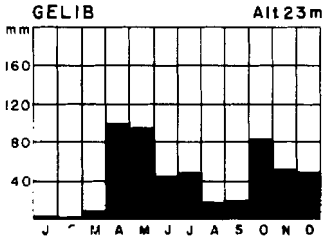


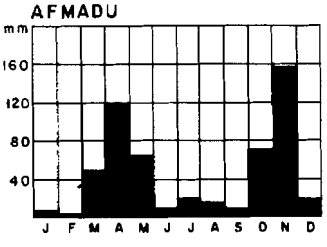




JUBA RIVER





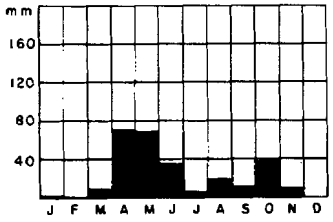


MEAN MONTHLY RAINFALL DIAGRAMS

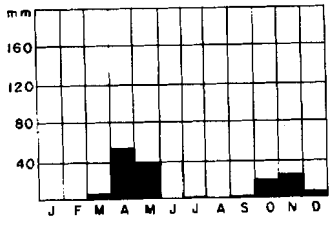
ARID ZONE

SHEBELLE RIVER

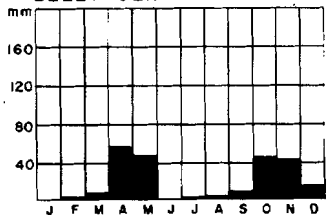
DAGAHBUR



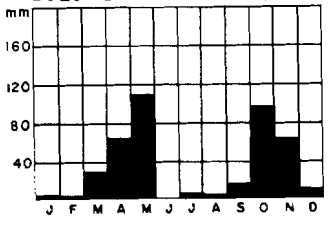
CALLAFO



BELET UEN Alt.183m

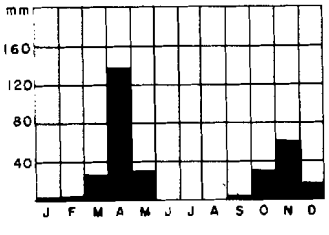


BULO BURTI Alt.144m



JUBA RIVER

LUGH GANANA Alt.150m



Vol. I Fig. 3 – Vol. II Fig. 3

CHAPTER 6

GROUNDWATER

PURPOSE AND SCOPE

1. Recognizing the importance of groundwater to the future development of the country, the purpose of this survey was to assess the possibility of increasing the supply suitable for irrigation, livestock and domestic use.

2. There was a substantial amount of information available from various sources, particularly on existing drilled wells. This was studied and augmented by additional information collected as part of this project. The new information included chemical analyses of samples from 176 wells, the establishment of three permanent wells and one temporary observation well, the location of existing wells on mosaics and the determination of the elevations of 30 wells and two springs. No extensive geological mapping was done, but use was made of the mosaics, the aerial photographs and the findings of the soil and landforms surveys to understand the geology of the area.

GEOLOGY

3. A large fault or fault zone with a downthrow to the southeast crosses the project area mainly parallel to the coast and at a distance of about 90 to 100 kilometers inland. To the southwest and northeast of the project area this fault appears to swing gradually inland. It is probably the western member of a system of faults that parallel the East African coast and which controlled sedimentation during Tertiary times. Henceforth, it will be referred to as the Banta-Gialalassi fault, after locations on the Juba and Shebelle rivers respectively, near which the fault most likely passes (see Map 5).

4. The fault structures created conditions in the coastal area that permitted the accumulation of great thicknesses of Tertiary sediments. Holes drilled for oil in the coastal area intersected sediments from recent down to Jurassic in age. On the inland or upthrow side of the Banta-Gialalassi fault only the basement and Mesozoic formations are exposed, except for local residual materials and alluvial deposits.

5. The basement system outcrops or is close to the surface northwest of the Banta-Gialalassi fault in a zone between 40 and 100 kilometers wide. It extends across the central part of the project area from the western limit northeastward to the area east of Bur Acaba. To the north it is covered by Mesozoic formations. It is composed of gneisses and schists that have been invaded by granite. The surface slopes gently towards the coast and granite inselbergs locally known as "Burs" form the only relief. Unconsolidated drift occupies depressions and wadi-floors and is particularly evident in the form of colluvial deposits adjacent to the Banta-Gialalassi fault.

6. The Mesozoic strata are composed mainly of limestone, marl and sandstone. In the Baidoa-Dinsor area these strata form an escarpment that rises above the basement, but the escarpment diminishes to the southwest and to the east. In the Shebelle Valley the outcrop ends at the Banta-Gialalassi fault, which trends almost perpendicular to the strike of the formations.

7. In the project area the regional dip of the Mesozoic formations is away from the "Bur" or basement area. It appears that in Somalia they form the southeastern limb of a syncline that extends into Ethiopia and northeast Kenya with its axis near the Ethiopian border.

8. The basal deposits are composed of coarse sandstone that has a patchy distribution and is only known west of the Dinsor area. This is probably equivalent to the Mansa Guda formation of Kenya, which is regarded as Triassic in age.

9. During Jurassic times a marine transgression took place and a variety of limestones and marls were deposited. In the west these are interbedded with sandstone and sandy-limestone formations which become more predominant among the deposits of uppermost Jurassic and Cretaceous age. To the east the equivalent of these arenaceous deposits are limestones and marls that contain gypsum.

10. The uppermost Mesozoic formation is the Jesomma sandstone that forms an escarpment in the extreme northeast of the project area. This has been described as continental in origin and Upper Cretaceous to Palaeocene in age.

11. Folding and faulting are evident locally in the Mesozoic strata. In the Upper Juba area one fold belt, which trends in a northeast-southwest direction and is called the Garba Harre axis by oil geologists, crosses the Juba River about 35 kilometers south of Lugh Ganana. It attains a width of about 10 kilometers and can be traced for 110 kilometers. A similar belt that parallels this about 60 kilometers to the northwest appears to be a continuation of the Hegalu structure of northeast Kenya. Between the two is a broad syncline with its axis in the vicinity of Lugh Ganana. Faulting is present particularly in the lowest strata and probably continues in the basement below. It is most evident in a complex area of faulting centered about 60 kilometers southeast of Bardera. Evidence of eastwest tear faulting between Baidoa and Uegit was noticed on mosaics.

12. Two distinct facies occur in the Upper Tertiary formations. Adjacent to the coast, littoral deposits are composed mainly of sand with layers of coquina. They form a coastal upland that rises to about 150 meters above sea level and varies in width from about 5 kilometers to over 40 kilometers in the northeast. Between these coastal uplands and the Banta-Gialalassi fault and beneath the flood plain, the Upper Tertiary formations are sand and gravel interbedded with clay and marl, probably of lagoonal and alluvial origin. In areas such as Uanle Uen and Bio Addio, where the inland edge of the lagoon was probably located, the deposits contain more marl; in the Beles Cogani area west of the Juba River the large quantities of sand were probably brought into the lagoon zone by rivers draining the area to the northwest. The area has emerged since lagoonal conditions prevailed, apparently more so in the north.

13. Oil geologists have indicated that the Oligocene deposits consist of limestone, marl, clay and sand formations that are difficult to distinguish from the overlying Lower Miocene formations.

HYDROGEOLOGY

14. The geology permits a division of the project area into three main groundwater provinces, a Coastal Province of Tertiary formations, and Inland Province of Mesozoic formations and a Bur Province where the basement outcrops or is close to the surface (see Maps 6 and 9).

Coastal Groundwater Province

General

15. The Coastal Province has an area of about 66,550 square kilometers and extends from the coast inland to the Banta-Gialalassi fault. It is a self contained hydrogeologic unit consisting of sediments from recent to Jurassic age, bounded to the southeast by the Indian Ocean, and with an impervious boundary of basement rock inland. In the north or Shebelle valley area, it is in contact with pervious Jurassic and Cretaceous formations.

Aquifers

16. There are probably aquifers throughout the whole sedimentary sequence, but information is restricted to a depth of 100 meters and locally to 300 meters. Below this level the presence of aquifers can only be assumed and their nature anticipated by comparison with formations of similar age exposed elsewhere.

17. Facies changes in the Upper Tertiary deposits result in changing aquifer conditions, but on a regional scale the aquifers appear to be hydraulically interconnected.

18. In the littoral zone the sand and coquina formations are among the best aquifers in the project area. The aquifer materials are known to extend locally to depths of at least 300 meters, but in the higher areas the water table is as much as 100 meters below ground level. A study of the aquifer was being made by U.S.A.I.D. to determine the feasibility of using water from it to supply Mogadiscio.

19. In the central flood plain area the Upper Tertiary aquifers are sand and gravel formations that are interbedded with clay and marl aquicludes. Along the inland margin of the province there is an increase in the amount of marl at the expense of aquifer materials, and in the area west of the Juba River the aquifers are composed mainly of sand.

20. Wells in the Genale area drilled to supply water for irrigation yield 70 to 140 cubic meters/hour and have specific capacities of between 5 and 20 cubic meters per hour per meter. (cu.m./hour/m.) It is estimated from these figures that the Coefficient of Transmissibility of the upper 100 meters of aquifer might be in the order of 300 cubic meters per day per meter (cu.m./day/m.) In the Afgoi area, where the aquifer conditions do not appear to be as good, it is estimated that the Coefficient of Transmissibility is in the order of 150 cu.m./day/m.

21. In the Lower Tertiary and Mesozoic deposits, sand, sandstone and limestone formations may constitute good aquifers, but because of their depth, it would be expensive to tap them with wells.

Chemical Quality

22. Fresh groundwater is present in the littoral zone, in aquifers beneath and adjacent to the rivers, in perched aquifers beneath intermittent watercourses and areas that are inundated during periods of flood. Elsewhere groundwater has a high dissolved solid content and in places is decidedly brackish. It appears that water with the highest mineral content comes from aquifers west of the Juba River and east of the Shebelle River, where the specific conductance exceeds 7,000 micromhos (mmhos), and chlorides reach 2,000 parts per million (ppm).

23. Groundwater in the Shebelle Flood Plain exclusive of the riverine zone is characterised by a high sulphate content generally in excess of 700 ppm. and locally more than 3,000 ppm. This condition does not exist in the Lower Juba area, where the water is characterised by high chlorides and an alkalinity greater than total hardness.

24. Brackish and salty water occur in places along the coastal fringe, particularly where the littoral zone is narrow or where the extraction of groundwater is relatively heavy, as at Mogadiscio.

Recharge and Groundwater Flow

25. It is known that recharge enters the aquifers by the direct infiltration of precipitation, influent seepage from the rivers and seepage from other provinces, but the amount of this recharge is not known (see Map 7).

