THE SURVEY REPORT
FOR
AGRICULTURAL COOPERATION PROJECT
IN
KILIMANJARO REGION, TANZANIA

1974

OVERSEAS TECHNICAL COOPERATION AGENCY

FORWORD

In line with the national policy of expanding our project work for agricultural cooperation to areas other than Asia, our country delegated a project-research group (March, 1973) to the four East African countries in order to investigate prospective projects and agricultural situations in each country. As a result, it was reported that the Kilimanjaro region in Tanzania was a good prospect for the project due to the favorable natural, social and agricultural conditions and space for development.

As the Government of Tanzania had also been waiting our help in establishing the overall development plan for the province of Kilimanjaro, it was very opportune to cooperate with the country on the agricultural project.

Accordingly, we delegated a seven men research group lead by Mr. Watarai (former Director of the Tohoku Agricultural Administration Bureau MAF) for a 35-day research tour beginning November 1st, 1973, for the purpose of laying the basic plans for our cooperation. This research tour included a 15-day field survey of the cultivated land in the Kilimanjaro foot hills area and the undeveloped land in the lowland area, fully observing the state of water utilization, agricultural products, soil improvement situation and the area planned for the project. Based on the findings, project policies were discussed between the research team and the Government officials of Tanzania.

Now, in 1974, it is expected that the "project" will finally be initiated. We sincerely hope that this report will be fully and effectively utilized so that the " "project" will contribute to the agricultural development of the province of Kilimanjaro and, then, in turn, to a closer relationship between Tanzania and Japan.

In want to take this opportunity to express our hearfelt gratitude to the chief of the research group and to all it members, and to the officials of the Federal Government of Tanzania, the Government of Kilimanjaro Province and to the overseas offices of the Japanese Government, all of whom warmly and actively assisted in the plan as well as those specialists in Tanzania who kindly joined the group there.

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Director General
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Schedule of the Survey Group

Day		Date	Schedule
November	1	Thurs.	Leaving Tokyo.
	2	Fri.	Arriving at Dar es Salaam and discussing with the Embassy on the schedule.
	3	Sat.	Courtesy call on the Tanzanian Government (the Office of Prime Minister, the Ministry of Agriculture and the Ministry of Water Development and Power).
	4	Sun.	
	5	Mon.	Visiting the Morogoro District (paddy field area, the Agriculture Department of Tanzania University, Ujamaa Village, etc.).
	6	Tues.	
	7	Wed.	Joint talking with the ministries concerned on surveying policy, outline of the scheduled assistance, etc.
	8	Thurs.	Discussion with the Ambassador and talking with the Ministry of Water Development and Power.
	9	Fri.	Talking with the Ministry of Agriculture.
	10	Sat.	Leaving from Dar es Salaam and arriving at Moshi.
	11	Sun.	Discussion on the field survey policy (within the sruvey group).
	12	Mon.	Courtesy call on the Governer of Kilimanjaro Province and talk with the provincial officials concerned.
	13	Tues.	Visiting The Lyamungu Institute and the Livestock Experiment Station and Surveying the West-Kilimanjaro Area.
	14	Wed.	Visiting Kiliya Pilot Farm and surveying the Naururu Area.
	15	Thurs.	Surveying the Moshi and Lombo cultivating area.
	16	Fri.	Surveying the Miwaleni and Msaranga Mandaka Area (Miwaleni Ir. and Kahe irrigation plan).
	17	Sat.	Surveying around Mr. Pare.
	18	Sun.	Preparing the sruvey report.
	19	Mon.	Talking with the provincial officials concerned on the survey results and the policy of the scheduled assistance.
	20	Tues.	Individually talking with The Lyamungu Institute, the Water Control Office and the Provincial Government.

Day		Date	Schedule
November	21	Wed.	Surveying the soil in the Lowland and the
	22	Thurs.	Miwaleni Area and visiting sisal estates.
	23	Fri.	Surveying the soil in the Lowland as well as the East-Pare paddy field area.
	24	Sat.	Calling on the Provincial Government.
	25	Sun.	The froup head and one member leaving from Moshi for Dar es Salaam.
	26	Mon.	Talking with Ambassador.
	27	Tues.	Five members leaving Moshi for Dar es Salaam.
	28	Wed.	Discussing on the survey results within the group.
	29	Thurs.	Reporting to the Tanzanian Government on the survey results and discussing on the policy of the scheduled assistance (joint meeting with the Ministries concerned).
	30	Fri,	Bidding farewell to the Tanzanian governmental organs concerned.
December	1	Sat.	Bidding farewell to the Embacy.
	2	Sun.	Leaving Dar es Salaam.
	5	Wed.	Arriving at Tokyo.

I. OUTLINE

1. Introduction

Except the limited number of urban residents, the majority of the people living in Tanzania are engaged in the primary industry such as agriculture stock-farming and fishing. The government of Tanzania is now promoting the Ujamaa plan, one of the most important plans to secure welfare and food supply for the majority of people.

The agricultural population in the state of Kilimanjaro, especially around Mt. Kilimanjaro and Pare, are dense; the managing scale is small, being 2-3 acre, and there is almost no space for them to extend farming. Both the national and state governments have therefore strong intention to introduce light industries to these districts and also to construct Ujamaa Village in the course of developing the low and middle lands, and thus to increase the income of the farmers and stabilize the crop.

With the background as mentioned above, the government of Tanzania has requested Japan's co-operation in the Tanzania's comprehensive development plan; and to answer to the request Japan is now prepared to begin the co-operation in the agricultural development. In our opinion, problems in agricultural development may vary with zones as per listed in the tabulation below. Generally speaking, in this co-operative project to cover such areas under entirely different natural and social conditions, priority should be given to the understanding of farmers' intellectual and technical level, rather than rapid and direct introduction of Japan's agricultural technology. Accordingly, the project should be proceeded step by step based on the effective support by specialists having full knowledges of Tanzania. Japan's co-operation is strongly desired in the agricultural development of Middle Land, development of Lowland (savanna), concentrated researches and tests on agricultural technology and improvement in agricultural technology based upon the above result.

Table Agricultural Development in Kilimanjaro State

Region	Present Condition	Development Items
Upper Zone	Advanced but densely populated agricultural region with abundant rainfall and effective use of land and water. Chief district of bananas and coffee production Almost no space for the expansion of farmland	Improvement of farming (Rotation of crops for maintaining soil productivity, prevention of soil erosion, labor saving by small-size machines and introduction of new crops) Introduction of new crops
Middle Zone	Field farming district in rainy seasons where sisal farm and large-scale farms with effective use of river and spring water are scattered Enjoying comparatively more abundant rainfall than in Lowland, comparatively stable crop	Expansion of irrigation area Improvement of farming Crop change in sisal farm Deep plowing for retaining rain water in soil
Lowland (Savanna)	Natural grazing district populated thinly Suffering from little rainfall and frequent droughts but occasional flood Undeveloped district with few water resources with some small-scale farms using flood water	Providing living facilities for drinking water supply etc. and constructing roads Providing irrigation and drainage facilities Improvement of alkaline soils Establishment of irrigation farming

2. Hydrographic Geology and Water Resources

(1) Hydrographic geology

The state of Kilimanjaro is located in the east-most of the East African Rift Valley which is well-known is geology. Mt. Kilimanjaro (19,324 feet), a globally famous strato volcano compared to Mt. Fuji in Japan, was created by the volcanic action caused by a large-scale movement of the earth's crust and located in the north of the state.

Many mountain streams run down along the side of Mt. Kilimanjaro except its west and northwest sides. Many of these streams and rivers, after alowing south in the piedmont district, join to the Pangani River in the lowland of the state, where the Rifty Valley runs from northwest to southeast.

The majority of these mountain streams are seasonal and generally dry in the dry season. The majority of permanent rivers have spring water sources.

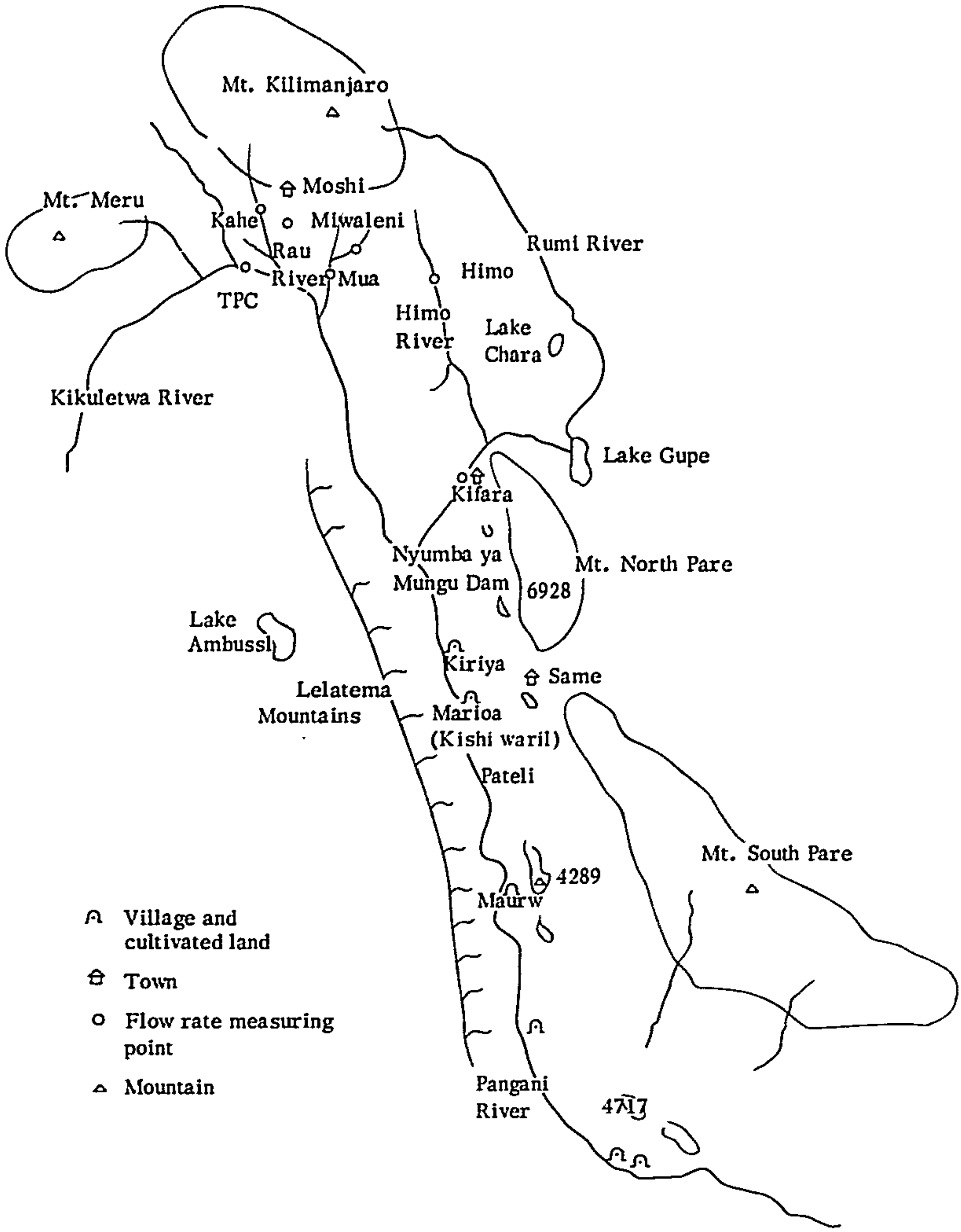
In the piedmont district of Mt. Kilimanjaro, springs are distributed within the zone of the altitude of 2,500-2,700 feet; it seems that the presence of Lakes Chala, Jupo, etc. has close relationships with the distribution of springs.

Distinct relatema mountains formed by the movement of the earth's crust run from northwest to southeast in the middle and southern part of the state. The northern part and the southern Pare district have steep folded mountains formed by lateral pressure, and the Pangani River runs along this upheaval. The plain land between the Mt. Pare and the Pangani River represents very unique spectacles with many small hills scattered from north to south. These mass of hills as well as the Mt. Pare are of shale, sandstone, conglomerate or lime stone, all of which are neritic aqueous rocks. Being strongly influenced by lateral pressure, shapes of these hills are very steep and it is difficult to imagine that many people are living on the hilltops.

The branches of the Pangani River are; The Kikuletowa River which rises in the Savanna of the northern Arusha and Mt. Meru (14,978 feet) and collects water from the west side of Mt. Kilimanjaro; the Wera Weru River and the Rau River which collect water from the south side of Mt. Kilimanjaro; the Lumi River which collects water from the east side of Mt. Kilimanjaro, flows south into the Jipe Lake, joins to the Ruva (Rufu) River, then forms a large-scale swamp while flowing west, joints with the Himo River at the point of Kifaru, and diverges from the northern Pare chain. The appended Table of Flow Rate of Main Rivers represents the flow rates of these rivers at the places of measurement.

As described before, many spring are distributed around the zone of the altitude of 2,500-2,700 feet, in the piedmont district of Mt. Kilimanjaro. The water of large-scale floods occurring in the southern foot of the mountain runs over the lava flow and the outcrop of the agglomerate and abundantly springs out along the contact surface with the lava. Such a hydrographic mechanism is also found at the springs at Asama Shrine in Fujimiya City, at the foot of the Mt. Fuji, and in Mishima City. (Refer to the Reamrks in the Table of Discharge of Main Rivers.)

In the case of Mt. Kilimanjaro, the yearly rainfall of approximately 1,800-2,000mm is recorded in its south side at the altitude of 5,000 feet. Whereas, in the case of Mt. Fuji, the yearly rinfall of more than 3,000mm is possibly obtainable, which means that the spring wate quantity of Mt. Fuji is more than that or Mt. Kilimanjaro.


Mt. Kilimanjaro
Moshi
Mt. Meru
Kahe
Miwaleni
Rau
River
Mua
TPC
Himo
Rumi River
Himo
River
Lake
Chara
Kikuletwa River
Lake Gupe
Kifara
Nyumba ya
Mungu Dam
Mt. North Pare
6928
Lake
Ambussi
Kiriya
Same
Lelatema
Mountains
Marioa
(Kishi waril)
Pateli
Mt. South Pare
4289
Maurw
Pangani
River
Village and
cultivated land
Town
Flow rate measuring
point
Mountain

Although Mt. Fuji has much rainfall in addition to the spring water, no surface water flows either in gullies or in torrents. On the other hand, an appreciable amount of surface water flows in the streams running in the lower parts than the middle of Mt. Kilimanjaro. Since the formation of Mt. Kilimanjaro is much oldest and the erosion is far developed that weathering of rocks and soils have more advanced to the extent that many people can engage in agriculture and secondary water-holding capacity is appreciable. Some earth-dams to supply drinking water are found along the mountain streams at the altitude of approximately 5,000 feet, while a considerably thick clay sediment is found in the soil.

Surface water is scarce on the west side slope where a broad plateau extends with thin bed of surface soil over lava and exposed lapilli, in addition to very little rainfall inspite of the higher altitude.

In the west Kilimanjaro area, trials have been vainly made in these several years to obtain underground water by digging deep wells. In this area underground water is present not in a water-holding pebble layer but in the form of linear fissure water. Therefore, investigations by boring is really inefficient, and physical and electric explorations for wate-holding pebble layers have been applied unsucessfully.

Natural Environment of the Pangani Basin and the Nyumba Ya Mungu Dam

The plain land between the Leletema Mountains and the north and south Pare Mountains along the Pangani River is so broad, being approximately 230,000 acre according to an extimate in the FAD report. The Pangani River flows southeast, forming vast swamps of 4-10 km in width, which consist of the permanent Papils swamps (vegetation swamps) and seasonal swamps.

As the result of constructing the Nymba Ya Mungu Dam, it seems that all the seasonal swamps have disappeared and the vegetation swamps have been much reduced in size. Accumulation of carbonate may be inevitable since then layers of lime stone are scattered in this zone at the bottom of the Rift Valley composed of naritic sediment. A phenomenon is known in Japan that the ground water containing salt comes up by a capillary action, and reach the rooting zone of vegetation, causing damages. The alkaline soil in the district of Pare is tightened and combined by underground water supplied by the floods so that it can be considered as an impermeable layer at occasional rainfalls. The salt is believed to have been educed by the strate reaching depth of certain degree, repeatedly been condensed near the surface of stratum by a keen evapotranspilation action in the dry season, and finally remain existent. On the other hand, flood water carries silt for sedimentation and also washes away the salt pricipitated on the soil surface. One of the most interesting studies on the relationship between water resources development and slkali soil is to investigate what will take place over the wide swamp area after no flood occurs as a result of flood control by the Nymbaya Mung Dam. The case with the Pangani River will cause less problems as as the majority of the lowland in the middle and southern parts of the Pare district are undeveloped savanna. The African Cultivation villages are scattered over the swampy area of this district. If irrigation farm be introduced to them it is necessary to construct and consolidate facilities for irrigation and drainage.

(2) Water Resources

Effective utilization of water will be a key factor in the successful achievement of the improvement and development project in the lowland and savannah, described in the preceding article. The need for water resources will increase with the development of this area. Water resources are not necessarily abundant throughout the whole country of Tanzania nor in this district, so that it is considered that the value of water resources will increase in the future.

On the basis of this judgement, the Tanzanian government (Ministry of the Water and Power Supply) has followed the investigation of water resources and their development, and intends to produce a Master Plan on water resource investigation and utilization, the government is undertaking this operation on its own or with the cooperation of technically advanced countries. The progress of the plan is in the situation described below. The Tanzanian government is requesting Japan to investigate the Kilimanjaro region.

The investigation and development of water resources in the most important on performance of the agricultural development in the Kilimanjaro State; and it can be said that it is included in Japan's cooperation with the Tanzanian government in this agricultural development to accept its request for the water resource survey described in this article.

The cooperative program undertaken by advanced countries in this Water Master Plan is mainly composed of a survey of the existing amount of water and its form of existence. Its utilization plan is seen to be carried out at the next step of this cooperative program.

For a long period, the plantation has been the suitable land for agriculture in the Kilimanjaro region, and a great dam of about 1.1 billion tons was constructed along the Pangani River.

From this reason, comparatively large amount of hydrological information may be collected. As future survey subjects, on the other hand, the following should be mentioned: collection and analysis of existing data, survey of river water centering the branch streams, and, investigation of present water utilization, etc. The ground water survey, which is expected to be developed later, will become a survey subject of importance, as well.

Table Progress in Water Master Plans of Each State

Region	Assisting Country	Progress: Preliminary Research	Progress: Principal Research	Remarks
Shinyanga	Holland	Finished	Under way	Launched in 1971
Musoma	Sweden	Finished	Not started	
Mwanza	Sweden	Finished	Not started	
West Lake	Sweden	Finished	Not started	
Mtwara	Finland	Finished	Under way	Launched in 1971
Tanga	West Germany	Unfinished	Under way	
Arusha	U.S.A.	Unfinished	Under way	
Maasutaru	Canada	Finished	Not started	
Kilimanjaro	Japan	Finished	Not started	
Dodoma	Tanzania	Finished	Under way	

3. Consolidation of Agricultural Production Basis in Middle Land and Development of Low Land (Savanna)

The most important subject for the agricultural development in the middle land is to make most effective use of the limited resources available. It should also be considered to establish a flood control system for minimizing damages, to improve and extend living facilities for drinking water supply, etc., thus to settle farmers. On the other hand, successful scientific researches and investigations are especially desired for the development of the savanna on the left bank of the Pangani River toward its down stream. Considerable time and preparatory works for a large-scale development of Savanna is also needed in view of the problems in rising fund, immigration from remote places, farmers' economical and living sense, etc. It is therefore advisable to begin with the upstream savanna adjacent to the middle land located near the cultivated areas, and to extend development on the basis of achieved results.

Development plans other than the ones already made based on secured water resources may also be formulated.

Part of the scheduled savanna development plan which Japan should set out in an early stage is the Upper Miwaleni Irrigation Scheme. The Scheme is to pump up irrigation water from the Miwaleni spring zone (underground water will partially be utilized) and reclaim 1,500 acre of land.

The Ujamaa Village will be constructed in the reclaimed land. The district is neighboring the upstream Low Land farmland, and the Kahe Irrigation Scheme covers the downstream area. The Tanzania government, therefore, intends to promote this scheme with priority because the district enjoys favorable climate and soil. In Japan's co-operation, materials for water-intake facilities and for construction work as well as engineering techniques are needed; also farming machines and tools and utility facilities should be offered.

It should be noted that the cultivating techniques will be developed step by step since the Ujamaa Irrigation Scheme is based upon the native farmers in the district, and wholly different from the estate farming system. In the tentative plan, combinations of staple food crops and cash crops, and small-size machines and hand work are programed.

Further review and improvement will be necessary on the basis of the field surveys to be conducted for a year or two.

4. Experimental Research on Agricultural Technique and Guidance for Spreading the Improvement of Agricultural Management

In case of promoting agriculture in Kilimanjaro, the following experimental research on agricultural production technique is necessary extensively: breeding, cultivation, soil fertilizers, damage by blight and harmful insects, etc.

If it is reasonable to state that the development of the middle land and savannah are most essential for the agricultural development in the Kilimanjaro state, the main subjects of experimental researches Japan conducts in cooperative activities, should stress experimental research for practical use such as improvement of alkaline soils, selection of crops suitable for alkalinity of soils, determination of the quantity of water required the cultivation, establishment of irrigation agriculture system, study of a reasonable transportation system, etc.

In the actual cooperative program to be undertaken, Japan's team is to belong to one department to be set up in the Lyamungu Experiment Station. Miwaleni Substation will be used for actualization experiments corresponding to the development of the lowland, while this Substation and Kiliya Pilot Farm will be used for verification experiments of new techniques.

Research rooms, materials and equipment at the present Lyamungu Experiment Station are insufficient. Therefore more should be planned by the enlargement of research rooms and supply of research materials and equipment.

In Miwaleni Substation, the enlargement of experimental farm (increase of about 10 acres) and completion of cropsurvey rooms, etc. will be necessary.

Kiliya Pilot Farm is a valuable experimental farm for the improvement of alkaline soils. The present facilities for taking up water are not capable of fully conducting experiments with respect to irrigation system useful for improvement of alkaline soils and aquatic rice cultiva tion, etc., since they are provisional ones for water intake by use of a tractor engine. Accordingly, the water pumping-up facilities including pumps and power sources must first be better arranged.

Guidance for spreading the improvement of agricultural production technique consists of improvement of conventional techniques irrespective of highland or lowland; and said agricultural production technique should be a feasible technique in consideration of drought durability and growth period of crops, management scale of petty farmers and social habits of farmers (replacement of breeding, prevention of erosion, fertilization, prevention of damage by blight and harmful insects, crop rotation, etc.)

5. Cooperation Plan for Agriculture Development

As to the cooperative schedule, the following sequence would be reasonable. As a first step, the preparation for foundation of production and the project and cooperation on fundamental experimental research and hydrological survey should be undertaken. Through these activities, studies on the concrete cooperative subjects, etc. for the arrangement of natural production base conditions should be promoted. Execution of the second stage will then follow.

(1) Cooperation at the First Stage

Cooperative Subjects

Water resource survey

- Collection of existing observation data and checkup.
- Analysis of the existing data, survey and observation.
- Survey of the actual conditions of water utilization, etc.

Research items for Development of Agricultural land

- Survey of actual conditions
- Vegitation survey
- Soil survey and classification
- Market research
- Investigation of crops to be introduced
- Determination of objective amount of income and management scale
- Selection of agricultural machines and equipment Cultivation System
- Establishment of the fundamental plan for the Upper Miwaleni Irrigation Scheme and performance of operation design.
- Other technical assistance and advice for the development of agricultural land in Musarangamandaka, the area around Lake Zupe and the basin of the Pangani River.

Experimental Research

- Improvement of the Lyamungu Experiment Station and initiation of fundamental experiments.
- Enlargement of the Miwaleni Substation and initiation of the experiments for practical use.
- Arrangement of water pumping-up facilities in Kiliya Pilot Farm, and guidance and advice on cultivation experiments therein.

Training of Technicians

- Training of technicians with stress on counterparts.

Technicians to be Dispatched and their Speciality

- The composition of a long-term team is generally considered to be the following:

1) Agricultural civil engineer -- Survey of water resources and arrangement of production base condition

2) Hydrological engineer -- The same above

3) Agricultural engineer -- Arrangement of production base condition and improvement of production technique

4) Soil scientist -- Experimental research

5) Corp scientist -- The same above

6) Coodinator

Team members in charge of experimental research will be attached to the Lyamungu Experiment Station under the jurisdiction of the Agriculture Ministry, and the other members will stay at Moshi, belonging to the Kilimanjaro state. Assignment of the member in charge of liaison, however, will necessarily be determined by consultation with Tanzanian officials.

In order to expect rapid results from cooperative activities, specialists who are well versed in the actual situation of on-the-spot agriculture and in the language thereof are required; especially, resident experts in the district concerned are required to perform as members in charge of the survey of the present situation and water resources.

On performing the cooperative activities in the preceding article, the aforementioned specialist team members of long term stay conduct them in cooperation with each other. On the other hand, the dispatch of a survey team of short term stay will be required for cooperation in special fields such as survey of ground water, etc.

(2) Cooperation Term: From one year and a half to two years and a half

(3) Cooperation Plan in Its Second Stage

Cooperative Subjects

- Survey of water resources: Succession to the first stage and its enforcement; particularly, survey concerning ground water.
- Planning of Water Utilization Plan

Arrangement of natural production base condition and guidance for spreading of the improvement of production techniques

- Performance of Upper Miwaleni Irrigation Scheme, Full scale technical aid and instruction in addition to other cooperating activities in the first stage, and enlargement of cooperation with relation to projects other than the Miwaleni Plan.

Experimental research

- Following the cooperation at the first stage and its enforcement.

Training of technicians

- Follows training of technicians placing stress on the counterparts, and, in addition, the study and training are carried out in Japan.

Technicians dispatched

- Planning for the strengthening of dispatched team at the first stage; particularly, dispatch of specialists in civil engineering construction and machinery desired.

Cooperation Period

From 5,5 to 6,5 years.

6. Enlargement of Japan's Technical Cooperation to the Development of Light Industry

Manufactured goods marketed in cities, such as toilet paper, pencils, etc. are almost are imported articles. In the view of the present foreign currency of Tanzania, domestic production of these daily necessities whose need is clear, should be enlarged increasingly in the future.

Furthermore, it is desirable that agricultural products for export be changed from the first products to items having additional value. The Tanzanian government is planning to lead this district, where labor with high education background and distinguished capabilities can be secured, to introduction and development of light industries.

Regarding this planning, Japan's cooperation is strongly requested.

It was not possible to inquire of the Tanzanian officials about concrete plans to introduce light industries, and, nor was it possible for the Project-Finding Team, to make a report on what promising projects can be considered in a concrete form. However, it may be said that, among first and second processing industries, industries highly dependent upon labor using resources available on the spot as the main materials, such as processing industries of agricultural products, cotton industry, leather industry, live-stock products, and ceramics, etc., are promising.

The promotion of a processing industry for agricultural products is closely related to agricultursl development of the lowland, etc. which is soon to begin. If some cooperation concerning the introduction of light industrial development as well as the agricultural technical cooperation is carried out, it will highten the effect correlatively, and the project is desirable to be performed.

II. AGRICULTURAL TECHNOLOGY AND THEIR DEVELOPMENT

1. Actual Conditions of Agricultural (Cultivating) Technology

The actual conditions of the cultivation of farm produce in the districts of Romb, Pare and especially Kilimanjaro have been reported by the research commissions who have conducted these studies. The purpose of this report was to inquire the methods of distribution of farm produce and the development of cultivating technology, and to study further proposed technological development in the future.

(1) Locality of farm produce distribution:

Farm products vary, depending on the district and much more on the altitude. Namely, in both the Kilimanjaro and Pare districts, coffee and bananas are the main crop, being interplanted in the upper zone. Maize, potatoes and yams are the minor crops, being cultivated as a catch-crop. In the middle zone, coffee and bananas are also the major crop as in the upper part, and maize and beans from the lower part, all of which are cultivated together. Sweet potatos and vetetables such as cabbages and carrots are the minor crops of this zone. In the lower zone of Kilimanjaro, sisal, maize and beans are the major crops, and cotton and sunflowers are the minor crops. Sugar cane, kenaf, maize and beans are cultivated all the year round in the districts where irrigation facilities are available, by such organizations as the Tanzania Planting Company or the East African Kenaf Company. The Miwaleni scheme aims to extend irrigation facilities to the upper part of this lower zone, and the Lyamungu Research and Training Institute has its substation in Miwaleni. In the neighborhood of the Lake Jupe in Pare, single cultures of rice and corn are the main crops, and mixed cultures of beans, cassava and vegetables are the minor crops. In they dry zone, along the Pangani River, maize and beans are the main crops. Rice and cotton are the minor crops, being distributed around the Pangani river. In the district of Lombo, distribution pattern of crops is generally the same as that in the district of Kilimanjaro, except for the higher ratio in the planting of maize and beans in the middle and lower zones. The middle zone is abundant in pyrethrum culture.

Local differences of farm produce are chiefly due to variations in rainfall and temperature, the rainfall especially influencing variations in crops. The yearly rainfall, for example, is 1,500 to 2,000 mm in the upper part of Kilimanjaro, 1,000 to 1,500 mm in the middle zone, 950 to 1,000 mm in the lower zone of the same district, and 500to 900 mm in the dry zone of Pare. Most of the yearly rainfall occurs during the heavy rainy season from March to May, very little of it seen during the light rainy season from October to December, and almost rain-less in the dry season. The production of such drought-resistant farm produce as sisal, sorghum, cotton, etc., therefore increases as the rainfall decreases and the altitude becomes lower, whereas the upper zone is abundant in coffee, bananas and oranges which although perennial, are not drought resistant. Bush savanna overgrows in the dry zone where the yearly rainfall is only about 500 mm and where the soil is strongly alkaline. A few varieties of farm products are cultivated along the river basin or near spring sources. As a result of poor drought resistance, such vegetables as cabbages, egg plants, tomatoes, carrots, etc., are cultivated near springs or in an area where irrigation is available. Irrigation priority is given to these vegetables in dry seasons. Temperature is also a factor in the distribution of farm produce, i.e., the culture of potatoes, wheat and barley is limited to the upper and middle zones where comparatively lower temperatures are desirable. The upper zone of the west Kilimanjaro is especially abundant in wheat. In conclusion, distribution of farm produce is basically influenced by the yearly rainfall and its seasonal distribution. Temperature is also a pertinent factor affecting those products requiring low temperature, and the area of cultivation is restricted accordingly.