26. Conditions appear to be most favourable for the infiltration of precipitation in the arenaceous littoral zone, but it is likely that much of the water is retained in the upper two or three meters and lost as evapotranspiration later. In the flood-plain areas much of the surface material is impermeable, but the infiltration of rainfall and seepage from inundated areas probably recharges shallow perched aquifers. These eventually discharge into the Shebelle River. This is the only way to explain the increase in Shebelle River flow between Afgoi and Audegle during the low flow period.

27. Recharge enters the aquifers by influent seepage from the rivers. This is indicated by the rise of the water table beneath the rivers and the presence of fresh water in the riverine areas. Two methods were used to estimate the amount of this seepage; one using the discharge relation curves and allowing for evaporation and withdrawals; the other using the estimated Coefficient of Transmissibility and slope of the water table in the Darcy equation. The estimates indicate that influent seepage probably varies up to a maximum of 9 hectare meters per month per kilometer of river channel. In the Genale area there is evidence that influent seepage takes place from the irrigation canals in addition to the river.

28. The slope of the water table indicates seepage into the flood-plain area from the limestone aquifers of the Inland Province between Uenle Uen and the Shebelle River. This compares to areas farther south where the only seepage likely is from the veneer of drift that covers the basement. The water table declines towards the south and in the Lower Juba region forms a depression below sea level. This can only be caused by poor recharge conditions, and it may be that much of the groundwater is connate.

Bur Groundwater Province

General

29. The Bur Province has an area of approximately 34,000 square kilometers. To the north and northwest, the basement is covered by Mesozoic rocks of the Inland Province, whereas to the south it ends at the Banta-Gialalassi fault.

Aquifers

30. No aquifers have been recognized in the basement system; but it may be that aquifers, at least of local significance, will be discovered in the area currently mapped by the U.N. Special Fund, Mineral and Groundwater Survey. At this stage the basement is considered as impervious, and the only aquifers are in the sandy drift that is present in depressions, wadi floors and in the colluvial deposits along the southeast margin of the province.

Chemical Quality

31. In the eastern part of the province the colluvial deposits contain brackish groundwater, but it is fresh in the Bur Acaba area. There is insufficient information to indicate if this condition continues throughout the rest of the province. It may be that the colluvial deposits contain fresh water in the central section where precipitation probably is relatively higher and recharge conditions are better.

Recharge and Groundwater Flow

32. Recharge occurs as the direct infiltration of rainfall and seepage from intermittent wadis. In the inland areas run-off from the impervious basement will concentrate in the depressions filled with drift. A minor amount of local recharge enters the area from intermittent streams that begin as springs along the Jurassic escarpment.

33. Groundwater flow in the colluvial deposits is likely towards the south into the Coastal Province. Elsewhere it probably follows the wadi beds or collects in depressions where it is extracted by means of wells or is used by vegetation.

Inland Groundwater Province

General

34. The Inland Province has an area of 107,950 square kilometers in the project area, but it extends beyond the border into Kenya, Ethiopia and the Mudugh Plain (see Map 9). It is characterized by Mesozoic sediments that rest on the basement. In the Shebelle Valley the province terminates at the Banta- Gialalassi fault, where it comes into contact with the Coastal Province.

Aquifers

35. The lowest aquifer is the Mansa Guda sandstone, but its distribution is patchy and it is only known west of the Dinsor area. It is probably hydraulically connected with the Jurassic limestone aquifers above.

36. The Jurassic aquifers are massive karstic limestones. Intervening marl formations probably act to prevent or retard flow between them. The lowest Jurassic aquifers form the escarpment in the Baidoa-Dinsor area and are separated from similar aquifers farther inland by the predominantly marl formation that outcrops to form the extensive Baidoa Plain. Faulting in these formations, by fracturing the rock, probably improved aquifer conditions locally; in some areas it may have interrupted the continuity of aquifers. The few wells existing in the limestone areas were drilled, presumably hand dug wells could be constructed in the softer marly formations.

37. In the uppermost Jurassic and Cretaceous formations the aquifers are generally thinner, culminating in the well-bedded gypsum formations. These aquifers are tapped by scattered hand dug wells.

38. The formations west of the Juba have not been drilled and it is not known whether they contain important aquifers. Many of the rocks appear to be impervious, but the formations may be good aquifers where fractured and well jointed, a condition that most likely exists in the fold belts.

39. The highest aquifer is the Jesomma sandstone formation east of the Shebelle River. This is a good aquifer, at least locally, but very few wells have been drilled into it.

Chemical Quality

40. The sampling program covered a wide area of the province, but little is known about the quality of groundwater adjacent to and west of the Juba River and in an extensive area east of Baidoa.

41. The Jurassic aquifers are characterized by fresh to slightly brackish water. The zones are high in chlorides, whereas the Cretaceous aquifers contain sulphate water, except in the Jesomma formation, where the water is fresh.

42. The fresh water in the Jurassic aquifers appears to be restricted to the inter-river area. This is known in a wide area north of Baidoa and southwest along the Baidoa Plain. It is believed that the lowest Jurassic aquifers east of Baidoa contain fresh to slightly brackish water.

43. An extensive chloride zone in the inter-river Jurassic aquifers begins west of Baidoa and widens westward towards the Juba River. The well at Tigieglo yielded water with a high chloride content. It is not known whether this is a local condition

or a condition common to the surrounding aquifers.

44. There is no evidence of fresh water in the Juba River area. Groundwater adjacent to and west of the river appears to be high in chlorides, but there may be fresh water in the lowest aquifers west of the river.

45. Water in the Cretaceous Belet Uen series and the Fer Fer gypsum, adjacent to and particularly east of the Shebelle River, has a high chloride content in addition to sulphates.

46. An exception to the general distribution of various groundwater quality factors is the water in wadi beds. In the upper Shebelle area this water is fresh, whereas the water in the underlying rock aquifers is high in sulphates.

Recharge and Groundwater Flow

47. The aquifers are recharged by the infiltration of precipitation, which appears to be at a maximum in the Baidoa area. The karstic Jurassic, and in places the Cretaceous limestones, have a surface that is ideal for receiving recharge, whereas the soils over the marl formations most likely return most of the water, which is then used by vegetation or lost as evaporation. Recharge to the well-bedded Cretaceous aquifers most likely remains at relatively shallow depths.

48. In the eastern part of the province the regional flow appears to be towards the coast. There is a seepage of groundwater into the Coastal Province northeast of Uanle Uen.

49. The discharge relation curves for the Upper Shebelle River do not indicate any substantial losses or gains from the ground during low flow periods. Small losses from Belet Uen to Bulo Burti can be accounted for by evaporation. Small gains between Bulo Burti and Mahaddei Uen may be the result of minor seepages from the Cretaceous aquifers.

50. In the western part of the province the groundwater flow appears to be towards the Juba River (see Map 7). The fresh water zones are in the faulted Baidoa Plain area and in what appears to be an east-west tear zone south of Uegit. These are probably pervious areas through which fresh water would pass from the groundwater divide area north of Baidoa. In the intervening chloride zone the chlorides increase westward towards the river.

51. Discharge relation curves for the Juba River show substantial gains in flow between Lugh Ganana and Bardera. When the flow is 10 cumecs at Lugh Ganana, the gain is of the order of 6.5 hectare meters per kilometer per month without accounting for evaporation losses. The increase in flow must be caused by a contribution from groundwater when there is no rainfall. Unlike the Shebelle Valley area, where groundwater seeps into the coastal province, in the Juba valley the inland and coastal provinces are separated by the basement, which acts as a dam to groundwater, forcing it to rise and discharge into the river. To do this, the aquifers below river grade must be saturated; it may be that there is important artesian water deep in the Jurassic aquifers below the border area. Whether or not this water is fresh, as at Baidoa, is not known.

52. Some water flows intermittently from the aquifers as springs along the escarpment.

POTENTIAL GROUNDWATER SUPPLIES

Irrigation

53. The suitability of water for irrigation depends not only on its chemical quality but also on the chemical and physical properties of the soil itself. For this reason it is not possible to set accurate standards based only on the quality of the water to be used.

54. To obtain an approximate idea of the potential water supply suitable for irrigation in this study, the maximum limits are set at a specific conductance of 2,000 mmhos. and chloride and sulphate concentrations of 200 ppm. each. These are the limits used for fresh water in this report and they are considered a maximum for most plants under most conditions, although, in this area, it is possible that sulphates in excess of this amount would not be harmful and might be beneficial.

55. Groundwater suitable for irrigation is contained in the riverine areas and littoral zone of the Coastal Province, in parts of the Jurassic karst aquifers, in the Jessomma formation of the Inland Province, and locally in drift filled depressions of the Bur Province. It is likely that only the aquifers in the Coastal Province will provide significant amounts of water for irrigation; in the other locations the quantities of water available may be sufficient only for the irrigation of small gardens.

56. In the riverine areas of the Coastal Province it has been estimated that losses to groundwater probably vary up to a maximum of 9 hectare meters per month per kilometer of channel. The maximum amount of infiltration probably takes place where the river flows over pervious materials at right angles to the direction of groundwater flow. In the project area this situation exists beneath the Shebelle River between Balad and Falcheiro. The most favourable area for development would be on the "downstream" side of groundwater flow or the coastal side of the river. Elsewhere the rivers generally follow the same direction as the groundwater flow and the seepage from the rivers is largely an underflow.

57. The amount of infiltration can be increased artificially. This is shown at Genale, where the water table rises beneath the irrigation canals (see Map 8).

58. The fresh water appears to be in equilibrium with brackish water below and, because of this, extreme care will be necessary when using it to avoid contamination of the fresh-water zone by brackish water. Already there are over 70 wells in the Genale area that are pumped to provide water for irrigation when the river is low.

59. The importance of fresh water for irrigation in the littoral zone cannot be assessed at this time. It will depend on the amount of recharge from the direct infiltration of rainfall. If most of the recharge comes from the rivers, it might be better used in the more fertile flood plain area.

60. It appears that the most important role of groundwater in the future will be to supplement river water and extend the irrigation season. Detailed studies involving geophysics, test drilling and pumping and an observation well program will be required to provide an accurate assessment of any irrigation schemes where the use of groundwater is contemplated.

Livestock

61. The upper limits of dissolved solids tolerated by livestock suggested by various researchers in this field vary from 5,000 ppm to 15,000 ppm, but in practice concentrations lower than the limits of tolerance would be preferable. It is claimed also that high concentrations of sodium, magnesium and sulphate in highly mineralized waters are undesirable.

62. In this report fresh and slightly brackish water with a specific conductance less than 5,000 mmhos is considered desirable; brackish water with a specific conductance between 5,000 and 10,000 mmhos is considered tolerable; water with a specific conductance greater than 10,000 mmhos and with more than 2,000 ppm of chloride or sulphate is considered undesirable. Sodium and magnesium concentrations were not determined by analyses, but it has been assumed that water with a high chloride content will have a high sodium content.