(2) Variety

The introduction of new varieties is being developed in largescale farming which aims at such high quality produce as coffee, maize, pyrethrum, rice, wheat, vegetables, etc. Maize F_1 has achieved good results and is now being cultivated on small-scale farms. Some farmers are introducing a change of seeds of potatos, white beans and red beans. Other farmers are engaged in stock seed production. On the other hand, grains currently available at the markets in Moshi are mixtures of 2 or 3 different strains and the necessity of selecting these types is apparent. Breeds of maize and vegetables are usually imported from Kenya. Except for the specific products mentioned above, no other change in either variety or seeds is being utilized by the farmers. It is therefore imperative that the use of a better type of seed be promoted, and the improvement in grain breeds to be expedited.

(3) Cultivating season

The major rainy season is the cultivating period for the yearly crops. Seeds are sown at the beginning of the rainy season, and are harvests made after the rainy season is over. Regarding the methods of interplanting, the following is an example of maize and beans. Farmers plant maize in a field about three weeks earlier than they sow beans; because beans develop more rapidly and grow faster than maize. Consequently, when corn matures and more water is required. The beans are nearly ripe. This minimizes the competing requirement for water. Planing methods such as this represent good ideas for the farmers who intend to make the maximum use of the short rainy season by the selection of plants of different growth periods. Double crops may be harvested in areas where comparatively little rainfall is seen in the minor rainy season or where springs enable the farmers to utilize irrigation. In the areas equipped with complete irrigation facilities, culture and plant breeding can be conducted at any time because irrigation is provided during the entire year.

In conclusion, the cultivating period for the yearly crops is dependent upon the rainy season as well as upon the irrigation supply.

(4) Planting pattern

Interplanting is the most basic and major pattern of cultivation except on large-scale farming such as on an estate. Let us inquire into the beneficial results of interplanting from the standpoint of the people s daily lives.

People require starches, proteins, and fats to maintain their lives. Among these elements, starch may be obtained only from such vegetations as the banana, corn, potato, sweet potato, cassava and yam, whereas both protein and fat can be obtained fromlivestock, game or beans, since this district is too far from the sea to depend upon fish as a source. Under situations, where a lack of monetary economy precludes purchases, it is possible for people to become selfsupporting and self-sufficient by cultivating vegetables from which starches are obtainable, growing livestock, and planting beans around their houses. Interplanting of maize and beans is one of the typical self-sufficiency methods. Another good example is seen among the farmers living in the upper and middle zones who cultivate bananas domestically and keep a small amount of livestock. After coming into the ages of monetary economy, cash crops needed to be produced. Simultaneously, with the introduction of coffee by the Kilimanjaro mission, people began to begin the mixed culture of coffee and bananas. In this case, the banana performs its function as a shading crop for coffee which does not thrine in strong sunlight. No one can deny the fact that mixed culture avails protection against soil erosion. Under the progression of monetary economy, farmers still had the intention to raise crops for their own use, while their farming acreage was generally small. Under these circumstances, they cultivated beans and maize between coffee and bananas. It is now fortunate that maize and beans will absorb strong sunlight while growing under bananas. Interplanting of these four products in the upper zone is a model of the "cash crop plus food crop", and corn and beans are not crops for sale. These facts should be taken into account upon commencement of studies on discontinuance of interplanting, which are of necessary improtance for the improvement of labor efficiency and productivity. Consciousness of self-sufficiency of foodstuffs is still a fixed idea among the farmers, who have no intention to cultivate all their fields with cash crops as is done by a large estate. Therefore, even though expansion of farm acreage and the feasibility of single culture might be realized by the development of the low land, it will be necessary for the food crop to remain among the rotation of crops developed in individual farming.

(5) Fertilizers and maintenance of soil productivity

No fertilizer is generally used in the mixed culture of beans and corn, while culture of coffee and pyrethrum by the general farmer, while that of sugar cane, sisal and Kenaf by an estate, employs fertilizers. Incomplete development of the fertilizer industry in Tanzania may be a factor that hinders the broader use of fertilizers, while a more substantial fact is that N and P_2O_5 fertilizers have no effects through tests conducted in the non-irrigated areas. Reasons for insufficient effects of fertilizers are that there is no variety which has a high fertilizer reaction; many cases of diseases and damage occur; and that increase in growth quantity is followed gy an increase in evaporation which results in lack of soil humidity and crop yields decrease. In other words, consolidated technology such as selection of variety, protection from diseases, damages, etc., is required for the development of fertilization in agriculture. Protection from soil erosion and application of organisms are advised as a countermeasure for maintenance of soil productivity. Therefore, this point has to be resolved by examinations before increased production will be realized by fertilization culture. Farmers practice the levee or contour plowing for the former, and stable manure for the latter. However, the ratio of application is still small and good maintenance of applica tion is doubtful. Further studies are therefore to be anticipated.

(6) Protection of crops

The use of agricultural chemicals against diseases and damage is restricted to such cash crops as coffee, pyrethrum, cotton, vegetables, etc. This restricted use is attributed to the fact that agricultural chemicals are not abundant and that incubation of insects takes place infrequenctly because of culture without fertilization. Frequent occurrence of diseases and damage may occur when irrigation facilities and fertilization techniques will be advanced in the future. Research on diseases and damage on grain crops should therefore be promoted progressively. In addition, grain crops damaged by animals are apparent in this area; the number of wild animals eating grain crops are increasing each year. These damages should be taken into consideration in the event of the development of the savanna zone in the low lands for agricultural purposes. Bird control is also necessary in the event of cultivation of small grains such as rice, sorghum, millet, etc., in newly developed areas; the Kilangali farm regards the bird control as one of its improtant projects. In the newly developed areas surrounded by waste land, all possible means should be taken to keep birds away.

(7) Formulas of cultivation

Repeated cultivation comprises the main formula of cultivation, and a few instances of crop rotation are found in the cultivation of vegetables. In the dry season, residues of crops are broken up and it is assumed that repeated crops are not affected. However, disease and damage increasingly occur after several years have passed since reclamation, and it is noted that the farms are abandoned on such occasions. It is therefore supposed that some damages are the result or repeated crops in dry farming. Regarding cultivation in irrigated farms, the East African Kenaf Company, for instance, is conducting rotation of the corn and bean crops because development of nematode is seen in the fields of repeated crops. It has also been observed in the Miwaleni test field that tomato's roots are infected with the nematode. These facts suggest that conditions of crop growh and environment for soil organisms are improved by the use of irrigation, and this fact should be taken into consideration in establishing irrigation farming in the low lands. Rationalization in the rotation of crops whould be established for irrigation farming, because notable damage to the repeated crops are certain to take place unless the irrigation canals are completely filled for more than one month.

Interplanting of beans and other crops, as well as closed farming, is imperative because it is the only way to maintain soil productivity, especially while farming without fertilizers. Researches on formulas for the rotation of crops will be necessary in the future in order to maintain good soil productivity while raising root and forage crops.

(8) Utilization of farming machines

Mechanization in farming is more advanced in the middle and lower zones where gentle slopes are prevalent. The scope of mechanization, however, is still small. The main scope of mechanized farming thus far being the use of the tractor, leaving the other work of harvesting and farm maintenance to the farmers. The following mechanization is deemed necessary in the future; harvesters should be of more use, effective use of large machines should be considered in the low land, and hand-tractors of about 10 HP and trailers used more frequently on slopes in the middle and upper zones. It is also improtant, for increased yields, to introduce trenches and to construct simple side ditches so that rainfall can be utilized more effectively.

(9) Irrigation facilities

It is no exaggeration to say that Tanzania's agriculture is a water problem. Crop harvests depend wholly upon rainfall. No irrigation facilities, however, are found except those established by such large farms as the Tanzania Planting Company and the East African Kenaf Company. There are many examples of furrow irrigation which the farmers have made use of by introducing water from springs and rainwater through side ditches. This method is mainly used in the production of vegetables and seeds. The problems of water rights and expensive co construcution costs may have hampered the development of the irrigation areas. In view of the absolute necessity for irrigation facilities in the development of the low land, a longrange program should be established for complete equipment of these facilities. We point out that the increased production of maize recently achieved in the United States has been the result of the use of F_1 fertilizer and the expansion of the irrigation areas.

(10) Others

What is especially noteworthy is the devastation of the sisal farms, which are distributed in the lower part of the middle zone and the lower zone where rainfall is comparatively small. Specially devastated farms are those which required improvement, many of them already abandoned leaving weeds to grow. Desolation such as this has been caused by low commodity prices during the past several years and the gap in technology between the individual farmers and the nationalized estates. Restoration of arable land should begin from these devastated farms. Maize and sorghum can grow in fields where no irrigation is available, and this fact suggests possible reconversion.

2. Problems in Developing Farmings Technology

(1) Upper zone

Areas for culture are small in space and many of the fields are on a slope. Drastic plans are required to improve the agricultural structure within this zone. Technically speaking, a reasonable use of fertilizers, agricultural chemicals, and mechanization of harvesting are important for coffee; dry farming and a rain water reservoir for soil for wheat; selection of seeds, uniformity of variety and type and proper density of begetation, etc., for beans, potatoes, maize, etc. The possible introduction of high quality vegetables or tea plants may be expected in consideration of the low temperature and small rainfall in this zone. Protection of soil erosion and established technology for farming of the slopes is generally advised for this zone. Established technology means laborsaving farming by the introduction of small tractors.

(2) Middle zone

Crops mainly cultivated in this zone are coffee and bananas in the upper part, and maize, beans, cotton and sisal in the lower part. The yearly rainfall is smaller compared with that of the upper part. The important items for this zone are the expansion of the irrigation areas, the development of farming with fertilization, discontinuance of mixed cultivation, restoration of sisal farms, improvement in variety, and establishment of dry farming. Expansion of the irrigation areas will bring about both extended selection of crops and stabilized production. As a matter of advice to sisal farms, sisal has a strong drought resistance and also needs water in its first growing stage. It is mainly distributed in the bottom zone of mountainous regions where water is available from springs or rivers. Therefore, introduction of sorghum and ground nut which are drought resistant is advised for sisal farms. Utilization of industrially used water for irrigation purposes is also advised. Mixed culture is based upon the farmers' idea to make the best use of rainfall as mentioned before, while it is possibly supposed that mixed culture will hamper the increased production of the respective crops and farm work as a whole. Conversion to single crop from mixed culture is impossible at the moment under non-irrigated farming in areas limited for cultivation. Expansion of areas for cultivation by means of the restoration of sisal farms will enable a single crop to be promoted. Established dry farming should also be promoted in view of the impossibility of expanding irrigation areas to entire cultivation areas. The measures worthy of studying are the reservation of rainwater in soil by deep plowing. Due to deterioration of property of seeds, introduction of new varieties should be repeated with shortest intervals of several years. This zone has manny fields of gentle slopes, and are suitable for machines to be introduced. Mechanization in harvesting work should be reviewed. Rotation of crops, fertilization and the growing of forage crops are recommended for maintaining good edaphic factors.

(3) Lower zone

Alkaline soil is widely distributed in this zone. Problems are water puddles produced in the rainy season in the lower part and drought caused by sparse rainfall in the upper part. Priority steps should be taken fro complete equipment of the alkaline soil. There will be fewer problems if irrigation facilities were available since this zone enables the farmers to have a broad selection of crops such as grain, vegetables, fruits, etc. Studies on farming utilizing irrigation, water-saving culture and formulas of cultivation, should be made for planned cultivation.

(4) Dry zone - Pare

Irrigation facilities are indispensable for this zone which is broadly covered with bush savanna and possesses a strong alkaline soil. If irrigation facilities were available, selection of suitable crops and the order of introducing these crops as a process of improving alkaline soil should be studied. That is, planting of storongly alkali-resistant crops and followed by those of weakly resistant crops. Promotion of stock-farming should also be considered in vast areas of this zone where it may be possible to cultivate pasturage and also to expand irrigation areas. The Kilya Pilot Farm belongs to this zone.

(5) Paddy zone - Pare

This zone is badly submerged in the rainy season, and draining the flooded areas is a big problem. Therefore, agricultural development should follow the construction of roads which can be usable even during the rainy season.

Problems on the respective zones may be summarized as follows:

1) Expansion of irrigation areas
2) Establishment of farming techniques on sloping fields
3) Establishment of farming techniques with accompanying irrigation
4) Water-saving procedures
5) Establishment of dry farming techniques
6) Discontinuance of mixed culture based upon the expansion of the scale of farming
7) Introduction of new crops (tea plants and mulberry)
8) Improvement in varieties
9) Utilization of restored sisal farms
10) Improvement in alkaline soil and selection of suitable crops
11) Establishment of scientific rotation of crops
12) Utilization of small machinery

3. Suggestions from Agronomist Regarding the Low/and Development.

The land is originally unsuitable for growth of crops because the soil is strongly alkaline, and there are many wild birds and animals and little rainfall. Also, in those areas where rainwater remains in the rainy season, there are mounds of soil which have been washed down from the upper zone. This soil would become fertile if the alkalinity was eliminated. Mechanization in farming would be easy, as the land has many plain areas. Land development should begin by the elimination of the hampering factors in production of crops. Namely, complete equipment for irrigation facilities in the first place, improvement of alkaline soil in the second, and in the third, selection of suitable crops and establishment of scientific rotation of these crops. For the third step also, technical researches and testing should be launched with a view toward creating a new technology.

Appropriate development of cultivation areas should be initiated from the waste lands with comparatively lower alkaline soil, adjacent to the areas under cultivation, and then gradually extended, based upon the results of researches and tests. Selection of suitable crops should be subjected to the establishment of formulas of rotation of crops, which are the consolidated results of scheduled feasibility of the water supply, fixed degrees of alkalinity and pretested results by category. In other words, culture technology should be based upon a menu system so that selection of crops will be able to be optional according to the conditions of introduction. In conclusion, development should preferably begin from the district of Miwaleni where the alkaline soil is not so strong, and adjacent to the middle zone, and then extended to the district of Pare which has worse conditions, on the basis of the development results. In line with this program, researches and tests will be promoted as follows: studies on selection of suitable crops and methods of cultivation will be carried out by the Miwaleni Sub-station in terms of weak alkalinity, and by the Kilya Pilot Farm in terms of strong alkalinity. As there are many crops which are alkaliresistant, the most suitable crops should be selected from among grain crops, root crops, pasture, vegetables and fruits.

As regards introduction of crops, assuming that a reservoir of water is the most effective in improving alkaline soil, it follows that the paddy is the most suitable in the course of soil improvement. Meanwhile, if the yearly cultivation of a paddy is impossible due to a scarce water supply, the period of its cultivation may be fixed during the rainy season; and in the dry season maize and vegetables having a comparatively stronger alkali-resistance may be cultivated. When the pH comes down beans may be introduced. Crops to beintroduced may also vary according to the scale of farming either in complete or partial cooperation. The project of Ujamaa village is an example of collective farming by individual farms. It seems that individual farmers are cultivating a certain acreage with bananas or maize which are their basic foodstuffs. Their culture of cash crops may be similar to the rotation of crops curently carried out by the East African Kenaf Company, rather than single crop throughout the year currently carried out by the Tanzania Planting Company. Possible formulas of rotation between cash crops and food crops may be as follows:

Rice - beans - maize. Maize - beans - vegetables.

Situations mentioned above, however, should be finally resolved by researches and tests.

It should be especially noted that no complete self-sufficiency of basic foodstuffs is available in Tanzania. Therefore, the program of rotation of crops should include maize which is virtually a basic and leading crop, having additional usage as a foodstuff.

In the district of Pare, uncultivated land extends widely and the water supply available is very limited. Utilization of water may be considered in correlation with possible cultivation of pasturage for the purpose of pormoting the small raising of cattle in stock-farming now currently in practice. For the low land development, a project should be reviewed to thin out bushes and build furrow irrigation in order that artificial grassland will be created. Production of hay may also be considered.

As mentioned above, agricuture in the low land depends mainly upon irrigation, as water is expensive and its supply is limited. Study on water-saving vegetation is therefore needed. Upon determing water requirments for different crop seasons, the method of culture will be selected from either complete irrigation culture or drought protective culture.

In conclusion, there are many unknown factors for the low land development, and a long-range program should be promoted, backed up by hydrologic data which will be collected, and the results of researches and tests on vegetation and soil improvement.

4. Existing Situations and Problems of Agricultural Experiments and Studies

(1) Status quo of researches and test:

(i) Cultivating technique

Crops under vegetation at the experimental station in Tanzania are maize, sorghum, rice, wheat, cotton and coffee. Plant breeding of these crops is carried out as one station, and other institutes and sub-stations are conducting tests on adaptability of strains and of varieties. Efforts are being made to breed a composite variety of maize and to breed sorghum by means of male sterility. Some breeds are being introduced from the East African Community Agricultural Research Division in Kenya. Twenty-four varieties of rice are also introduced from I.R.R.I. No breeding center is available here for bulrush millet, finger millet, potatoes, sweet potatoes and grasses; they are introduced from Kenya, the Netherlands, etc., and only comparative tests are carried out between these and Tanzania's local variety. Selections of crops through comparative tests of variety are to determine suitable crops, depending upon the situations whether N fertilizer is available or not. This suggests that non fertilized culture is affirmed and fertilization culture will not be able to occur in the near future.

Vegetation tests consists of tests of the seeding rate, seeding time, seeding method, formulas of culture, etc. Items of investigation are limited to the quantity of crop harvest, and few academic studies are noted from the standpoint of crop growing. In other words, basic tests are incomprehensive and the test results can not be analyzed, data of creating technical innovations being very few. Also there is almost no tests of water requirements by crop seasons and by type of soil which are required for low land development and irrigation culture.

Examples of fertilization tests are very few, while stuides of plant pathology and entomology are being developed steadily, although cases of study are minimal.

Studies of agronomy and soil chemistry are yet in the stages of experimental tests and analytical data are lacking, which is attributed to the fact that the staff, and especially a chief agronomist or chief soil chemist are unfilled in the sections and there is little equipment and material for research. Conditions at the Lyamungu Lyamungu Institute are no exception, and equipment for research is also lacking at the Miwleni Sub-station.

(ii) Status quo of studies on soil and fertilizer and necessity of technical cooperation

(ii) Status quo of studies on soil and fertilizer and necessity of technical cooperation

Agricultural researches and studies in Tanzania are being promoted at the Lyamungu Research and Testing Institute in the state of Kilimanjaro, and at five other institutes (Ilonga, Marti, Mtwara, Mpwapwa and Katrin) being under the management of the Agricultural Ministry. However, testings on soils and fertilizers are being conducted by only two institutes of Lyamungu and Ilonga.

The Ilonga Institute is conducting studies on soil fertility and tests of fertilizers, while the tests are limited to pot tests and field tests only.

The Lyamungu Institute has a section of Agricultural Chemisty, while the staff (research officer) is not appointed and no research is now under way. There is another section, Agronomy II, which is a special team of 7 members delegated from Canada, including research officers of soil and fertilizer. The team is now developing researches and tests on wheat.

Research officers are:

G Dargie and G. Myovela - Soil Fertility

E. W. Presant - Soil Pedology

J. L Henry - Tillage and Soil

They have so far achieved a soil map covering the Basotu district of 26,500 acre and the Arusha - Menduli district of 100,000 acre, and are also carrying out researches on humidity and pH, etc. in fields. The national soil map of Tanzania has been prepared by the staff of FAO, and the outline map has reportedly been worked out.

The above mentioned is the outline of researches and studies on soils and fertilizers by the Agricultural Ministry, which represents the fact that even basic testings are not developed yet for the Low Land Development of Kilimanjaro, due to insufficient research equipment and unfilled staff.

(2) Problems of studies on culture technology in agricultural development in the Kilimanjaro district

As mentioned above, the majority of researches and tests have been practical tests. No noticeable results have been achieved at the Lyamungu Institute, where studies on such grain crops as maize, sorghum, beans, millet, root crops, vegetables, etc. have just been launched; whereas study on coffee only has been steadily developed, achieving certain results. Shortages of staff and equipment is seen here also.

Under these situations, there is almost no knowledge or information on the discontinuance of interplanting or rotation of crops to improve soil productivity, methods of protecting soil erosion, and dry farming, all of which are necessary for increased production in the high land. In addition, only one or two tests were conducted regarding methods of improving alkaline soil or selection of suitable crops in the course of the said improvement, and the water requirements of the crop season, as well as methods of irrigation culture, and uses of water-saving vegetation. With a view toward creating a new technology to be applied to the areas now under cultivation, and also to establish a menu for technical vegetation in the low land, the number and quality research specialists as well as research equipment should be completely improved, especially at the Miwaleni Sub-station which is important for the low land development.

5. Cooperation in Respect to Development of Agricultural Technology

Promotion of technical cooperation to be appropriate, is divided into two phases, i.e. by collection of data on natural environment in the low land, improvement in soil and crop vegetation tests will be put into practice while the motivation research of the farmers will also be carried out in the first phase; these projects will be continued and Ujamaa village constructed in the second phase.

As chief agronimists and soil chemists, as well as laboratory and research equipment, are lacking at the Lyamungu Institute, research specialists will be dispatched and the necessary equipment will be loaned. In the low land, selection of suitable crops can be made on a borad scale, and cultivation is subject to irrigation. Selection of research specialists will therefore be made from among those who have made a career of research and culture in farm produce, especially grain crops, in the field of irrigation, and who have had experience in irrigation tests.

The following assistance will be put into practice:

(1) Two agronomists and one soil chemist.

Of the two agronomists to be dispatched, it is necessary that one be a crop scientist and the other must possess a knowledge of horticulture. These specialists will remain in Lyamungu and will be engaged in such works as basic tests, surveys and the analysis of test samples, testing irrigation culture at Miwaleni, and teaching testing methods at the Kilya Pilot Farm. Residences for these specialists will be located in Moshi city in view of the convenience of travel to the Miwaleni Sub-station for testing purpose.

Soil conditions of experimental fields are as follows, and the selection of experimental field will be subject to the onjective of testing.

Lyamung Institute: Volcanic ash and acid to a degree

Miwaleni Branch: Plain land with alkaline to a degree

Milya Pilot Farm: Alluvial soil and acid to a degree

(2) Training and education of counterpart

The counterpart will be trained and educated through the training course arranged in Japan and through guidance given by the specialists.

(3) Supplying of fresh crops and research instruments for dry materials:

Steelyards, electic dryers, leaf-planimeters, evapotranspiration measuring apparatus, etc. will be supplied.

(4) Supplying of farm machinery and instruments:

Tractors, plows, disk-harrows, subsoilers, sprayers, harvesters, trenchers, pots, atomic extinction analyzer, colorimeter, pH meter, conduction current meter, balance, etc. will be supplied.

(5) Furnishing data processor, etc.

Calculators, typewriters, copying machines, etc. will be supplied.

(6) Expansion and completion of the Miwaleni Sub-station.

The crop investigation room and a storage place for farm machinery and instruments will be constructed. A portion of the 76 acres of area currently available will be used for the experimental farm, to gether with a newly extended 10 acres where irrigation facilities can be secured. Spare sprinklers will also be installed.

(7) Perfection of irrigation facilities at Kilya Pilot Farm

Efforts will be made for the perfection of facilities because at present those available do not cover complete irrigation of the farm.

(8) Main themes of studies

1) Improvement in alkaline soil
2) Selections and methods of culture for suitable crops for irrigation agricu agriculture
3) Determination of the quantity of water required
4) Water-saving vegetation
5) Reasonable rotation of crops
6) Verification of creative technology

The above-mentioned assistance will take place in the first phase, but the studies and testings which will be continued in the second phase. When the pilot farm is established in Miwaleni in the second phase, the specialists will cooperate with the farm in its farm programing.

In addition, when a project agreement is executed, the specialists concerned will make detailed supplementary surveys and reviews on the machinery and instruments supplied, scope of farm expansion and size and/or dimensions of the investigation room and storage spaces.

III. CONDITIONS OF SOIL AND AGRICULTURAL DEVELOPMENT

A object of the present report respecting soil is to summerize the results of this survey and of several reports which concerned for the soil conditions in the Kilimanjaro State (i.e. "A Survey of the Soils and Land Use Potential of the Southern and Eastern Slope of Mt. Kilimanjaro, Tanganika" by G. D. Anderson, 1968; and "Report to the Government of Tanganika on the Soil of the Pangani Valley" Food and Agriculture Organization of the United Nations" Rome, 1959). Thus, the report intends to indicate clearly the problems with respect to usefulness of the soil in the surveyed area and, furthermore, to offer a proposal concerning future agricultural development in said area from a standpoint of soil fertilization science.

1. Soils of Surveyed Areas

There is copious rainfall, fertile soil and have a heavy population density in the high land of Kilimanjaro-region, a foothill areas of Mt. Kilimanjaro which has an elevation higher than 3,000 feet, and the norhtern areas to the main road between Moshi city and Tabeta village. On the other hand, in the areas lying below 3,000 feet. There is with rainfall, salt, or alkaline soils, therefore the soils have low productivity and there is a low population density which is most distinctly shown on the condition of soil development in this area in the following tables.

Moshi district	Large scale farming	54.715 ha
(Highlands are	Small scale farming	54.458
included)	Rough grazing land	167.056
	Unused land	154.218
	Total	430.447

Pare district	Large scale farming	10,000 ha
(lower land)	Small scale farming	30,000
	Rough grazing land	738,000
	Unused land	2,500
	Total	780,500

(1) The soils in the Highlands of the Kilimanjaro Region

In the highlands of the Kilimanjaro region, soils are generally fertile in comparison with lowland areas which will be discussed later.

The soils are of alkaline volcanic ash and rich in alkali, dark red brown, moderate humus, fine grains indicating a slight acid reaction. The soils are bulky and have a large water holding capacity. In the highland areas of the Kilimanjaro region, there is no alkaline soil (an inferior soils) which can generally be observed in the tropics.

We surveyed the following areas as patterns in the Kilimanjaro region high-land areas.

1. Lyamung laboratory (coffee plantation)
2. The west of Kilimanjaro - Mr. Brown farm (soils are sampled in the pasture)
3. Kiruwa village (Soils were sampled in a cabbage farm)
4. Furma village (Soils were sampled in a beans farm)

Soils of Lyamung laboratory and Kirwa village are of the same sort (Kilimanjaro No.8). In these belts, soil layers are deep fertile clay, the slope being 5-20^{o}. The quantity of rainfall amounts to 1,000-1,500 mm a year, former vegetation was forest, but nowadays cultivations of coffees and bananas are conducted. It is said that the cultivation of coffees, bananas, citrus fruits, pasturage of Leguminosae and vegetable are possible because of the fertile soils, and the phosphatic fertilizer can be expected to be effective.

The soils of Furma village are almost same as these of Lyamung and Kiruwa (Kilimanjaro No.27), but there rainfall is scanty (850-1,150 mm a year), the slope is 2-15^{o}, the soil layer is deep fertile clay containing a small quantity of gravel. This area was formerly a wood-like plain, but nowadays cultivations of maizes, beans, millets and coffees can be carried out, due to irrigation. The soils of Mr. Brown's farm in the west of Kilimanjaro resemble it, but it is said that there is often seen no crop of wheats, due scanty rainfall causing droughts.

Table 1 shows the results of a simple analysis of soils picked up during the surveys for reference.

(2) Soils in the Lowland of the Kilimanjaro Region

In this belt, there is little rainfall. The quantity of rainfall is 800 mm a year at the north part of the belt, and 600 mm or less in the south part. The topography is plains or moderate slopes along the Pangani river. Most of the soils in the belt are alkaline (salt soil), and most of the land are the steppe and utilized to pasturage of beef cattles, goats, etc. In the northern part of this belt, however, the development of irrigation agriculture by large scale farms such as Tanzania's Planting Company (13,000 acre of sugar cane farm), or Kenaf Factory (2,000 acre of Kenafs, maizes and beans) etc. was observed. Soils can also be seen which are comparatively weak in alkalinity due to the topography or soil properties.

Table 1. Values of Simple Analyses of Soils in the Highland Areas of the Kilimanjaro Region* (Surface soil 0-15 cm)

Soils	Colors	Soil Properties	pH (HCl)	pH (KCl)	Phosphoric Acid mg/100g	Phosphate Absorption Coefficient	Lime %	Potassium mg/100g	Organic Matter
Lyamung	Dark brown (5YR 3/3)	L:C	6.4	5.5	2.5	1000	0.2	30	Much
West Kilimanjaro	Dark brown (5YR 3/4)	L:C	6.8	5.7	10.0	1000	0.2	30	Much
Kirwa village	Dark brown (5YR 3/4)	L:C	- **	4.5	0.1	1500	0.1	3	Moderate
Kurma village	Dark brown (2.5YR 3/4)	CL	- **	5.3	0.1	1500	0.1	3	Moderate

* Denotes that the chemical analyses was carried out by the soil tester of FHK.

** Denotes that the measurements have not a high degree of accuracy because of the dispersion of soil perticles.

In the lowland areas, irrigation is indispensable to farming because of the shortage of rainfall, but the lands from disqualified irrigation due to bad condition of soils (mainly by its alkalinity) are considerably large. In the report on soil investigation of the F.A.O. which had been conducted formerly in this belt, the irrigation suitability in Pangani valley in this belt was decided as follows:

Lands suitable for irrigation (class II)	3,000 acre
Lands barely suitable for irrigation (class III)	13,750
Lands still under consideration regarding irrigation (class V)	113,150
Lands not suitable for irrigation (class IV)	97,000

The main zones surveyed in the lowland of Kilimanjaro are as follows:

1) Kiliya pilot farm (testing farm)
2) Naururu village (natural grassland)
3) Kishiwani village (natural grassland)
4) Lyamung laboratory, Miwaleni testing farm (natural grassland)
5) Pateeri village (natural grassland)

In these zones, soils in the natural grassland in the pilot farm of Kiliya and in Naururu are the most common ones (Pangani valley, second soils, irrigation adaptability V, F.A.O. which are seen in the Pangani valley). These soils are distributed in the plains along rivers, the soil properties are clayey and drainage is not good, due to the loose texture and overcloseness of the lower layers, though the soil layers are deep. Both the surface soils and lower soils are alkaline, and each soil layer contains carbonate. Substitutive sodium in the surface soils consists 7-25% of all substitutive alkali, and amounts to 50-90% in the case of lower layer soils. Soil reformation, therefore, is necessary for the farming which necessitates the desalting of the soil by fertilization by chemical substances (gypsum is normally used), irrigation and drainage.