63. In general, the most favourable groundwater supplies for livestock are available in the Shebelle Flood Plain and Coastal regions and the Jurassic limestone and Jesomma sandstone aquifers of the Inland Province. Groundwater conditions are poor in the Lower Juba area and doubtful in the Eluviated Plain Region where the carrying capacity of the range is high.

64. The following is a summary by natural regions of the groundwater conditions and potential in the rangelands (see Maps 6 and 9).

Mandera-El Wak Uplands

65. Water at present obtained from dug wells in the valley bottoms is apparently brackish. Test drilling may prove other sources of tolerable water from the Jurassic and Cretaceous aquifers, particularly in the syncline north of Garba Harre, but this water may be high in chlorides. The lowest Jurassic aquifers at depth might contain slightly brackish water.

Upper Juba Valley

66. Most areas are within range of the river. Limited supplies of tolerable ground water may be obtained from drilled and dug wells, but this will be high in sulphates and probably high in chlorides.

Central Uplands Plain

67. Tolerable groundwater supplies may be obtained throughout most of the region. The most desirable water is in the Jurassic aquifers, with the exception of the undesirable chloride zone west of Baidoa. High sulphates in the Cretaceous aquifers, chlorides in the Jurassic aquifers adjacent to the Juba River and near the Cretaceous aquifers to the east make water less desirable. The water may be obtained by means of drilled wells and locally in the Cretaceous aquifers by dug wells. The construction of "uars" on the impervious Baidoa Plain to augment groundwater supplies would be good conservation practice.

Upper Shebelle Valley

68. Groundwater is tolerable and in places desirable, except in the Debi Adle area west of Bulo Burti, where it is undesirable. Tolerable water may be found at depth in the Jurassic aquifers, but it would be hard to justify deep drilling in an area where the carrying capacity of the range is so low. Limited supplies of desirable water are available in the beds of intermittent wadis.

Mudugh Plain

69. Desirable water supplies can be obtained from the Jesomma sandstone by means of drilled wells.

Bur Region

70. Desirable to tolerable water can be obtained locally from drift filled depressions and wadi floors by means of shallow wells.

Eluviated Plain

71. In general, groundwater conditions in this region appear to be poor. Several wells drilled in the eastern section west of Uanle Uen were abandoned because of high salinity. Limited amounts of tolerable water might be obtained from the colluvial deposits beneath and adjacent to intermittent wadis.

Marine Plain

72. Tolerable water can be obtained from drilled wells, but in places, particularly west of the Juba River, high chlorides make the water unsuitable except for camels. The water table is below sea level in an extensive area west of the Juba River. This indicates poor recharge conditions that will limit the quantity of water available. Fresh or slightly brackish water might be available in perched aquifers beneath desceks and intermittent wadis and adjacent to the Coastal region. The surface in this region generally is suitable for the construction of "uars".

Lak Dera Plain

73. Conditions are similar to those in the Marine Plain region but limited quantities of desirable fresh water are known in perched aquifers beneath and adjacent to intermittent wadis. Much of the surface material is pervious but conditions are suitable for the construction of "uars" locally.

Shebelle Flood Plain

74. Tolerable water supplies can be obtained by means of drilled wells. In the extreme eastern section, in the area near Uanle Uen and perhaps in the area north of the Shebelle River downstream from Afgoi, high chlorides and sulphates make the water undesirable. Desirable fresh water is available adjacent to the river. The surface generally is suitable for the construction of "uars".

Lower Juba-Shebelle Flood Plain

75. Conditions are similar to those in the Marine Plain region. In areas close to the river where desirable fresh and slightly brackish water can be obtained, the tsetse fly is a problem.

Fafadun Plain

76. Test drilling may prove the existence of useable quantities of fresh to slightly brackish water in the Jurassic limestones. In the southern part of the region, conditions probably are similar to those in the adjacent Eluviated Plain region.

Dudumali Plain and Coastal Region

77. Fresh to slightly brackish water is present throughout most of this region. Care will be necessary not to over-pump along the coastal flanks and where the region is narrow, otherwise the fresh water zone probably will be contaminated with brackish water from below; in more serious cases an invasion of sea water will take place.

Public Supply

78. In most of the project area the dissolved solid content in both present and potential groundwater supplies is greater than the maximum allowable concentrations generally accepted for drinking water.

79. Most of the larger settlements are near the rivers or along the coast where potable water supplies can be obtained.

80. Wells or infiltration galleries constructed near the rivers would make available naturally filtered river water; where this is not possible, a high standard of public health can be maintained only by treating the raw river water.

81. Coastal settlements can generally obtain potable water from wells, but these should be drilled well away from the coastal fringe. Where heavy withdrawals are anticipated, it will be necessary to plan well fields very carefully to avoid contamination by underlying brackish water and an invasion of sea water. The feasibility of using this source for Mogadiscio is being studied already by U.S.A.I.D. For Kismayu, where the conditions are not as favourable for groundwater supplies, treated Juba River water would be the best supply.

82. An adequate groundwater supply under present conditions is the reason for the locations of the inland villages and towns. Individual exploration programs will be necessary to determine the amount of water that can be made available in the future for each of the settlements.

Planning the Use of Potential Groundwater Supplies

83. Groundwater is in a dynamic condition moving through the ground from areas of recharge to areas of discharge. This natural movement is upset when water is withdrawn by means of wells, and withdrawal in one area may interfere with established interests or future plans elsewhere.

84. Specific conditions of this kind are foreseeable at Balad, north of Uanle Uen and at Baidoa. If most of the groundwater in the littoral zone comes from the Shebelle River, withdrawals of large quantities of groundwater for irrigation or any other use near Balad would deplete the supply available to Mogadiscio. Similarly the withdrawal of water from the Jurassic aquifers north of Uanle Uen would diminish the supply available in the flood plain to the south. At Baidoa, the water supply available to the town would be in jeopardy if large quantities of water were withdrawn to the north.

85. The conditions cited all involve possible conflicts of interest and illustrate the need for planning the use of groundwater on a regional scale.

RECOMMENDATIONS FOR GROUNDWATER DEVELOPMENT

86. The work involved in the following recommendations should be supervised by a qualified hydrogeologist. Recommendation (b) would be carried out best in the form of a project.

Water Resources Inventory

87. The collection of basic hydrogeological information should continue and should be expanded to include the following:

(a) Observation wells drilled and equipped to record the fluctuation of water levels in well fields and under natural conditions.

(b) Records of water levels and pumpage at all producing wells. This would include equipping the wells with meters and air lines. Regular readings should be taken by men from a regional or central office where the well operator is incapable.

(c) All existing wells should be adequately test pumped before the pump is installed, or when the well is rehabilitated, and all new wells should be test pumped.

(d) The precise elevations of wells, particularly observation wells, should be determined wherever possible. In fact, wells make the best possible bench marks.

88. This program should be most intensive where the development of one area might be detrimental to another.

Development of the Shebelle Flood Plain and Coastal Region

89. A detailed study of the Shebelle Flood Plain and the adjacent Coastal region should be carried out to determine how much water is available for irrigation and other uses, and by how much this can be increased.

90. Investigations should be concentrated mainly from the river between Balad and Falcheiro down to the coast between Mogadiscio and Merca, bearing in mind that the main uses anticipated will be agricultural in the flood plain area and munioipal along the coast.

91. Specifically the investigations should be set up to determine the following:

(a) The amount of infiltration from various sections of the river.

(b) The amount of recharge from the direct infiltration of precipitation.

(c) The thickness of the fresh water zone. A contour map is required of the interface between fresh and brackish water where development seems most feasible.

(d) Areas with the most favourable aquifer conditions.

(e) The most favourable areas for artificial recharge and the best method of artificial recharge under the prevailing conditions.

(f) The design of well fields that will permit the optimum and most economical use of water and avoid contamination of the fresh water zone.

92. The investigations would involve extensive test drilling, test pumping, geophysical studies, topographic mapping and an observation well program. In addition, a detailed study of the amount and distribution of rainfall would be required. An estimate of the cost, equipment and personnel required for these investigations is given in Volume 2 of the main report.

Reconnaissance Test Drilling

93. Reconnaissance test drilling should be carried out in areas about which little is known. These are as follows:

(a) In the Jurassic limestone formations between the Bur Province and the Shebelle River, in the vicinity of El Adde and Missarole.

(b) In the Jurassic limestones and Mansa Guda formations west of the Juba River.

(c) In the syncline north of Garba Harre.

(d) In the Upper Tertiary deposits between the Shebelle River and the Banta-Gialalassi fault in the vicinity of the Dinsor-Brava road and Bohol Madagoi.

(e) A deep test to the Jurassic aquifers north of Uegit.

Development of the Rangelands

94. More wells should be drilled for livestock in those areas where water quality is suitable. As part of the inventory program, records of the water levels and pumpage should be kept and studied regularly to avoid an overdraft. The estimated cost of materials for each well including casing, pump, motor, well house, water tank piping meters and valves is So.Sh. 42,000 for wells in the Jurassic limestones, and So. Sh. 50,000 for wells in the unconsolidated materials in the flood plain and littoral zone areas. Wells in the latter areas would be more costly because of the extra casing and screen required. The drilling of the wells and installation of equipment would be in addition to the above estimates.

95. In the Bur Province a seismic survey would be a rapid way of establishing the extent and thickness of saturated drift in depressions.