In a part of Naururu village area, vegetation was a forest savanna, and its soil reaction was weak alkaline. In this area, the natives were cultivating maize, beans, onions, bananas, sweet potatoes, cotton, etc. Conducting soil reformations by irrigation. The texture of the surface layer of the soils developed into fine clod, and it was now regarded to be highly fertile (Pangani valley, second soil, irrigation adaptability II, F.A.O.).

Only one zone in the vast Pangani valley has such suitable soil for irrigation.

The soils of Pacheri were alkaline, but carbonate was not detected. These soils are of rough grain, and the topography is a slope of 1-2^{o}, and conditions for drainage were considered to be appropriate (Pangani valley, first soil, irrigation adaptability III, F.A.O.).

The soils of Kishimani and Miwaleni indicate an alkaline reaction in the surface layer, but carbonate was found in a very samll quantity. Data were not obtained in the adjoining areas, but it is considered that stabilized farming can be easily conducted by appropriate countermeasures which include irrigation and drainage. In fact, in the adjoining areas, such as that of Tanzania's Planting Company, sugar canes are now cultivated successfully by use of drainage in the area of 13,000 acre.

For reference, the values of simple analysis of soils of the surveyed areas are shown in Table 2.

(3) The Soils of Miwaleni Testing Farm of Syamung Laboratory and Kiliya Pilot Farm of Water and Electric Department in the Lowland of Kilimanjaro Region

Miwareni Branch and Kiliya pilot farm are considered to be especially important in performing a technical combined project of Kilimanjaro region. Soil prospectings were carried out, and sectional examination of the soils were conducted.

1) The soils of Miwaleni

Miwaleni is located in the most nouthern part of the lowland of the Kilimanjaro region. The soils indicate alkaline reaction, which is comparably weak due to topographical and meteorological influences. Therefore, oil parms, cabbages, onions, tomatoes, citrus fruits, red peppers, vines, etc. were growing fairly well due to drainage. In the surface layer (0-15 cm), a clod structure exists, and in the layer lower than 36 cm from the surface, structures are not detected, the closeness of the soils being high. Soils are heavy and clayey. These soils need great care in farm drainage.

The outline of sections of soils is as follows:

0-15 cm: Red brown (5YR 3/3) heavy clay, pH (KCl) 7.0, abundant in lime and potassium, quantity of carbonate is very small, organic substance exists, and square clods are of very tight closeness.

15-36 cm: Red brown (5YR 3/3), heavy clay, pH (KCl) 7.0, abundant in lime and potassium quantity of carbonate is very small, organic substance exists, and square clods are of very tight closeness.

Table 2. Results of Simple Analyses of Soils in the Lowland of the Kilimanjaro Region* (Surface soil 0-15 cm)

Location	Color of Soils	Soil Properties	pH (KCl)	Phosphoric Acid mg/100g	Phosphate Absorption Coefficient	Lime %	Potassium mg/100g	Organic Matters	CO_3**
Kishiwani	Dark brown (5YR 2/1)	L	6.8	12.0	1000	0.2	30	Much	$\pm$
Kiliya Pilot Farm	Yellowish brown (10YR 5/3)	CL	7.5	7.5	700	0.2	30	Much	+++
Naururu Village (A)	Brown (7.5YR 4/4)	SiLC	7.5		500	0.2	30	Much	+++
Maururu Village (B)	Black (7.5YR 1.7/1)	HC	7.0			0.2		Very Much	$\pm$
Pacheri Village	Red brown (2.5YR 3/4)	LS	7.0			0.2		Moderate	$\pm$

* Denotes that the chemical analysis was performed by FHK soil tester.

** Denotes foamings by HCl.

36 cm : Red brown (5YR 3/3), heavy clay, pH (KCl) 7.0, abundant in lime and potassium, quantity of carbonate is very small, combined from, absolutely tight closeness.

2) The soils of Kiliya Pilot Farm

These soils are the most typical alkaline soils in the lowland. There exists a great quantity of carbonate, and the soils show an alkaline reaction. The surface soil texture are clods, but layers deeper than 36 cm is of a combined form, and is not considered to show permeability in most parts. In the pilot farm 50 acres were prepared, and beans, bananas, citrus fruits, fruits, and maizes etc. were cultivated. According to the staff of the farm, many alkaline troublesarise in the growing period, and the alkalinity of soils is still high, even two years after the beginning of irrigation.

Outline of the section of soils in the farm land is as follows:

0-14 cm: Brown (10YR 4/6), light clay, pH (KCl) 7.5, abundant in lime, bubbles violently with HCl, clods

12-27 cm: Brown (10YR 4/6), light clay, pH (KCl) 7.5, abundant in lime, bubbles violently with HCl, there exists many combined matters of spotted carbonate (lime), very close texture, clods.

27 cm : Dark red brown (5YR 3/4), light clay, pH (KCl) 7.5, abundant in lime, very close texture, combined form.

2. Problems and Countermeasures

When performing farming exploitation in this area, the following questions on soils, and countermeasures at present will be given.

(1) The Highland of the Kilimanjaro Region

As formerly mentioned, the highland of Kilimanjaro is a slope and there is copious rainfall, therefore, there are not the alkaline soils which exist in the lowlands. And there are no important obstacles against the productivity of soil concerning land development in this belt which depend on comparatively abundant irrigation water. It is observed, however, that there happens considerable erosion of soil in the rainfall period when the farm land is a non-cultivated one, owing to its slope. According to the results of the existing survey examining the farms which are bare lands in south and west kilimanjaro, efficient nourishment in the bare land soils is much less than in others, which shows that on these farm, an outflow of fertile surface soil presumably occurs. Therefore, on the average farm, countermeasures such as contour line cultivation or manuring of organic matter containing mulch will be necessary to stop the errosion of soils. In this area, however, interest in manure is considered to be very low, because the soil is very fertile, but in order to perform efficient farming production, a measure of fertilizing processes as well as irrigation will be important subjects in the future.

(2) Lowlands of Kilimanjaro

It is considered that between the northern part and middle southern part in the lowlands, there exists a difference of alkalinity in the soils owing to the difference in quantity of the rainfall. In the northern part, farming exploitation is considered to be comparatively easy, but in central and southern part, it will be accompanied by considerable trouble because of the strong alkalinity.

1) North parts

Taking the soils of Miwaleni Branch as a example, the main feature is that it is consisted of heavy clay and shows very close textures, and there exist a non-constitutional upermeable layer adjoining the surface of soils, therefore irrigation and drainage must be conducted with great care, because of the water-holding power of the soils, and stagnent water. The alkalinity of soils is weak in this area so any outbreak of injuries by alkali will be comparably slight.

The reforming of its phisical properties will become in future a target for soil management.

2) Central and southern areas

Pangani valley remains in an undeveloped state in its greater parts, due to the strong alkalinity of the soil as well as extremely small quantity of the rainfall.

In most of Pangani valley, the effect of irrigation is reduced by the following factors, 1) The accumulation of carbonate (alkali) is remarkable throughout various layers of soils. 2) Soils are close and the quantity of efficient remaining water is small. 3) Accordingly, rainfall meets only the surface of soils, and fair portion of rain water runs out. 4) Soils are readily dried up. 5) Soils are readily dispersed and have a erosive property.
6) Vast area especially later plain alluvial soils shows a strong alkalinity.
7) Alkaline obstacles of soils exists.

An establishment of the reforming process of alkaline soils as well as decision of irrigation method in the farm land can therefore be expected as an important countermeasure for exploitation of the lowland zone. Where there is a high concentration of salts in soils or existence of an alkaline reaction, plants are subjected to damage. In these soils, it is necessary to remove the surplus salts from soils, and to regulate the soil reaction. In order to remove the surplus alkali, gypsum is added to the soil, and sodium in soils resolves into sodium sulfate by irrigation.

The F.A.D. report said that most soils in this area are considered to be expensive to reform, because the soils require 10-15 ton of gypsum or more per acre, but even in this case, it is considered that a large quantity of gypsum is not always required if inexpensive water can be utilized for it. It is said that some successful soil reforming effects have been obtained, as the result of the irrigation test carried out in Naururu by the Ministry of Agriculture.

Enormous water flows in the Pangani river today which should be utilized as water for farming. A complete drainage system should also be performed as well as institution of irrigation.

Irrigation is at first needed in alkali areas because of the dryness of the soil, but in the case of bad drainage, the complete drainage equipment becomes a more important matter, as well as irrigation, as there is the promotion of alkaline damage due to accumulation of alkali in the soil.

It goes without saying that an optimistic view about the reformation of the soil is not good because a considerable quantity of alkali has accumulated in the lower layer as well as in the surface layer of the soil of this area, and it must be considered that any reformation, even in the deeper layer of the soil, would take many years. The reformation of soil, however, must be conducted ranging from the surface of the soil to the lower layer little by little, and the crop increase should be gradually attempted, as some crops can be expected in the first or second year of exploitation.

Concerning agricultural products to be introduced, bananas, maize, various regetables, citrus fruits, vines etc. which have already been tested in Miwaleni, and Kiliya farms are all considered to be suitable. Judging from this belt having been left in the rough pasturage condition, grazing of beef cattle and goats, the acceleration of stockbreeding by the introduction of the grass is considered to be useful. Especially the introduction of deep rooting lucerne is considered to be hopeful because these soils are comparatively rich in nourishments such as alkali and phosphoric acid. Lucerne fixes a large quantity of atomospheric nitrogen and enriches the soil with organic matters. Consequently, lucerne will be a profitable crop especially for the soil which contains little organic matter and has bad phisical properties.

3. Technical Cooperation for Soil

As one of Japan's technical cooperations, the dispatch of specialists has been planned, and some views will be given about correlated matters as follows, on the standpoint of facilities of test and investigation.

The Present Situation of the Study of Soils and Fertilizers at the Agricultural Experiment Station of Tanzania and Requirement of Aids

Agricultural research in Tanzania is conducted in the Syamung National Research and Training Institute in Kilimanjaro and in five laboratories (Ilonga, Marti, Mtwara, Mpwapwa, Katrin) under the jurisdiction of the Ministry of Agriculture. Among them, in only Syamung and Ilonga, did they carry out the investigation concerning soils and fertilizers.

In Ilonga, investigations of fertility of soils and fertilizers are carried out, which are made by a greenhouse or pilot farm experiment.

In Lyamung, the Agricultural Chemistry Section has been established, but as there is no research officer, investigations has not been carried out. In this section, however, there are an Agronomy Section II and special team consisted of seven researchers dispatched from Canada, who are carrying out test and research of wheat. The members examining soils and fertilizers are as follows:

Soil fertility: G. Dargie and G. Myovela

Soil pedology: E.W. Presant

Tillage and soils: J. L. Henry

Concerning these tests and researches, there are maps of 26,500 acres of the Basotu region, and 100,000 acres of Arusha-Monduli on soil research. Soil chemical research on moisture and pH etc. of soils of pilot farms are carried out. It is said that the preparation of a soil map in Tanzania has been made by the officers of the F.A.O. and a simple soil map has completed. The above-mentioned are outlines of the research of soils and fertilizers under the Ministry of Agriculture, which explains that Tanzania is in a condition it being impossible to do the fundamental research required for the development of the lowland of Kilimanjaro, due to the shortage of material and researchers.

IV WATER RESOURCES AND THEIR DEVELOPMENT

1. Water resources and utilization

(1) Rainfall

Because detailed reports have already been submitted by the previous survey group as well as the preceding one on the statistics of rainfall in the Kilimanjaro Region, it is deemed unnecessary to repeat here again. However, the average rainfall amounts based on year round averages at the various locations of different altitudes in land as well as others are summarized in the following table. (See below.) It is seen in the table that higher altitude areas away from the sea receive greater rainfall. For example, the greatest amounts occur in the southern part of the Kilimanjaro region, followed by the eastern districts and that very small amounts are received in the western parts.

The rainy season is further divided. The heaviest rainfall occurs from March to June with somewhat less falling from November to January. The agricultural areas utilizing the rainfall are in widely separated locations around the base of Mt. Kilimanjaro and the lowlands adjoining. In the eastern regions of Kilimanjaro, the heaviest rainfall occurs from November through January, while in the other areas, the majority of rainfall occurs from March to May, and the agriculture profits accordingly.

Table: Year Round Rainfall at Different Altitudes in Kilimanjaro Region

(See attached references.)

Altitude (Feet)	Year Round Average Qty. of Rainfall (Inch)				Note
	East Mt. base	South Mt. base	West Mt. base	Pare Area	
5,500	51.4				
5,000		76.6			
		76.5			
4,800	40.0		24.6		
4,600	58.0	78.1			
4,500		73.9			
		70.4		51.0	
4,300		60.8	28.0		
		66.2	18.6		
4,200		86.9			
		58.8			
4,000		51.3		46.8	
3,300		52.7			
		53.2	39.6		
2,900		31.8		25.1	
		33.8	17.5	15.7	
2,500		26.8			
		23.7		21.7	
2,300		16.4		33.9	
		17.1		18.6	
2,200				18.1	

(2) Utilization of brooks and rivers

There exist several brooks in the high land of Mt. Kilimanjaro in the dry season as well as in the wet, and these are utilized for drinking and agricultural purposes in the areas under cultivation surrounding the mountain base.

The irrigation facilities are mainly established in the banana and coffee fields by digging water trenches for natural flow. Up to the present, the plan of supplying drinking water through the pipes has been followed at 21 locations in the Moshi and Rombo areas and the plan is now additionally under way at 20 other such locations.

In addition to the brooks, small reservoirs (the earth dams), H = 20 - 30 m, Q = 50 - 1000 x 1000 m^3 constructed at the altitudes of 5000 - 5400 feet, are also used as water sources. At the present, 150,000 people in the entire region are said to be supplied with water by these pipes.

There are a number of small brooks and rivers originating at high altitudes in Kilimanjaro which diminish upon reaching the flat areas. These small brooks and rivers have enough force and volume to reach these areas only in the rainy season, and die out at other times for lack of channels. On the other hand, they overflow in the downstream areas in the wet season. Yet, this flooding is helpful to the irrigation of the cultivated areas in these latter areas.

There exist permanent rivers flowing into Nyumba Ya Mungu Dam (except Nairobi), located in the upper area of the Pangani River, such as, (from the north to south), Lume (Lumi) Himo, Mue, Rau, Ruvu Kikuletwa, Weruweru and Nairobi. The following table suggests the approximate quantities of inflow from these rivers, keeping in mind that the quantities during flooding are not clearly known.

Table: Quantity of Water-flow from Major Rivers

Rivers	Location of Survey	Quantities of flow		Term of Survey	Remarks
		Dry Season	Wet Season		
Ruvu	Kifaru Estate Bridge	88 - 386		1952 - 1959	Lake Jupe
Mue	Railway Bridge	98 - 179		1952 - 1956	Miwaleni Spring Zone
Rau	Kahe Forest	0 - 2	1 - 2	1972 - 1973	"
"	Kahe	11 - 38	21 - 89	1953 - 1956	"
"	National High-way Moshi-Taveta	2 - 30	16 - 232	1952 - 1959	"
Miwaleni Spring	Spring	110 - 154		1958 - 1959	Miwaleni Spring
Himo	Himo	11 - 46	47 - 268	1952 - 1957	
Weruweru	T.P.C.	12 - 132		1971 - 1973	
Sholo	National High-way Moshii-Taveta	0	1 - 43	1952 - 1958	
Uchira	"	0	2 - 67	1953 - 1959	
Nairobi S.	National Highway	1 - 40		1956 - 1964	

From the rivers flowing into the Pangani River, the representative river chosen for this agriculture study will be the Weruweru River flowing down to the west of Moshi City. Water is taken at two locations below the latter's juncture with the Kikafu River for use in irrigation regarding the sugar cane planted in 13,000 acres on the left bank of the river.