Municipal Water Supplies

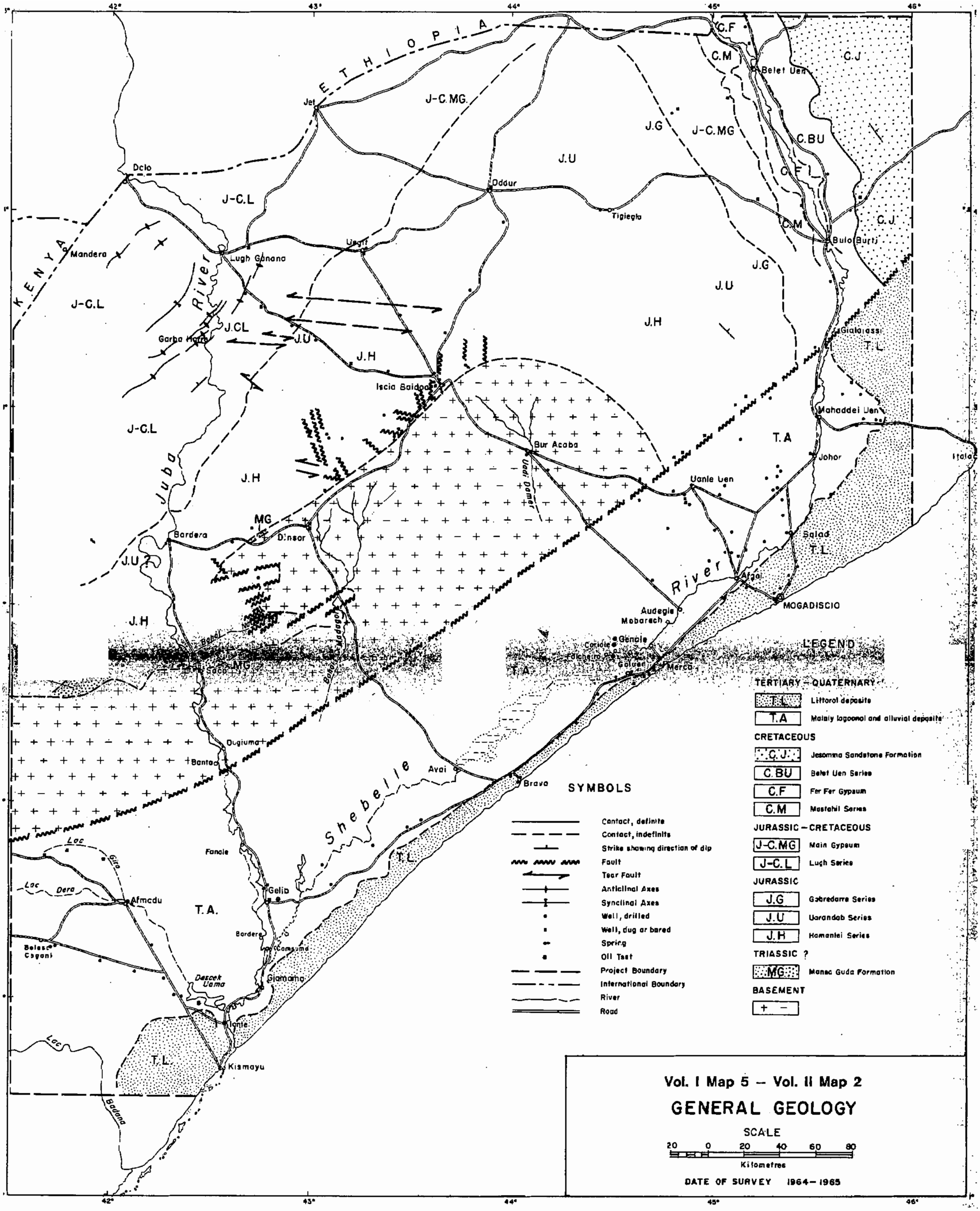
96. Test drilling should be carried out and observation wells set up at the main towns and villages to establish the amount of groundwater available for future use.

Well Construction

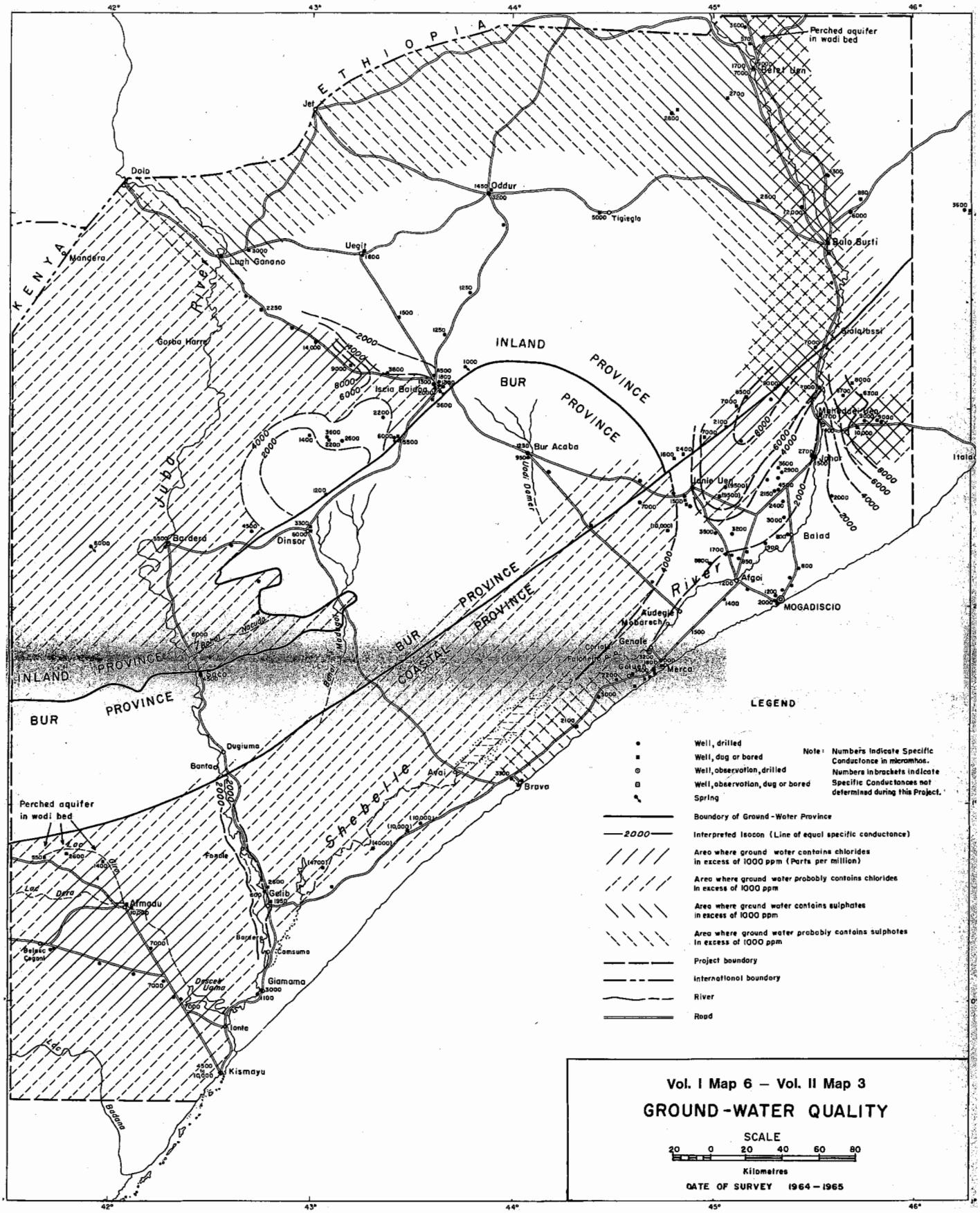
97. More attention should be paid to the sanitary construction of wells and to the selection of materials and equipment to suit local conditions. Specifically this would involve placing sanitary seals and grouting at the well head, sealing off polluted aquifers, mechanical analysis of aquifer materials to select the most efficient screen and selection of the most efficient pump, bearing in mind the head and yield required.

Water Law

98. The water law prepared with the assistance of F.A.O. should be passed by Parliament and regulations regarding well construction and the use of water should be made and enforced immediately.



ETHIOPIA
KENYA
LEGEND
TERTIARY – QUATERNARY
T.L Littoral deposits
T.A Mainly lagoonal and alluvial deposits
CRETACEOUS
C.J. Jesomma Sandstone Formation
C.BU Belet Uen Series
C.F Fer Fer Gypsum
C.M Mustahil Series
JURASSIC – CRETACEOUS
J-C.MG Main Gypsum
J-C.L Lugh Series
JURASSIC
J.G Gabredarre Series
J.U Uarandab Series
J.H Hamanlei Series
TRIASSIC ?
MG Mansa Guda Formation
BASEMENT
SYMBOLS
Contact, definite
Contact, indefinite
Strike showing direction of dip
Fault
Tear Fault
Anticlinal Axes
Synclinal Axes
Well, drilled
Well, dug or bored
Spring
Oil Test
Project Boundary
International Boundary
River
Road
Vol. I Map 5 – Vol. II Map 2
GENERAL GEOLOGY
SCALE
Kilometres
DATE OF SURVEY 1964–1965