This is under the management of T.P.C. (Tanganyika Plantation Company) which holds most of the water utility rights to the Weruweru River. It is currently extending affairs to the upper stream also.

The water source for this expansion is to be the underground as cited in the plan. The system of irrigation consists of channels created between dikes as well as by sprinklers.

(3) Utilization of spring water

There are a number of springs, not only in this field study area but also at the base of Mt. Kilimanjaro including the environs of Moshi City. They are used directly as drinking water without any purification process because of the good quality of them.

There is a spring area with a quantity of about 115 cusec at Miwaleni (15 km south east of Moshi City). This quantity is held constant regardless of the season (minimum 110 - maximum 154 cusec, as recorded in 1958 & 1959), and is used at present in the Kahe Irrigation Scheme (present area is about 4,000 acres).

This scheme, aided by water utility rights established to cover about 100 cusec, has brought about a completion in the construction of the water intaking facilities and major water channels. It is furthermore expanding the agricultural field areas. At present, by means of irrigating the large dike area (about 10 acres) by natural flow, they are able to grow kenaf and have inter-related processing factories within the areas.

At Taveta, Kenya, located about 40 km east of Moshi City, a large volume of springwater considered a hidden water source from Mt. Kilimanjaro, exists. It is utilized for irrigation and other purposes in the down stream areas, while the remaining unused water flows into the Papangani River (via Jipa Lake) and Ruvu River of the Pare area.

(4) Utilization of Nyumba Ya Mungu Dam and Pangani River

There is a dam (constructed in 1966) at Nyumba Ya Munga. This dam was created for generation of electricity and for irrigation of and control of water as a prevention against flooding. It has a surface area of 15 km^2 and has a maximum capacity of 11,400,000,000 ton of water. At the moment, it is used solely for the generation of electricity and to aid the Hale Power Plant located further downstream.

Water capacity following completion has come to operate on a cycle. The dam is filled to higher level at the latter part of the large rainy season annually and is lowered afterwards, but may be not filled to the maximum capacity according to annual conditions. The largest maximum over-flow rate is about 100 m^3/S and less than maximum flooding quantity, 920 m^3/S, according to the plan.

From this view point, it can be said that the water resources in the Kilimanjaro River areas are, despite floods, extremely well maintained. However, the Hale Power Plant which uses the stored water is located 120 km downstream, and the loss of water quantity in flowing this distance is said to be up to 40%. In addition, the precious water supply is used only for local energy purposes and is lacking further usefullness, the water flowing into the Indian Ocean. This method of water utilization, from the view point of available water supply of the present, cannot be said to be appropriate.

1) Specifications of the dam

Capacity:	1,140 million m^3
Type:	Slope-core, rock-fill
Length:	400 m
Height:	43 m
Volume:	603,000 m^3
Maximum flood-water storage planned:	2,200 m^3/S
Capacity for excess water:	920 m^3/S
Surface area of water filling the dam:	50 km^2

2) Water utilization plan outlined at the time of the dam's construction

		(acres)	($4m^3$)
1)	Irrigation scope of upper Miwaleni	2,000	16,800
2)	Kahe irrigation scope	8,800	72,000
3)	Marwa pump irrigation scope	7,000	43,200
4)	Naururu irrigation scope	2,200	24,000
·	Total:	20,000	156,000

3) Current utilization of dam water

		($4m^3$)
(a)	Annual average quantity flowing into the dam	1,056,000
(b)	Amount used	1,251,000
	Generation of electricity	819,600
	Evaporation and loss	240,000
	Kahe allowance	72,000
	Water resource rights in Kenya	120,000
(c)	Amount in deficit	195,600

As can be seen above, there exists a substantial difference between the degree of utilization of N Dam water now and at time the plan was outlined. The major reason for this is considered to be the increased requirement for electricity, although the overestimation of inflow quantity and the underestimation of loss must also be seen as factors.

The deficit is indicated on the statistics shown above, but a balance between the demand and the supply is barely maintained as the Kahe development is at the half-way work and the actual use of water in Kenya is less than the estimated figure shown in the original statistics.

Anyway, from the view that priority has to be placed on the supply of electricity, it is almost impossible to take any quantity of water from downstream or upstream areas since it is there in proportion to agricultural needs as planned. However, the future plans for the generation electricity point to the completion in 1975 of the Kidatu Power Station (100,000 KW) in north-east Tanzania. It is under construction by The Great Ruaha Power Project.

The electricity generated will be supplied to the eastern coastal area (Dar es Salaam being the center), and the present power station at Nale (20,000 KW) will be used only for emergencies. N Dam Power Plant (8,000 KW), when filled to capacity can meet the requirements for Moshi Arucha area at the present, but the great pressure existing upon the electricity supply in this area should be eased by the completion of the electricity supply connection line in 1975 (Connections with the east coast area).

It is necessary to have an appropriate definition of the water rights with TANESCO (Tanzania Electric Supply Co.) and Kenya in the near future.

Including water stored in the dam, the water resources in the Pangani area will now be available for agricultural uses. Regarding the utilization of water from the Pangani river, there exists only natural flow irrigation on a small scale with water being taken at three places. At Naururu, only 0.4 cusec of water is obtained for the Kiliya Pilot Farm.

This Kiliya Pilot Farm is an experiment in the development of N Dam downstream area water utilization.

(5) Utilization of underground water

In various places the Borehole pump is being used to supply drinking water and water for the raising of cattle. Regarding agriculture, the Branch Institute at Miwaleni of the Lyamungu Agriculture Institute, where the utilization of underground water for irrigation is being undertaken other than the TPC Plantation mentioned above.

The Miwaleni branch is located in the upper area of the spring reservoir at Miwaleni. At present, they have 76 acres of farmland, of which 22 acres are being used for the experiment. The Borehole Pump is being employed for drawing water from the underground. This seems to be appropriate for the irrigation of about 50 acres.

The following is a record of the utilization of underground water by these experiments.

Table: Kilimanjaro Region Underground Water Situation

B.H. No.		Total depth	Water level	Qty. of water drawn	Quality of water	Water containing layer	Remarks
		(ft.)	(ft.)	(g.PH)	(PPM)	(ft.)	
36/65	5km South of Moshi, South of National Highway	220	7	20,100	Good	70,160,200	
27/65	7km East of Moshi, South of National Highway	245	26	26,400	"		
29/65	15km East of Noshi, South of National Highway	198	18	32,000	"	40.92	
8/65	20km South east of Moshi, South of railway	200	26	22,000	"	35	
12/65	20km South east of Moshi, South of railway	175	22	22,000	300	12 - 175	
22/65	20km South east of Moshi, South of railway	178	21	38,000	300	25	
29/61	30km North east of Same	3.50	200	3,000	Good	262.308	
13/61	15km North of Same	215	155	2,000	"	160 - 305	
7/65	Country border in North East of Kenya	300	224	2,100	"	245 - 260	

2. Water Resource Survey and Technical Cooperation

(1) Future Investigation

Cooperation on water resource survey will commence with the collection, examination, and analysis of existing data, the reorganization of existing observation net-works, and the performance and analysis of observations. In particular, a survey will be required to ascertain the underground water resources in this area. The details of future investigations are as follows:

1) Collection of existing data

The problems of existing water observation facilities and systems will be examined, and relevant data will be utilized.

The data thus collected will be analyzed and an effective observation system will be organized.

The actual conditions of present water utilization and future water requirements will be studied.

2) Reorganization of observation networks and performance and analysis of observations

Existing observation facilities and systems will be reorganized and expanded as required and new observation objective shall be consistent with the requirements of proposed water utilization schemes.

A survey of underground water will be performed will reference to existing data. The requirements of future development schemes will also be considered in this case.

The results of this hydrological investigation (drought, rainfall, underground water, effluence, etc.) will be examined and analyzed to study long-term water utilization.

3) Terrain studies

Terrain conditions such as ground configuration and soil will be investigated for future development schemes.

4) Training of local engineers

Water resource investigations will be conducted together with the local counterpart team to provide them with in-service training.

(2) System of Technical Cooperation

For the water resource investigations described in the previous paragraph, hydrological engineers who will work with the local survey organizations shall be dispatched. Since this investigation will be geographically and technically extensive, and will effect future development schemes, these engineers shall carry out the investigation in cooperation with the irrigation specialists and civil engineers dispatched to assist with the development of the agricultural lands mentioned below. At least two hydrological engineers will be required for water resource investigation on a long term basis because of the level of technical competence of local engineers.

Additional specialists shall also be dispatched for a short-term survey and for technical guidance. A jeep shall accompany the dispatched engineers. Local observation equipment shall be used as a rule but ten self-registering rain gauges and ten hydrographs (once per day winding) will be required. Boring machines with accessories will also be required because of the importance of underground water investigations. In addition, a desk computer and a photocopy machine will be necessary.

Many kinds of the instrument may be provided for the survey. However, temperature difference between daytime and night is very large in the tropics, and such troubles as temperature distorsion of the parts of the instruments and solidification of ink by evaporation tend to occur in the area. For this reason, recorders of long interval winding type fail often in continuous measurement; therefore it is advisable that the daily winding and simple type is installed in area capable of daily measurement.

V. DEVELOPMENT AND IMPROVEMENT OF FARM LANDS

1. Condition of Farm land and Possibility of Development

(1) Moshi and Rombo Area

This area has Mt. Kilimanjaro to the norht and is a mountain region more than 9,000 feet above sea level. There is a forest reserve 6,000-6,500 feet above sea level on the south-east slope and 5,000-5,500 feet above sea level on the west slope of the mountain. High level regions adjacent to the mountain region have high rainfall and are agriculturally developed with irrigation facilities. The region up to 3,500-4,300 feet above sea level is the most stable agricultural region and perennial crops, mostly coffee and bananas, are cultivated there. The most important export product of Tanzania, coffee, is also produced in this region. However, since the cultivation area of this region is as small as 1.5-4 acres per household, the population density is high, and with an average slope is 1/5 - 1/10, there is little margin for new development. On the south slope of the mountain, coffee estates have been developed by the government and distributed to peasant proprietors in accordance with government policy.

The lower regions from 2,600 feet (on the south slope of the mountain) to 4,000 feet (on the east slope of the mountain) above sea level are comparatively stable lands for cultivation utilizing the rainy season. The average slope is 1/10 - 1/40, with little flood damage in the rainy season.

The above regions are called the Highland, or Kilimanjaro Agriculture Regions, and agriculture here is the most developed in Tanzania. The Lowland, adjacent to the Highland, has little rainfall and is occupied by undeveloped such savanna and experiences drought conditions, although agriculture utilizing the rainy season in developed in the part nearest the Highland. In particular, the south slope of the mountain suffers extensive damage by intermittent flooding because of the gentle slope (1/100 - 1/300) which starts here.

The Lowland has comparatively good soil conditions and could be agriculturally developed with an adequate water supply. However, since soil conditions become poor downstream, the T.P.C. and Kahe irrigation schemes make the region of 2,200-2,350 feet above sea level the lower limit of development.

The rainfall on the high west slope of the mountain is less than on the south-east slope, making stable cultivation difficult to the south of the 3,000 feet contour line. There are a few coffee farms, and fields in the flat parts suffer drought conditions.

(2) Pare Area

Although the Pare area was not studied thoroughly, the tops of both Mt. South Pare and Mt. North Pare have 1,000-1,500 mm of rainfall annually and are suitable for cultivation, but the plain has only 300-500 mm of rainfall, and is not utilized agriculturally. Most of the area west of the Pare range and extending to the Pangani River is sparse bush savanna has been utilized for nomadism, with only sisal farms and some agricultural land on the left bank of the Pangani River, The soil conditions of this area are as mentioned before. For future development, a detailed survey and examination of soil conditions will be required. The east Pare area was not studies. Noticeably, two-crop culture by flood irrigation, for example aquatic rice culture by utilization of flood in large rain season and corn culture in small rain season, have been continued in a part of the farms near the foot of mountains of the area.

2. Agricultural Land Development and Improvement Schemes and Their Implementation

The state government has the following development and improvement projects under construction or consideration.

Most of these schemes are for the improvement of existing cultivated lands in the Lowland using known water resources, or for the development of immediately adjacent undeveloped lands, but there are few largescale schemes for the development of savanna. Therefore, quick results from these schemes can be expected with small development cost.

The schemes shown in the Table 2-1 were made by Egyptian engineers dispatched for technical cooperation by the Egyptian government in 1966 to 1972. The Kahe irrigation Schme was also carried out by these engineers. Egyptian technical cooperation has been suspended since the Middle East War in 1972, and most of the Egyptian engineers have been recalled. At present, Indian engineers are helping the Water Department of the state government. Most of their work involves the design and construction of pipe lines for drinking water and agricultural development works are not yet started.

Therefore, there are not enough technically skilled personnel available for the design and construction of the above development and improvement schemes, which is causing the implementation of these construction works to be delayed. It seems that there are many effective and feasible projects in addition to these schemes.

Table 2-1 Irrigation and Flood Control Schmes

Kilimanjaro Region Financial Year 1972/73

No.	Name of Project	District	Acreage	Estimated Financing Cost (Shs)	Agency	Work to be Done	Remarks
1.	Mlwaleni Irrigation Scheme	Kilimanjaro	200 (Pilot Farm)	460,000	Central Govt.	Desings to be completed	1973/74 budget, design for 2,000 acres for Ujamaa
2.	Pangani Irrigation Scheme	Pare	200 (Pilot Farm)	-	"	Construction to be continued to finish 200 acres	Land levelling
3.	Mtakuja Ujamaa Village Irrigation Scheme Phase 2	Kilimanjaro	200	160,000	Regional Development Fund	"	
4.	Kileo Irrigation Scheme	Pare	500	1,000,000	Central Govt.	Construction to be started and to be completed	
5.	Msaranga/Mandaka Flood Control Scheme	Kilimanjaro	-	650,000	"	Survey	
6.	Gunga Hedaru Irrigation Scheme	Pare	200	500,000	"	To finish a detailed survey and design	
7.	Gonja Irrigation Scheme	"	1,000	-	"	To investigate soil survey and design	
8.	Kalimawe Irrigation Scheme	"	-	15,000	"	"	
9.	Lower Middle Mkomazi Irrigation Scheme	Pare	-	-	Central Govt.	Topographic survey and soil survey	
10.	Ndungu Irrigation Scheme	"	-	-	"	To improve existing scheme	
11.	Uru Chini Irrigation Scheme	"	640	-	"	"	
12.	Naururu Irrigation Scheme	"	2,600	8,500,000	"	Survey and design had been done	By UNSF & FAO

(1) Upper Miwaleni Irrigation Scheme

The details of this scheme will be described later. It involves the cultivation of about 2,000 acres of bush savanna in the upper Miwaleni spring zone by utilizing Miwaleni spring zone by utilizing Miwaleni Spring as the main water source. The project also involves the development of Ujamaa Village. This project area also includes 200 acres of the Miwaleni Experimental Farm (presently 76 acres).