Vol. I Map 6 – Vol. II Map 3

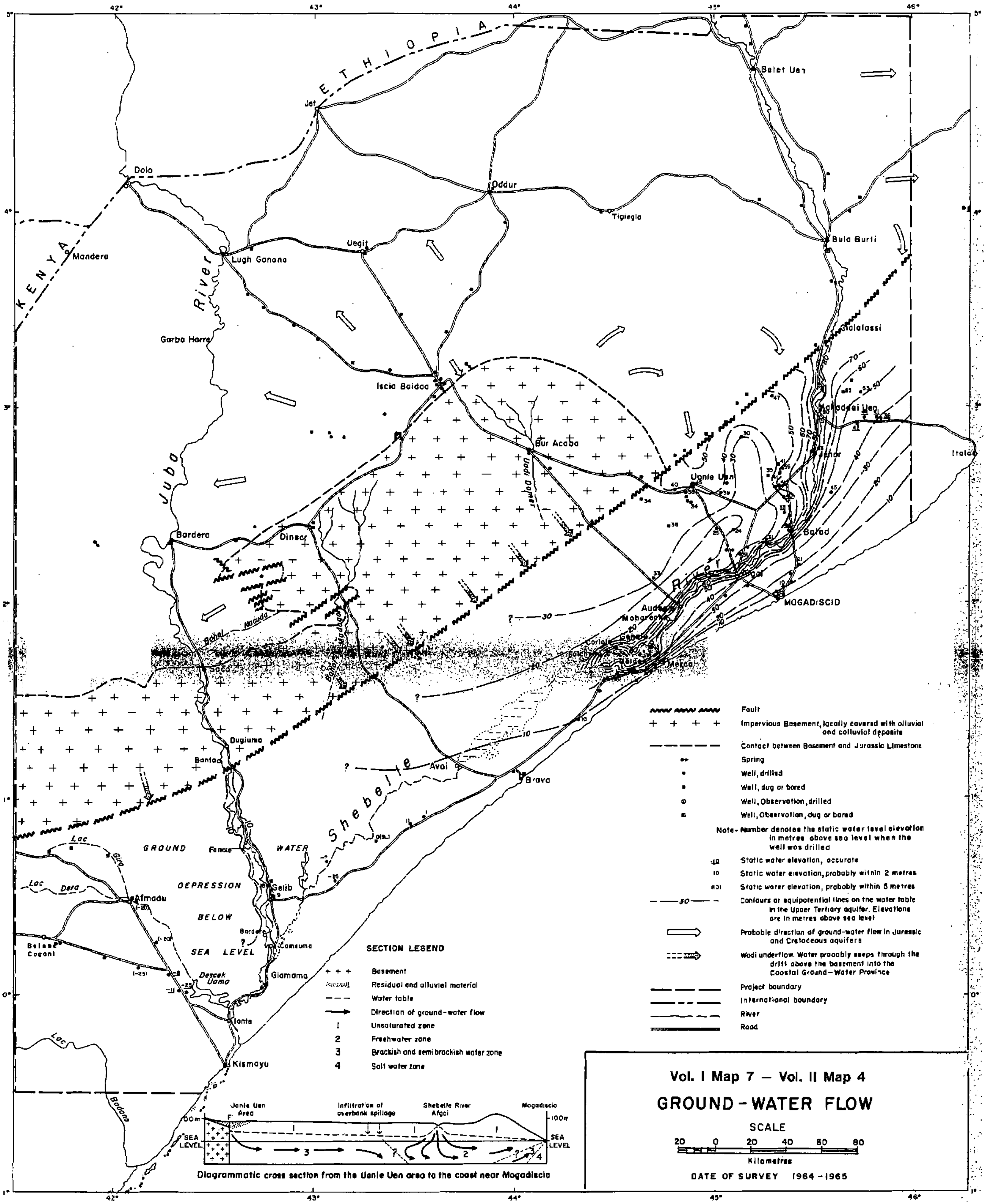
GROUND-WATER QUALITY

SCALE

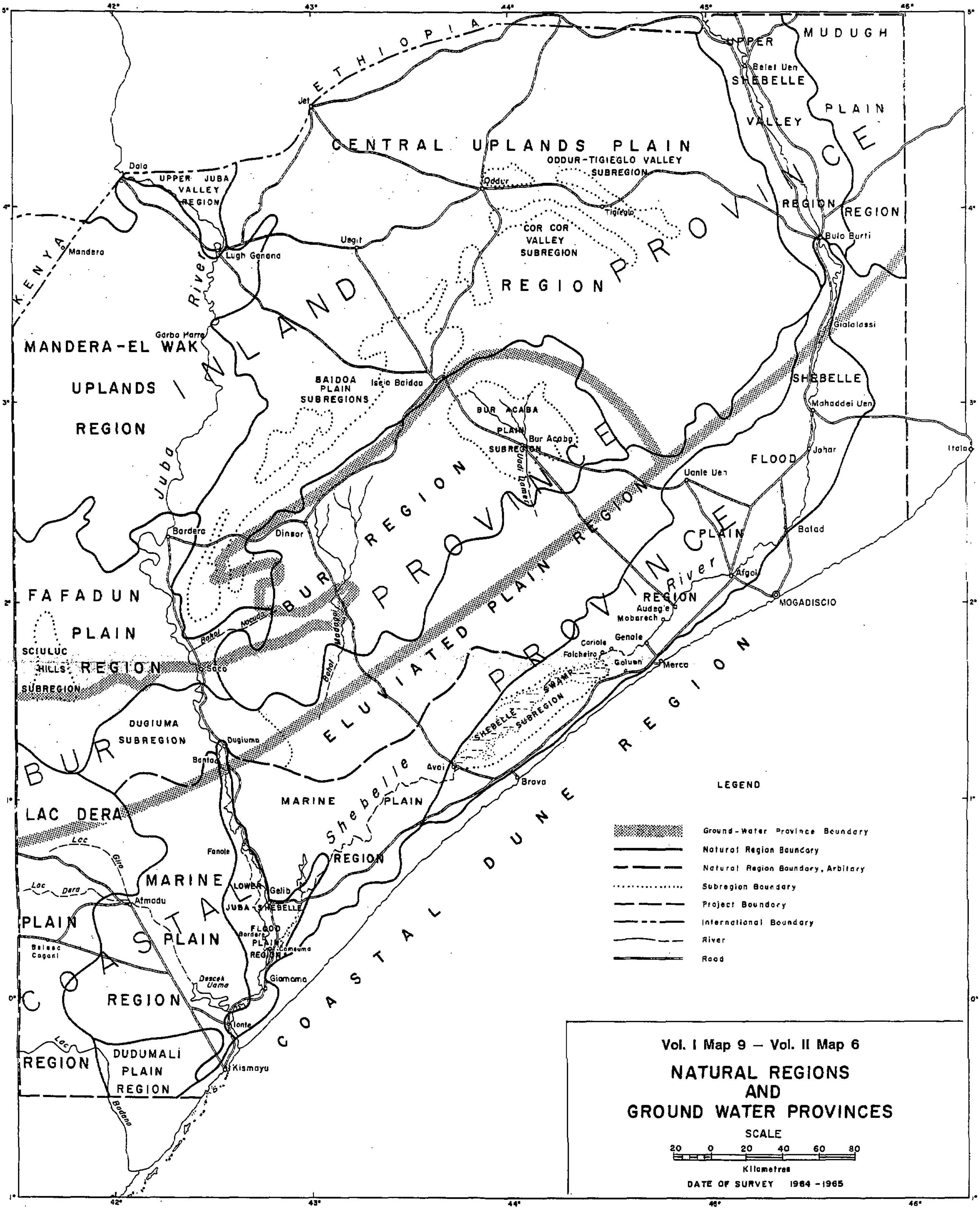
20 0 20 40 60 80

Kilometres

DATE OF SURVEY 1964 – 1965

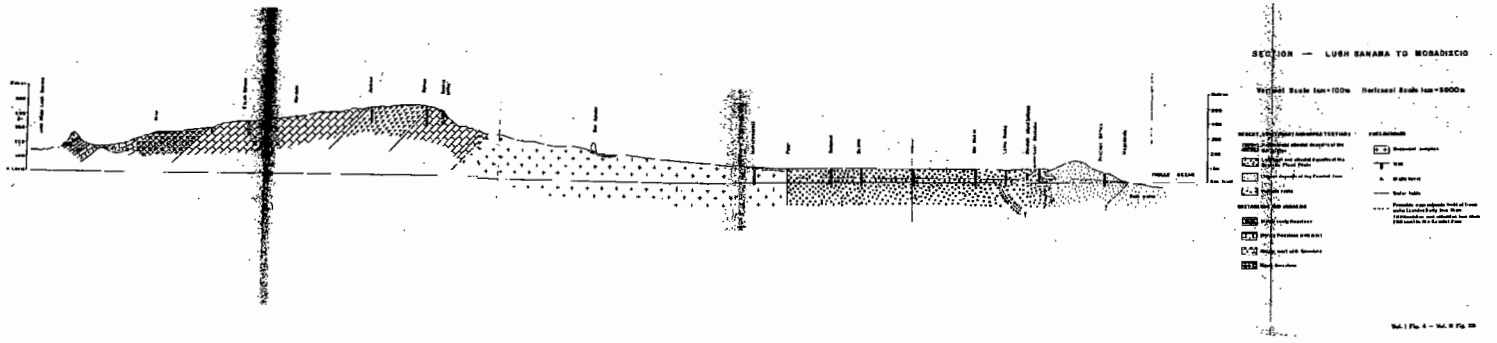

ETHIOPIA
KENYA
Belet Uen
Jet
Dolo
Oddur
Tigieglo
Mandera
Lugh Ganana
Uegit
Bulo Burti
Garba Harre
Juba River
Iscia Baidoa
Bur Acaba
Uanle Uen
Italaa
Bardera
Dinsor
Balad
MOGADISCIO
Audegle
Merca
Brava
Avai
Shebelle
Dugiuma
Bantac
Famale
Gelib
Afmadu
GROUND WATER DEPRESSION BELOW SEA LEVEL
Giamama
Ionte
Kismayu
Fault
Impervious Basement, locally covered with alluvial and colluvial deposits
Contact between Basement and Jurassic Limestone
Spring
Well, drilled
Well, dug or bored
Well, Observation, drilled
Well, Observation, dug or bored
Note- Number denotes the static water level elevation in metres above sea level when the well was drilled
Static water elevation, accurate
Static water elevation, probably within 2 metres
Static water elevation, probably within 5 metres
Contours or equipotential lines on the water table in the Upper Tertiary aquifer. Elevations are in metres above sea level
Probable direction of ground-water flow in Jurassic and Cretaceous aquifers
Wadi underflow. Water probably seeps through the drift above the basement into the Coastal Ground-Water Province
Project boundary
International boundary
River
Road
SECTION LEGEND
Basement
Residual and alluvial material
Water table
Direction of ground-water flow
1 Unsaturated zone
2 Freshwater zone
3 Brackish and semibrackish water zone
4 Salt water zone
Uanle Uen Area
Infiltration of overbank spillage
Shebelle River Afgoi
Mogadiscio
SEA LEVEL
Diagrammatic cross section from the Uanle Uen area to the coast near Mogadiscio
Vol. I Map 7 — Vol. II Map 4
GROUND-WATER FLOW
SCALE
Kilometres
DATE OF SURVEY 1964-1965


LEGEND
BRACKISH
UPCOMING WATER
Shebelle
River
Merca
INDIAN
OCEAN
Vol. I Map 8 — Vol. II Map 5
GROUND-WATER LEVELS AND QUALITY
GENALE-BULO MERERTA AREA
SCALE
Kilometres
DATE OF SURVEY 1966 - 1968



Vol. I Map 9 – Vol. II Map 6

NATURAL REGIONS AND GROUND WATER PROVINCES


SECTION — LUSH SANABA TO MOGADISCIO

CHAPTER 7

SURFACE WATER

PURPOSE AND SCOPE

1. The purpose of this survey was to assemble information on the main water courses to determine the quantity and quality of water and to train Somali personnel in river gauging and sampling.

2. Use was made of existing data and reports made available by the Government, but more reliability was attached to the new information obtained as part of this survey during the years 1963 to 1965 inclusive.

3. Ten permanent river gauging stations were established early in the project. Six of these were equipped with automatic water level recorders. During the course of the survey the rivers were metered and sampled regularly, although sediment sampling was done only in the last six months. The chemical analyses were done utilizing a Hach DR-EL portable laboratory, and specific conductance determinations were made by U.S.A.I.D. at their laboratory in Afgoi.

RIVER BASINS

4. The Shebelle and Juba rivers occupy the only large drainage basins in Somalia. Other watercourses, though locally important for water supplies, are comparatively small and generally intermittent (see Map 10).

5. Both the Shebelle and Juba rivers rise along the eastern slopes of the eastern plateau of Ethiopia, approximately 1,000 kilometers inland from the Indian Ocean.

6. The areas of the drainage basins are estimated at 300,000 square kilometers for the Shebelle and 275,000 square kilometers for the Juba, but most of the effective drainage takes place in the upper reaches of the basins. In Somalia and the arid border zone of Ethiopia, contribution is limited to a relatively narrow zone adjacent to the rivers. The flow in small watercourses is diminished by infiltration and evaporation to such an extent that it ceases before reaching the main rivers.

7. In the highland area of Ethiopia, where most of the flow originates, the drainage areas of the two rivers appear to be similar, with that of the Shebelle perhaps slightly larger than that of the Juba; yet the flow in the Juba is more than twice that in the Shebelle. This can be explained only by differences in precipitation and/or in the run-off coefficients. There is insufficient data on precipitation in the Upper Juba basin of Ethiopia to compare it with the Shebelle basin, but geological maps indicate that the headwater tributaries of the Juba flow on the basement, which presumably is impervious, whereas the head water tributaries of the Shebelle probably are influent over sedimentary rock.

THE SHEBELLE RIVER

Physical Description

8. The Uebi Shebelle rises in the high plateau of eastern Ethiopia. Its tributaries drain the eastern slopes of this plateau from Dodola in the southwest to the area east of Harar, a distance of over 500 kilometers.

9. The drainage basin is between 900 and 1,000 kilometers long, extending from the Harar Plateau to the Indian Ocean. Its area has been estimated at 300,000 square kilometers, of which 90,000 square kilometers is within Somalia. This has no real significance, particularly in Somalia and the border area of Ethiopia, where tributary streams are short and intermittent and the river is known to be influent, at least in the reaches downstream from Gialalassi.

10. From the Harar Plateau the river flows in a general southeast direction for about 700 kilometers before entering Somalia at Fer-Fer about 31 kilometers north of Belet Uen (see Fig. 5).

11. Within Somalia the river traverses a distance of approximately 630 kilometers before the last significant traces of it disappear about 30 kilometers east of the Juba River and about the same distance from the ocean. The length of the channel within Somalia is approximately 1,100 kilometers.

12. With minor exceptions, the river receives no contribution within Somalia; the discharge decreases progressively downstream, the flow being reduced by evaporation, infiltration, use and by overbank spilling when the stage is high.

13. From the border to the area between Bulo Burti and Gialalassi, a distance of about 150 kilometers, the river flows south-southeast in a wide valley over, and generally parallel to, the strike of Cretaceous formations. The channel is 50 meters wide at Belet Uen and 45 meters wide at Bulo Burti.

14. The river flows southwest from the area south of Bulo Burti as far as Balad. The hills that form the upstream valley gradually disappear in the vicinity of Bulo Burti, and at Gialalassi the river enters a broad flood plain underlain by deep alluvial deposits. The flood plain is 50 to 60 kilometers wide downstream from Mahaddei Uen. At this point the river is approximately at the centre, at Balad it is at the extreme eastern limit of the flood plain.

15. At Balad the river is forced, by a coastal ridge of littoral deposits, to flow south-southwest, parallel to the coast. The width of the channel continues to decrease and is only 35 meters at Audegle.

16. At Falcheiro, downstream from Coriole, the nature of the river changes entirely. The single well-defined channel is replaced by a network of small channels and ponds that form approximately 61,800 hectares of swamp land. The swamp varies in width from 1 to 10 kilometers and ends about 8 kilometers upstream from Avai, where a single channel is again formed, about 20 meters wide.

17. Beyond Avai the small channel continues towards the Juba River, but is scarcely defined in the final reaches. Flow may end anywhere after Avai and only when flows are unusually high, as in 1961, does the Shebelle actually reach the Juba. This takes place near Camsuma (see Map 10).

River Flow

18. The flow of the Shebelle River is torrential ranging from less than 10 to over 270 cumecs at Belet Uen. This is illustrated in Figure 6, which contains hydrographs for the Shebelle River for the years 1961 to 1965. It can be seen that high flows of short duration occur in April to May and of longer duration from August to December. The higher flows generally are experienced in the latter period, but this is not always the case. At Belet Uen, in 1963, the first peak reached 250 cumecs, as compared to a little more than 170 for the second peak. The peaks are not attained at the downstream stations because of overbank spillage.

19. The low flow period, when the flow is less than 10 cumecs, occurs between December and May. It generally occurs over a period of more than two months, but it can last as long as five months, or take less than two weeks. The relevant periods for the years 1925 to 1963 are illustrated diagramatically in Figure 10.

20. The flow decreases progressively downstream, as shown in Figures 6 and 8, and by the maximum recorded discharges and channel capacities at the various gauging stations given below:

	Max. Recorded Discharge, Cumecs	Approx. Channel Capacity, Cumecs
Belet Uen	281	350
Bulo Burti	276	310
Mahaddei Uen	130	140
Balad	93	105
Afgoi	93	110
Audegle	80	90

21. Exceptions to the general downstream decrease in flow are caused by local rainstorms, by local exfluent groundwater and by the return of overbank spillage to the channel.

22. The median monthly total flow passing gauging stations and the changes in this flow between stations are shown in Tables 2 and 3.

23. In the section between Belet Uen and Bulo Burti there are water losses in most months. These are highest when the river stage is high and overbank spillage takes place. The small gains, which more than offset evaporation losses in January, can be attributed only to an inflow of groundwater, probably from wadi beds and bank storage; whereas the higher but still small-gains in March are the result of surface run-off.

24. From Bulo Burti to Mahaddei Uen losses occur throughout the year except in June. The increase in flow during June is probably the result of a return to the river of some of the overbank spillage that occurred in the previous month. The channel losses from January to April appear to be offset slightly by subsurface inflow, provided no overbank spillage takes place, as sometimes happens in April.

25. The losses in the stretch from Mahaddei Uen to Balad are high and occur every month, the highest occuring in May and from August to November, when the river stage is high and overbank spillage takes place. The spillage is aggravated by a weir at Johar which was constructed to raise the water level and allow water to flow by gravity to a sugar plantation. Embankments that were constructed upstream from the weir are damaged through lack of maintenance and are now totally ineffective (see Map 17).

26. The channel from Balad to Afgoi is unique in that it is capable of carrying, without overbank spillage, all the water that enters at Balad. Consequently, the losses are relatively low.

27. From Afgoi to Audegle the flows, as tabulated, show that there is normally a slight increase between these two stations in the period January to July, except in May, when overbank spillage occurs. This is not the result of rainfall and surface run-off, and must be ascribed to subsurface flow. No measurements of water passing the control gates at Falcheiro have been made, hence the natural losses and the water used by controlled and inundation irrigation downstream of Audegle are not known. Water will pass into the swamps below Falcheiro when the stage is high and when irrigation requirements are only a fraction of the flow. In the period January to early April and in June and July, very little water, if any, will pass. It has been esti-

mated, on the basis of orop requirements, that the reduotion in flow in the median year is approximately 40,000 hectare meters, whereas the total flow in the median year is approximately 110,000 hectare meters.

28. Careful examination of the channel at Avai indicates that the outflow from the swamps never reaches the high rates of inflow that are often maintained for many weeks at Faloheiro from September to December. It may be safely assumed that the total annual inflow to the swamps is greater than the outflow. However, outflow is always maintained, although inflow often ceases entirely for a month or two. It is likely that most of the losses from the swamps are due to evapotranspiration. Some infiltration may take place, but it is thought that the floor is relatively impervious, and the swamps are perched above the water table.

29. The distance beyond Avai along which flow takes place depends upon the amount of flow upstream.

30. Monthly flow frequencies expressed as the percentage of times that the monthly flow values are equalled or surpassed at the various stations. These are tabulated in Volume 2.

Water Quality

31. The Shebelle River water carries more dissolved solids than does the Juba. Values of specific conduotance, which generally are less than 1,500 micromhos, vary from less than 500 up to 4,000 micromhos. The high values occur after a long, dry spell when the first rains wash the soluble materials that have accumulated along the land surface into the river.

32. Sulphates vary from 100 to 600 ppm., but the high values do not necessarily correlate with high chlorides and specific conduotanoe. The relatively high sulphates probably arise from dissolved gypsiferous rocks upstream.

33. Sediment samples were taken at various stations along the river during the latter part of the survey. The sediment concentrations measured during 1965 are listed in Table 6.

34. The swamps act as a huge settling basin for the suspended load of the Shebelle River. The river is very turbid down to Falcheiro, but the outflow from the swamps at Afai is virtually clear.

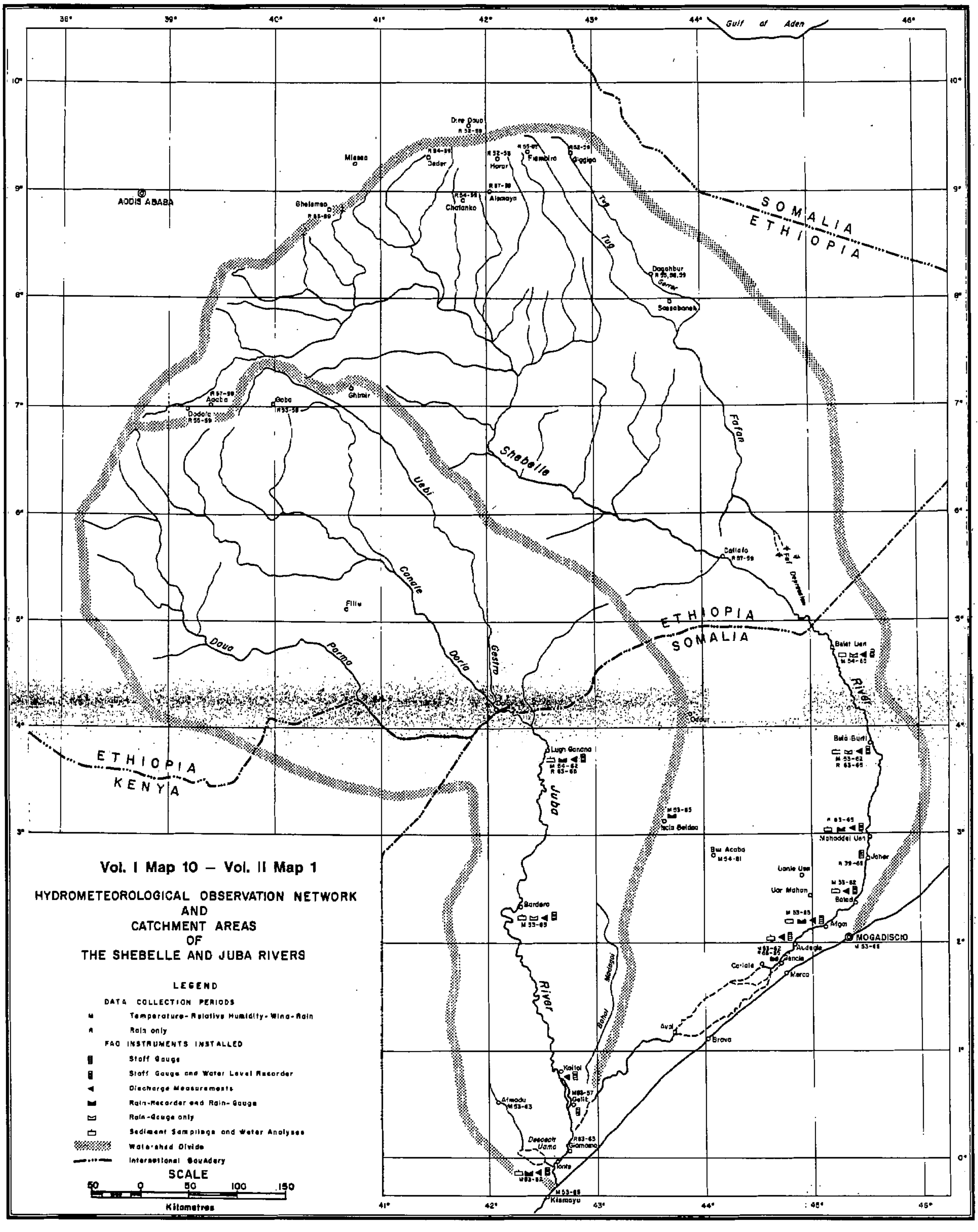
THE JUBA RIVER

Physical Desoription

35. The Juba River rises in the eastern plateau of Ethiopia immediately south of the Shebelle basin. Three main tributary streams drain the eastern slopes of this plateau for a distance of about 300 kilometers southeast of the Dodola-Goba area. The Uebi Gestro and the Canale Doria unite to form the Juba River at Dolo, having formed the Kenya-Ethiopia border and the Somalia-Ethiopia border in the area west of Dolo.