Priority is given to this project among the previously mentioned agricultural land development and improvement schemes of the State of Kilimanjaro.

1) Rights are already given for 18 cusec. of water intake from Miwaleni Spring and the pumping of underground water from upstream.

2) Soil conditions are better than those of the Pare area downstream.

3) This area is adjacent to Highland agricultural land, which is convenient for the settling of farmers and for the transportation of the products.

For these reasons, this project deserves a high priority. This project has the following features:

1) It is not to manage the farms by the government or by enterprises such as the Kahe irrigation scheme or the T.P.C. sugar cane plantation, but to construct Ujamaa Village for the performance of irrigation agriculture.

2) As are the Msaranga and Mandaka areas, this area is subjected to annual flooding by small streams flowing into the area. The project involves the prevention of flooding and irrigation by the utilization of flood waters.

These features will make the project a model for future development and improvement of undeveloped lands, since the development of agriculture in Tanzania will succeed only by the modernization of villages using Ujamaa as a center.

(2) Flood Prevention and Irrigation Schmes of the Msaranga and Mandaka Areas

About 20,000 acres of the Lowland area south-east of Moshi, surrounded by the Kahe-Moshi railway and Kahe-Taveta highway, are fertile with good soil conditions and include lands which are already used for the cultivation of maize and beans. However, these areas experience flooding by small streams including the Mola, Sholo, Uchira and Nanza rivers, which flow from Mt. Kilimanjaro into the areas. (These streams disappear in these areas.) Since the water from these streams is the only water available for the irrigation of these areas, the flood is an opportunity for an irrigation water supply, especially in the downstream areas. These areas suffer alternate upstream flood damage in flood years and downstream drought damage in drought years. Extensive flooding to depths greater than one meter occurs every five or six years and causes great damage to crops and to structures. Since these areas are adjacent to the Highland, great improvement and development can be expected if flood control and an irrigation water supply are possible. Even if underground water resources are developed in the future, this would not provide a secure, full time water source for irrigation. Therefore, the present problem is the prevention of flooding and the effective utilization of flood waters.

We would suggest you the following tentative plan to be investigated.

(3) Development of Savanna by Utilizing Water from the Nyumba Ya Munga Dam

The most attractive scheme among the Lowland development schemes of the State of Kilimanjaro is the development of the downstream area by utilizing water from the Nyumba Ya Munga Dam. In this area, there are more than 30,000 acres of undeveloped plain and adjacent savanna made usable by the flood control action of the dam. Although the dam water is presently being utilized only for the generation of electric power, the demand for hydroelectricity will filled almost after the completion in 1975 of the Kidatu Power Plant. Therefore the agricultural development of this area seems to be taken up as an important theme for the effective utilization of this valuable water resource.

The FAO also has agricultural land development schemes for the Pangani River basin, including 7,000 acres to be irrigated by the Marwa pump irrigation scheme and 2,200 acres to be irrigated by the Nanruru irrigation scheme utilizing dam water. The project will be enlarged if the problem of soil conditions is resolved. However, agricultural development of this area involves following various problems:

1) There are soil problems to be resolved.

2) More construction funds are required for the development of agricultural lands.

3) Since this area is far removed from existing agricultural zones, not only will the development of agricultural lands be complicated, but facilities, such as health and educational facilities, will be required for the settlement of farmers and for village development.

4) Marketing, transporting, and processing facilities for the agricultural products must also be developed.

3. Cooperation of Japan for the Development and Improvement of Agricultural Lands

(1) Steps for Lowland Development

Although the effective utilization of lands and water and the modernization of agricultural management are required on a continuing basis for Highland agriculture, effective land utilization in the Lowland, by agricultural development and improvement, is also indispensable to provide a stable and secure food supply.

The ultimate aim of Lowland development in the State of Kilimanjaro is the development of the downstream area by utilizing water from the Nyumba Ya Munga Dam as a stable water resource. For this development, however, a great deal of funds are required. The establishment of schemes for the most effective utilization of lands and water and further studies of basic soil problems are also necessary. Since this area is undeveloped land with few inhabitants, there are many remaining problems to begin village development and advanced irrigation agriculture by the settlers.

There are many areas requiring development and improvement in the upstream and east Pare areas in the State of Kilimanjaro (of. Table 2-1). Although these projects are generally small in scale and involve many problems such as the development of flood preventation facilities and water resources for irrigation and drinking water, the soil conditions of this area are better than those of the downstream area. Therefore, results can be expected from small funding if the projects are carefully planned and since in these areas (at least in the adjacent areas) there are existing cultivated lands and inhabitants, these results should occur quickly. For these reasons, it would seem that development should be started in the upstream areas and then extend to the downstream areas with the accumulation of irrigation agricultural engineering experience. The government of Tanzania agrees with this concept.

(2) Technical Cooperation of Japan

a. Course of technical cooperation

If the agricultural development and improvement schemes in the State of Kilimanjaro are started in the upstream Lowland areas, and then extend to the downstream areas, Japan's cooperation should meet the needs of these schemes. For the development of the upstream Lowland areas, there are many concrete schemes, as shown in Table 2-1. There are many other development schemes covering small areas that are effective for small-scale flood prevention and for the utilization of surface water in the rainy season. There are also schemes for developing drinking water facilities for the settlement of farmers.

The development of agricultural lands involves:

1) An offer to provide engineering personnel for the design and construction of these development schemes in the Lowland areas, including land utilization and agricultural management schemes;

2) An offer to provide the machinery and equipment needed for the construction of facilities on projects for which Japan's cooperation is required;

3) Guidance of agricultural management in areas to be developed and improved, and guidance of irrigation agriculture for the effective utilization of available water.

For these purposes, a team consisting of irrigation, civil engineering, and agricultural management specialists should be dispatched on a long term basis.

b. Cooperation on the upper Miwaleni irrigation scheme

The details of this project have been worked out and the project is ready to enter the design stage. Therefore, the project should be given high priority.

The basic land utilization, water utilization and agricultural management schemes should be examined by the specialist team, and design and construction assistance should be given as quickly as possible. An assistance design team will be required for a short period. The dispatched euipment operators and mechanics will help to train local personnel.

The assistance for this project includes an offer of machinery and equipment (pumping facilities, water pipes, etc.) for the construction of Ujamaa Village. Since this village will be a model for irrigation agriculture performed by the local farmers, only the minimum necessary amount of agricultural equipment (tractors, sprinklers, etc.) and other facilities (warehouses, drinking water supply facilities, etc.) whould be provided. As this project involves irrigation by pumping, local engineers should be trained to operate and maintain the pumping facilities.

TENTATIVE PLAN FOR FLOOD CONTROL AT MSARANGA MANDAKA AREA

About ten torrents with their source on the south side of Mt. Kilimanjaro, flow into the districts of Mandaka and Miwaleni. After passing through the Moshi-Taveta national road district, the streams spread out and overflow into the level lands. The overflows pass across the Taveta-Kahe reilroad area anf flow towards the south-east finally emptying into the rivers of the Rau and Mua. In normal times. These streams have little water; whereas the Rau and Mua rivers rise in the southeast portion of Moshi city or in the springs of the Miwaleni district and their flow is about 100 ft^3/sec. even in the dry season. (Please refer to the Table - Flux in Main Rivers - in the preceding Chapter).

The angles of descent of the streams are very steep until they descend to an altitude of 3,000 ft. The grade then suddenly becomes more level. Before flowing into this district, the sectional areas of the streams are forced to become smaller, especially at the points across the National Road Bridge and at the National Road culverts. While flowing through this district, the streams form many separate streamlets due to the influence of the terrain which consists of many small irregularities. The descent of the running water may be far less rapid (five to ten times) than the grade of the terrain, which is approximately 1/100 - 1/300. Actually, the streams have lost their strength to carry down earth and sand as they could have in the upper streams. Their loss of strength has resulted in less soil erosion while the alluvial soil carried by them is deposited in the neighborhood of the national road. As a result, the soil in this district is extremely fertile.

The result is that heaps of pebbles are found in the upper streams, while there are no such deposits of pebbles found in this district.

The following equation is widely used in determining planned peak flow rate:

Q = 1/360 C.I.A.

Q: Planned flow rate (m^3/sec.)

C: Coefficient of outflow (Peak flow rate)

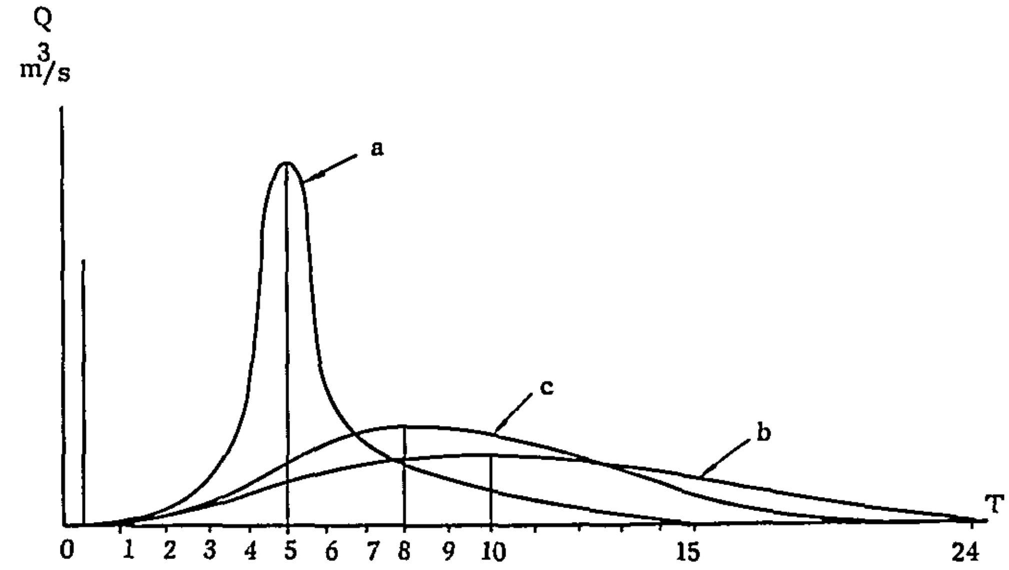
I: Rainfall Intensity within Time to reach (mm/hour)

A: Area of Basin

The following figures are generally used in C:

Mountain district with steep grade	0.50 - 0.60
Mountain district with gentle grade	0.30 - 0.40
Plain land with dense vegetation	0.10 - 0.20

On this assumption, the following hydrograph is drawn:



In the case of A, the curve of the outflow takes the pattern of (a) in the upper part of the national road, whereas it takes the pattern of (b) at the confluence with the Rau river. The starting time of the peak flow rate is delayed by 5 hours and the flor rate is 1/5. The area surrounded by the curve (a) is equal to that surrounded by the curve (b) (the total quantity in both cases is the same). When considering the curve (b) under the actual conditions here, the area of the river is very large as the river is reticule. Whereas the average flow of water is less and the speed of current is less rapid since the degree of inaccuracy is increased by the abundant vegetation. This results in the phenomenon of retardation, and the water which enters in 15 hours, flows out in 24 hours.

In connection with this phenomenon of retardation, the curve (b), when compared against the curve (a), represents a very low response to the rainfall intensity at its peak flow.

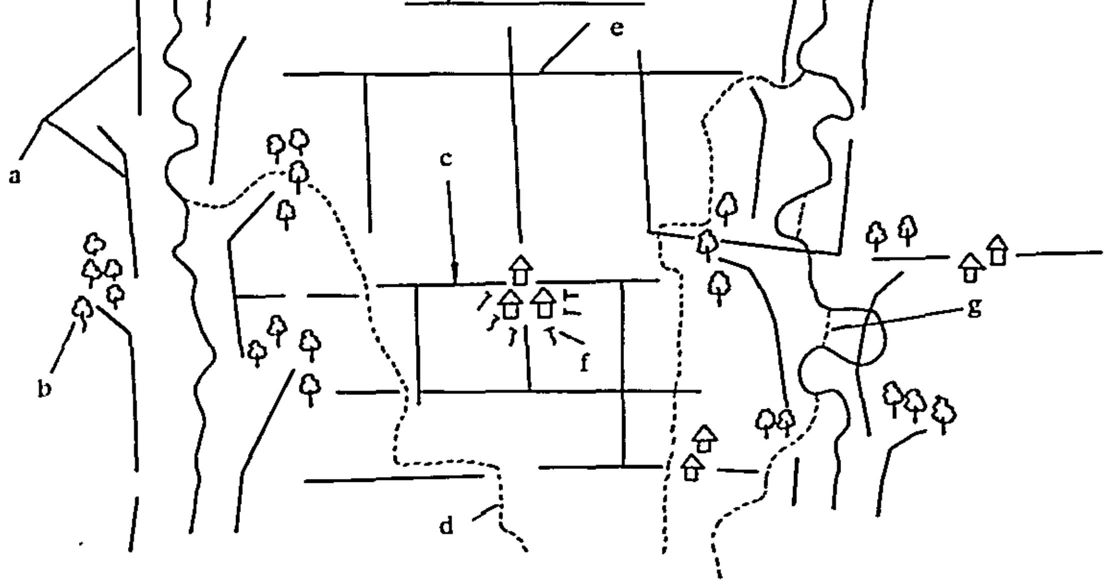
Apparently, there are no permanently fixed waterways in this district. Should the waterways be improved artificially on a consolidated plan, the curves of the flow rate would follow the pattern of (c). Contrarily, if cross levees of gabion were to be constructed along the contour lines to secure both more water reservation and a greater retardation of the outflow. A more decreased flow at the peak and a much longer time for the outflow than in the curve (b) will be obtained.

In the event wider area sections of the rivers may be planned as in this district, it would not be a sound policy to stick to the curve (a) in terms of the seasonable rainfall intensity. It would be more advisable to givae thought to the retardation of the flow of water which is important and valuable for irrigation, with no resulting damage to the farmland.

The following matters should be taken into consideration in planning construction of storage facilities on the basis of existing streams, with a view of obtaining less retardation and quicker outflow in such a pattern of curve as (a). The peak flow rate which is currently high, will multiply. Both the flow rate and speed of current will greatly be increased. Natural disasters are liable to be caused by these conditions. Various kinds of engineering techniques will also be necessary for maintaining the river-bed in good condition until the river reaches the debouchment.

It would be advisable to plan and build reticule waterways which may decentralize damages due to overflow in the event it occurs. For this purpose, the construction of intermittent levees (termed open levees) of corss levees, to be utilized as farm roads in the future, is appropriate. These levees may be built for the best use of natural terrain in view of the most effective application of flood irrigation, and the widths of the levees may be optional. Seemingly, there is comparativaely less influx of earth and sand in this district. However, engineering techniques may be aided in the preventionof shifting sand by making more use of the natural resources, e.g. planting trees at the back of the openings of the levees.

Map for Reference



a. Intermittent levees b. Reforestration or Natural vegetation

c. Cross levees used as farm road d. Outlet for overflow

e. Farm load f. Banking g. Arrangement of flows (blocking)

Note: It is advisable to widen the river with intermittent levees for the following reasons: Sixty percent of rainfall during a day can drain in 24 hours. The depth of water should be kept at not more than 1 m with a view toward keeping the velocity in its minimum, depending upon the materials used for the river bed.

VI. DEVELOPMENT OF UPPER STREAM OF MIWALENI (TENTATIVE PLAN)

1. Present conditions and basis of selection

The reasons we selected this area are as follows:

(1) Neighborhood of the highland - To avoid rapid changes of social and living environment surrounding immigrant farmers.