36. The drainage system is about 900 kilometers long from the plateau to the Indian Ocean. Its area has been estimated at 275,000 square kilometers, 98,000 of which are within Somalia; but like the Shebelle River the effective surface drainage basin is limited to the head waters and a narrow zone adjacent to the river. Groundwater that apparently discharges into the upper stretches of the river within Somalia may have flowed a considerable distance through the ground, but in the lower reaches the river is influent.

37. The tributary rivers generally flow towards the southeast, and, after uniting to form the Juba River, this direction is maintained into Somalia as far as Lugh Ganana,

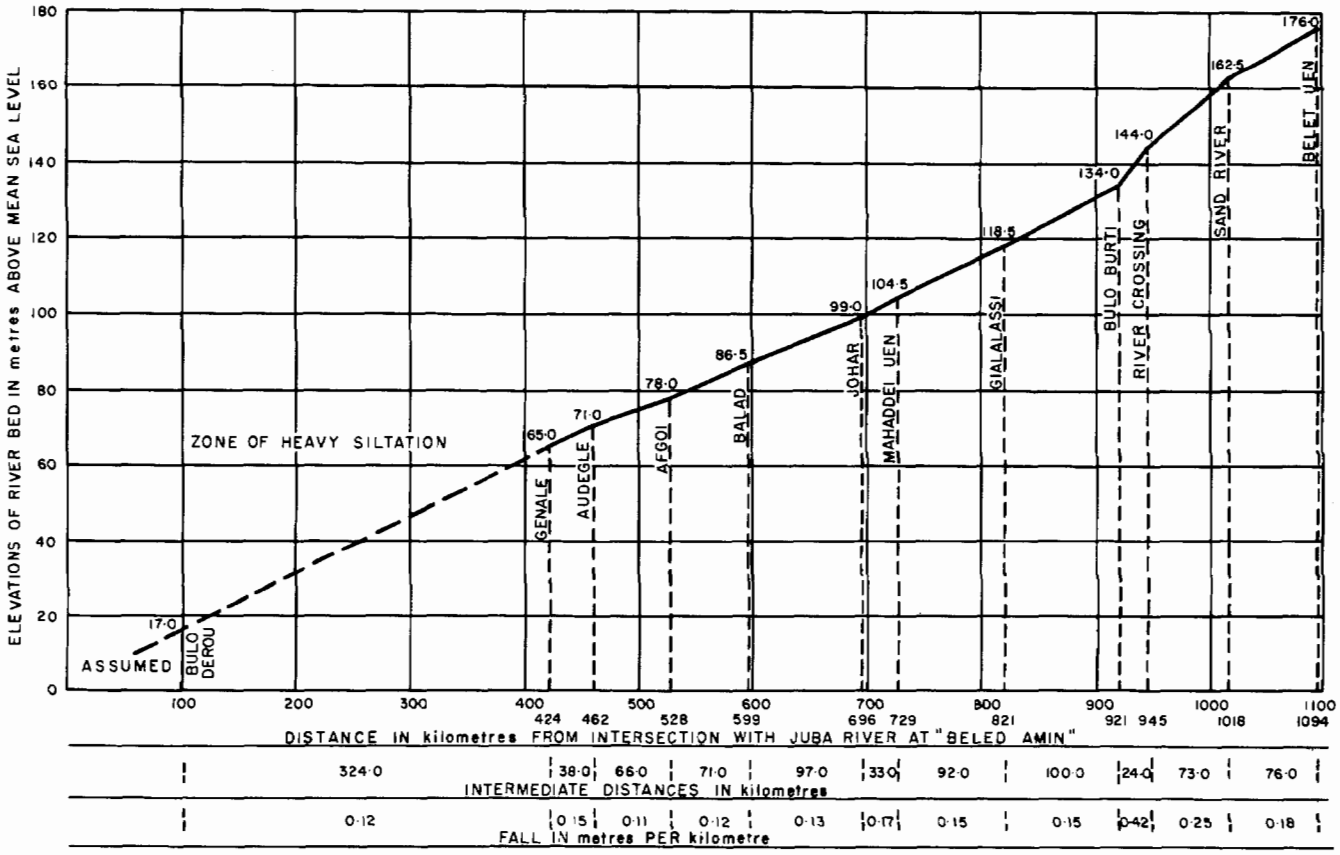


Vol. I Map 10 – Vol. II Map 1

HYDROMETEOROLOGICAL OBSERVATION NETWORK AND CATCHMENT AREAS OF THE SHEBELLE AND JUBA RIVERS

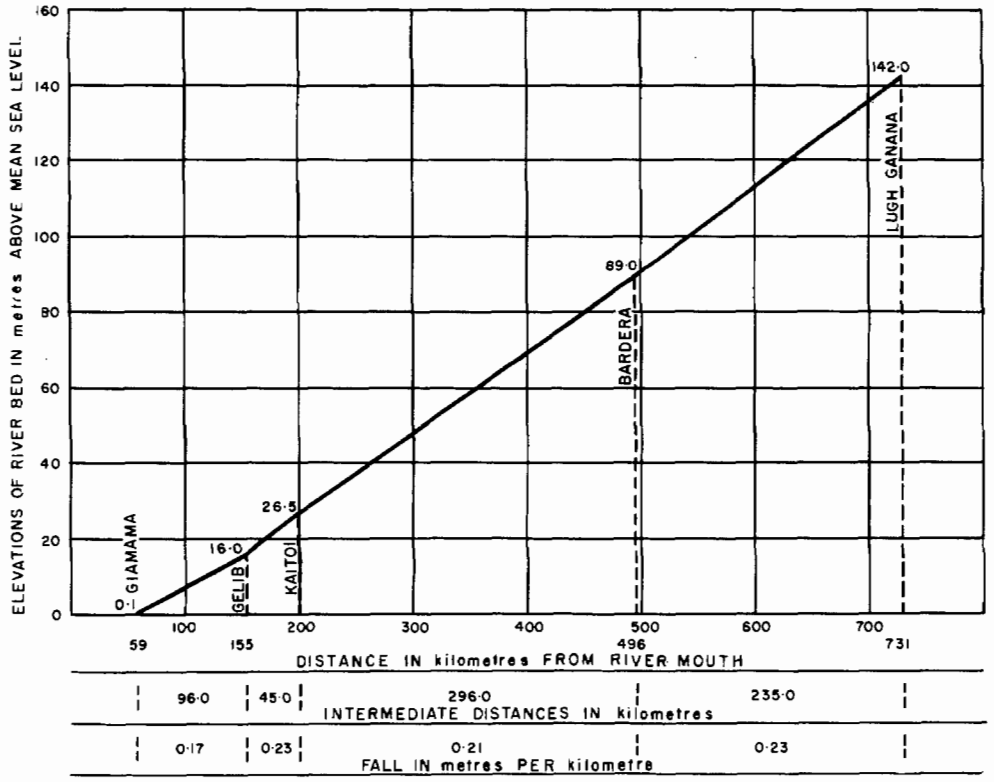
PROFILE OF THE SHEBELLE RIVER COURSE

FROM JUBA INTERSECTION TO BELET UEN

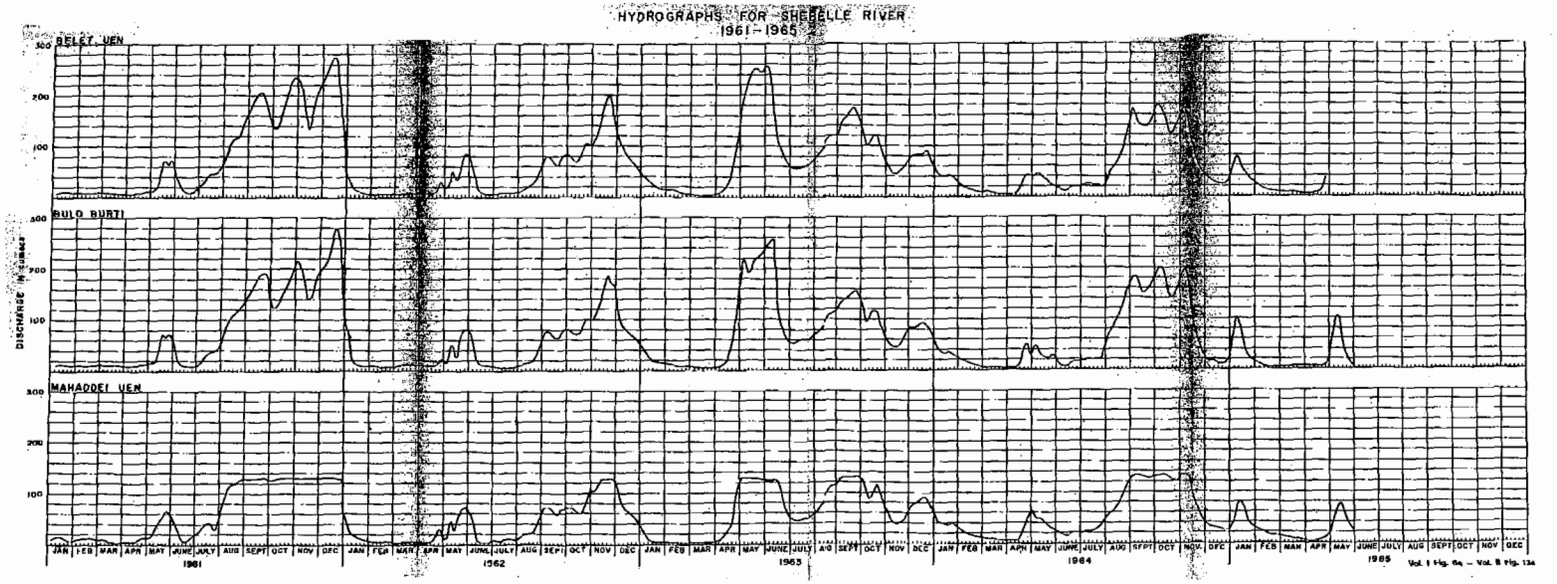


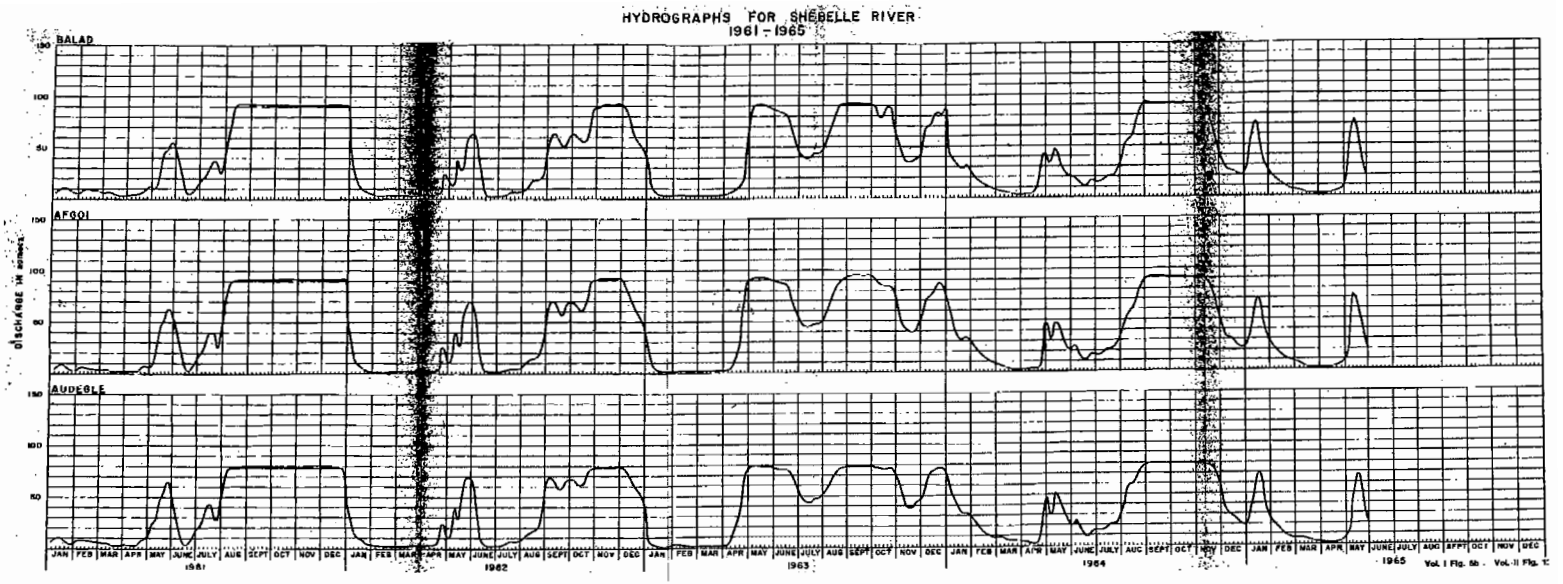
PROFILE OF THE JUBA RIVER COURSE

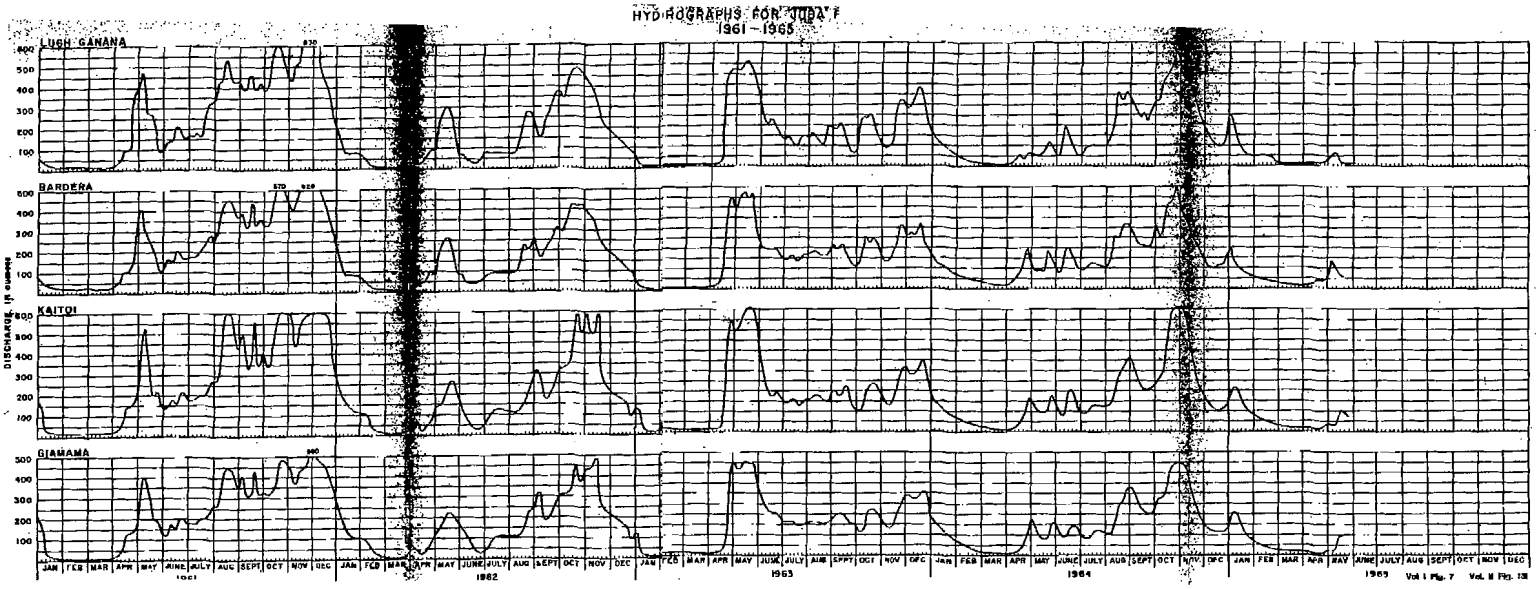
FROM THE MOUTH TO LUGH GANANA



Vol. I Fig. 5 — Vol. II Fig. 10


HYDROGRAPHS FOR SHEBELLE RIVER
1961 - 1965
BELET UEN
BULO BURTI
MAHADDEI UEN
DISCHARGE M³/SEC
300
200
100
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1961
1962
1963
1964
1965
Vol. I Fig. 64 — Vol. II Fig. 134


HYDROGRAPHS FOR SHEBELLE RIVER
1961 - 1965
BALAD
AFGOI
AUDEGLE
DISCHARGE IN CUSECS
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1961
1962
1963
1964
1965
Vol. I Fig. 5b . Vol. II Fig. 1


HYDROGRAPHS FOR JUBA F
1961 – 1965
LUGH GANANA
BARDERA
KAITOI
GIAMAMA
DISCHARGE, in cumecs
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1961
1962
1963
1964
1965

NTHLY FLOW DIAGRAM (SHEBELLE RIVER)

STATION **BELET UEN**

RCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	YEARLY FLOW IN 1000 Ha/m
1·5	2·1	12·3	2·8							
1·8	6·0	8·7	4·2	6·2	32·9	41·1	41·9	25·2	7·9	190·1
2·1	15·7	62·9	32·5	16·6	29·0	41·0	26·6	14·2	21·3	272·5
1·9	3·5	15·8	4·6	2·4	8·3	19·6	23·7	40·7	20·0	146·5
2·1	2·4	14·1	3·9	12·4	32·9	47·7	51·0	49·5	56·7	278·0
2·4	5·1	17·7	10·0	4·5	11·0	22·8				
2·0	1·9	19·7	5·7	3·2	20·6	37·0	32·8	29·0	5·9	162·1
12·0	5·3	16·9	2·8	3·7	31·5	41·7	45·6	21·1	4·5	192·1
5·4	15·5	49·5	27·5	13·9	33·3	38·8	14·1	14·6	11·3	228·9
2·5	8·6	52·3	7·6	6·8	26·5	39·1	38·2	46·1	7·9	241·7
2·4	2·5	11·8	3·3	2·0	8·0	25·3	36·3	11·0	2·3	108·8
2·7	23·1	15·8	6·6	1·8	27·4	39·7	51·0	19·9	9·3	202·5
2·1	2·1	23·4	6·1	2·7	7·2	32·6	22·6	10·9	2·1	116·6
	41·8	54·0	41·6	6·6	16·5	21·0	19·4	46·4	24·8	

Figures indicate monthly flow in 1000 ha/m. Scale: 1mm = 6000 ha/m

Scale: 1mm = 30,000 ha/m

NTHLY FLOW DIAGRAM (SHEBELLE RIVER)

STATION **BULO BURTI**

RCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	YEARLY FLOW IN 1000 Ha/m
0·7	1·1	13·2	1·3							
1·1	5·2	7·4	3·0	8·6	32·3	44·5	46·1	26·5	4·3	190·8
0·9	15·5	57·9	36·4	16·1	26·4	36·9	25·7	14·6	22·2	260·6
2·5	3·2	14·5	4·4	2·6	6·9	19·0	22·3	39·1	21·8	143·5
2·5	2·6	13·2	3·1	8·6	30·8	44·5	43·8	46·7	59·5	260·8
2·8	3·7	10·1	8·6	3·6	8·3	21·3				
2·6	2·5	18·6	4·6	3·0	19·5	34·0	30·8	26·3	4·5	151·4
10·6	5·2	15·4	2·8	3·3	29·6	36·7	40·6	19·0	3·7	173·3
5·1	13·8	40·7	26·1	11·9	30·8	30·4	12·5	13·3	10·0	199·9
2·8	7·6	50·0	5·9	6·6	24·5	35·5	34·4	46·9	6·0	225·1
2·6	2·5	8·8	3·0	2·4	5·8	24·5	33·6	9·5	2·6	100·1
2·8	21·1	12·0	5·7	2·2	18·3	35·6	45·5	19·5	7·8	175·8
2·5	2·5	22·4	5·2	2·7	6·1	30·5	21·8	9·5	2·6	111·0
	39·3	47·2	42·2	4·7	14·9	19·7	16·1	42·3	23·5	

Figures indicate monthly flow in 1000 ha/m Scale: 1mm = 6000 ha/m.

Scale 1mm = 30,000 ha/m

TABLE 4

JUBA RIVER

MEDIAN MONTHLY TOTAL FLOW*

PASSING GAUGING STATIONS

Hectare Meters
(thousands)

Station	J	F	M	A	M	J	J	A	S	O	N	D
Lugh Ganana	6.0	3.1	2.6	11.8	55.5	26.9	39.2	73.3	75.8	119.4	80.7	32.1
Bardera	7.5	4.7	4.3	16.6	51.6	34.9	41.8	66.1	82.1	104.1	76.5	34.7
Kaitoi	12.4	3.8	3.2	16.1	54.6	40.4	47.8	68.3	70.4	120.3	94.5	41.8
Giamama	10.3	2.4	1.3	13.6	53.5	39.2	46.2	60.4	68.6	89.4	84.9	39.6

* The median is based on the thirteen year period 1952 to 1964 inclusive.