(2) Alkalinity: pH 8.0 - Soild in the low land have generally alkalinity of pH 8.0 - 10.5. Trials to higher pH such as 10.5 may cause troubles in soil improvement, cultivation methods, etc. For this reason, this area is appropriate for development and study.

(3) Water rights - Water rights of 0.5 m^3/s have been entitled in respect with the Miwaleni spring water.

(4) Irrigation by pumping - The development may be a model of irrigation by pumping since the low land utilizes rivers (including water-intake by pumping) and ground water as water resources.

(5) Scheme or Kilimanjaro state government - The development scheme of this area had been given the highest priority by the Kilimanjaro state government.

Present Conditions

1) Climate

The annual rainfall of 600 - 1,000 mm is comparatively small. The rainy seasons come twice; the major rainy season in from March to May and the monor rainy season in from September to November. There are no rainfalls in other months and no crops can be produced under natural conditions.

The annual mean temperature is 24 to 25°C.

2) Conditions of land

(a) Altitude: 720 m at the highest and 700 m at the lowest.

(b) Gradient: Not less than 3 - 5° over the whole area. Marks of small erosion by water flow exist in some parts.

(c) Soil stratum: Research over the whole area is needed.
Investigation at one test pit represents 1 m or more of stratum.

(d) Soil property: Research over the whole area is needed.
Investigation at one test pit represents that the soil is of volcanic ash CL.

(e) Pebbles: Research over the whole area is needed.
Investigation at one test pit represents that there are no pebbles.

(f) Soil improvement: Research over the whole area is neended.
Investigation at one test pit represents alkalinity pH 8.0 and requires necessity of soil improvement.

3) Conditions of vegetation

Thorny bushes (Nghi) thickly grow all over the area. Vegetations are 1 - 2 per 3.3 m^2 and bigger ones have diameter of some 25 cm, and the average diameter is from 10 to 15 cm . Trees are not so tall, being from 3 to 6 m in general.

4) Ownership and utilization of land

(a) Land ownership

All the lands of Tanzania are the national land. Individuals are entitled to the land utilization right, while this area is an uncultivated area and is freely opened for utilization.

(b) Land utilization

The area is luxuriant with thorny bushes (Nghi) which are not being used effectively. Wild plants growing autogenetically between the bushes are utilized as feed for grazing.

5) Water utilization

There is the Miwaleni spring water in the down stream of this area (min (minimum: 115 cusec = 3.1 m^3/s), and water rights of 0.5 m^3/s has been established for the development of this area.

6) Road conditions

Between this area's eastern-most end and the national road (paved) running from Moshi to Same, there is a road of 3.0 m width.

2. Scheme of Undertaking

(1) Farming project

1) Crops to be introduced

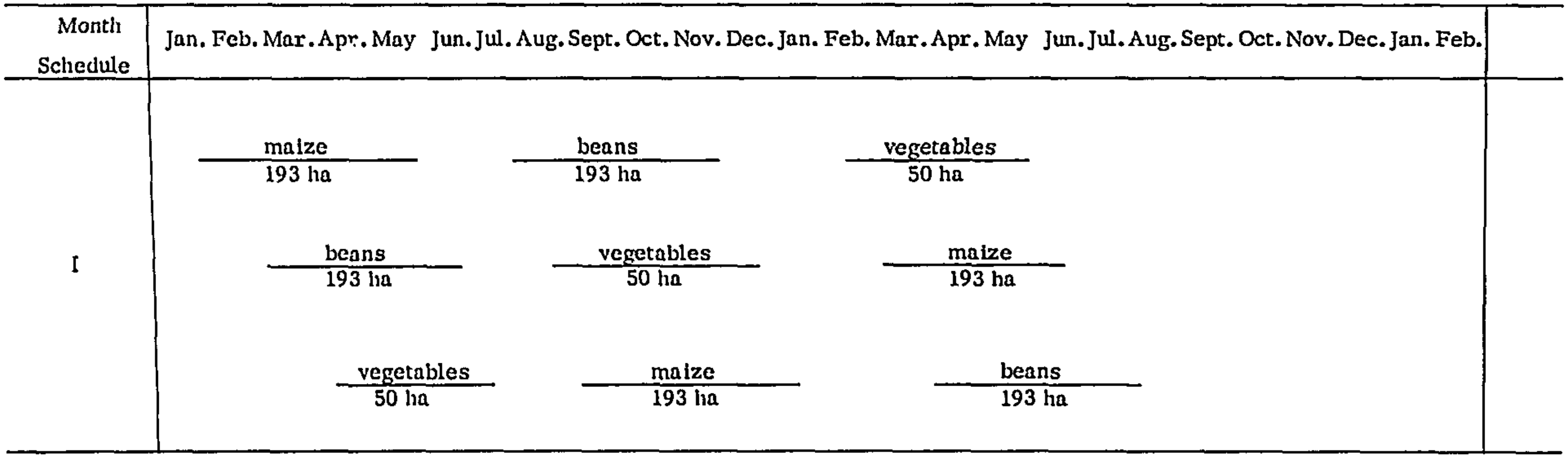
Major-food crops, such as maize, beans and vegetables, are to be introduced in the course of development.

2) Land utilization project

The district area covers h.a., where ordinary farms are to be developed in connection with the water rights.

While annual single cropping relying on the rainy season has generally been practiced in this district, multiple cropping is to be made possible by the project by providing irrigation facilities.

(a) Planting schedule


Month
Schedule
Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sept. Oct. Nov. Dec. Jan. Feb.
I
maize
193 ha
beans
193 ha
vegetables
50 ha
beans
193 ha
vegetables
50 ha
maize
193 ha
vegetables
50 ha
maize
193 ha
beans
193 ha

(b) Methods of cultivation

Methods based mainly on small-size farm machinery and manual labor are to be established from the standpoint that stepwise mechanization is desirable in developing countries.

a) Cabbage

Operation / Item	Growing seedlings	Laying compost	Soil preparing + plowing	Fertilizing	Transplanting	Weeding	Preventing disease/ insects	Additional fertilizing	Water control	Harvesting and shipment
Planting pattern Contents of operation (per h.a.)		20 t	plowing depth: 25 cm	composite 1 t		herbicide once	twice	composite 20 kg	manual	manual
Operation period	Mar. 1- Mar. 30	Mar. 5- Mar. 10	Mar. 11- Mar. 20	Mar. 21- Mar. 31	Apr. 1- Apr. 15	May 1- May 10	May 15-	May 15 May 20		
Operation technique Farm tool used	manual	small tractor, manual	tractor 50 ps	manual	manual	power-sprayer	power-sprayer	manual	manual	manual
Size of operation team	2	2	(1)	2	2	2	2	2	1	2
Machinery operating hours (per h.a.)		6.0	(4.0)			5	10			
Man-power required (hr. per h.a.)	90.0	30.0	(4.0)	20.0	200.0	10.0	20.0	20.0	40.0	800.0
Material requred (per h.a.)	seed	compost 20 t	plowing free ¥5,000	composite 1 t		herbicide	Chemicals	composite 20 kg		

Labor 1234 hrs
$1234 \times 1.6^{SH} = 1974^{SHS}$

Fertilizer	1,020	530 SHS	(¥21,200)
Chemicals		337	(¥13,500)
Miscellaneous materials		250	(¥10,000)
Plowing fee		250	(¥10,000)
Others		700	(¥15,000)
Subtotal		2,067	(¥68,800)
Capital interest 1,033.5 x 0.04		41	
(Labor)		(1,974)	
Total		4,082 SHS	(¥163,280)

b) Maize

Operation / Item	Laying compost	Plowing	Soil Crushing Preparing	Water control	Fertilizing seeding	Spraying herbicide	Cultivating Fertilizing	Preventing insects	Harvesting	Peeling	Thrashing Finishing
Planting pattern Contents of operation (per h.a.)	20 t	depth 25 cm	once once	manual		Atrasine 1.5 kg water 800	N. 25 kg	Powder chemical 60 kgs x 2	manual	manual	natural drying
Operation period	Jan. 1- Jan. 1C	Jan. 11- Jan. 20	Jan. 21- Jan. 31		Feb. 1- Feb. 15	Feb. 5- Feb. 20	Mar. 20- Mar. 30		Jun. 1- Jun. 20		
Operation technique Farm tool used	small tractor 10 ps manual	tractor 50 ps	disc harrow	manual	manual	power-sprayer	manual cultivator	duster			corn-picker
Size of operation team	2	(1)	(1) (1)	1	2	3	2	2	2	2	2
Machinery operating hours (per h.a.)	6.0	(4.0)	(1.4)(1.4)			3.0		3.0			8.0
Man-power required (hr. per h.a.)	30.0	(4.0)	(1.4)(1.4)	40.0	80.0	9.0	40.0	6.0	160.0	300.0	16.0
Material required (per h.a.)	light oil 199 compost 20 t	plowing fee Y5,000	plowing fee (¥5,000)		seed 40 kg Fertilizer 1,500 kg	Atrasine 1.5 kg gasoil 2.0	powder chem. 60 kg x 2				gasoil 12.0

Family labor 681 hrs — 1.6^{SH}/hr — $641 \times 1.6 = 1{,}026^{SH}$

7-hr labor per day
$681 \times 1.6 = 1{,}090^{SH}$

Seed	40 kg @ 1.3	52^{SH}	(¥2,000)
Fertilizer	525 kg @ 0.52	273	(¥10,920)
Miscellaneous materials		250	(¥10,000)
Chemicals		337	(¥13,500)
Plowing fee		250	(¥10,000)
Others		375	(¥15,000)
Subtotal		1,537	(¥61,480)
Capital interest	769 x 0.04	31	(¥1,240)
(Labor)		(1,090)	
Total		2,658	(¥106,320)

c) Beans

	Plowing	Soil Crushing Preparing	Fertilizing Seeding	Spraying herbicide	Cultivating	Weeding.	Preventing disease/ insects	Harvesting	Finishing	Water control
Planting pattern Contents of operation (per h.a.)	depth 25 cm	once once		once	twice	once	twice			
Operation period	Feb. 1- Feb. 10	Feb. 11- Feb. 25	Mar. 1- Mar. 15	Mar. 7- Mar. 20	Apr. 20- Apr. 30	May 1-	Apr. 25- May 20	Jun. 20- Jul. 10		
Operation technique Farm tool used	tractor 50 ps	disc harrow	manual	power-sprayer	cultivator	manual	power-sprayer duster	manual	thrasher	manual
Size of operation team	(1)	(1) (1)	2	3	2	2	2	2	2	1
Machinery operating hours (per h.a.)	(4.0)	(1.4)(1.4)		3.0	20.0		10.0			
Man-power required (hr. per h.a.)	(4.0)	(1.4) (1.4)	100.0	9.0	40.0	30.0	20.0	120.0	50.0	40.0
Material required (per h.a.)	plowing fee Y5,000	plowing fee Y5,000	seed 60 kg fertilizer 250 kg	herbicide gasoil	gasoil		chemicals gasoil			

Labor 409 hrs
409 x 1.6 = 654

Seed	60 kg	80 SHS	(¥3,200)	
Fertilizer	250 kg	130	(Y5,200)	Import 0.52 SH/kg (30% over-estimated)
Chemicals		337	(Y13,500)	Import 10.52 SH/kg (20% over-estimated)
Miscellaneous materials		250	(¥10,000)	
Plowing fee		250	(¥10,000)	
Others		375	(¥15,000)	
Subtotal		1,422	(Y63,600)	
Capital interest 711 x 0.04		28	(¥1,272)	
(Labor)		(654)		
Total		2,104 SHS	(¥84,160)	

(2) Water resource project

1) Rainfall

Water rights of 0.5 m^3/sec are established at present.

For making effective use of this water resource, the monthly effective rainfall has been surveyed as follows:

MIWALENI SUBSTATION 1971 1972

Month / Item	3	4	5	6	7	8	9	10	11	12	1	2	Z	3
Precipitation	42.9	241.9	103.2	26.8	13.0	1.5	1.7	3.1	11.8	36.6	26.1	128.1	636.7	196.0
Effective rainfall for paddy fields	33.8	181.8	70.6	18.6	6.5	0	0	0	8.5	16.9	7.2	97.1	440.5	148.3
Effective rainfall for ordinary fields	33.3	163.0	70.6	18.6	6.5	0	0	0	8.5	16.9	7.2	97.1	421.7	128.3
Shortage for paddy fields	586.7	418.2	549.4	581.4	613.5	620.0	600.0	620.0	591.5	603.1	612.8	462.9	6859.5	471.7
Shortage for ordinary fields	183.7	47.0	146.4	191.4	210.5	217.0	210.0	217.0	201.5	200.1	209.8	98.9	2133.3	88.6
Shortage days (ord. fields)	26	7	21	27	30	31	30	31	29	29	30	14	305	13

4	5	6	7	8	9	10	11	12	1	2	Z
127.5	231.1	1.2	11.0	4.5	53.7	66.4	71.7	64.2	191.4	20.1	1038.8
91.4	162.6	0	x 0	0	42.2	49.4	43.1	37.3	150.8	8.5	733.6
91.0	162.6	0	0	0	42.2	49.4	43.1	37.3	112.8	8.5	675.2
508.6	457.4	600.0	620.0	620.0	557.8	570.6	556.9	582.7	469.2	551.5	6566.4
119.0	54.4	210.0	217.0	217.0	167.8	167.6	166.9	179.7	104.2	187.5	1979.8
17	8	30	31	31	24	24	24	26	15	27	270

As seen in the table above, more than 20 shortage days in rainfall days which required to obtain sufficient field irrigation were recorded in ten different months in 1971 and in eight different months in 1972. Accordingly, efficient use of a water resource of 0.5 m^3/sec by utilizing the rainfall is difficult.

2) Investigation of the irrigatable area

Daily evapotranspiration:	7 mm
Pump operating hours:	20 hours
Irrigation efficiency:	85%
Water resource:	0.5 m^3/sec

72,000 sec x 0.5 m^3/sec = 36,000 m^3/sec

36,000 m^3/sec x 0.85 = 30,600 m^3/sec

36,600 m^3/sec   7 mm/day = 437 h.a. = 1,093 acres ---- 1,300 acres destrict area

This area is the irrigatable paddy-field area in a case of 20 hrs pump operation.

3) Data on pumping station

Quantity of Water Pumped Q : 18 Cusec = 0.5 t/sec.

Head H :

Actual head in plan = 2400' - 2324' = 76'

Loss 76' x 0.1 = 7.6'

Head = 76' + 7.6' = 83.6' = 25 m

Model of Pump - Double suction volute pump 500 x 360

Output of Driving Motor (Kw), Pm

$$Pm = \frac{0.163 \times r \times Q \times B}{\quad \times \quad t}(1 + \quad)$$

r : Specific gravity of water 1.0

Q : Quantity of water pumped (m^3/mm) (0.5 t/s = 30 m^3/min)

H : Head 25 m

P : Pumpint efficiency (0.75 - 0.80)

: Transmitting effect (Planetary gear-one stage: 0.95 - 0.98)

a : Excess ratio (0.1 - 0.15)

$$Pm = \frac{0.163 \times 1 \times 30 \times 25}{0.8 \times 0.97}(1 + 0.15) = \underline{173\ Kw}$$

4) Power transmission line

A power transmission line is laid along the national road (from Moshi to Himo), and installation of another power line is needed from the said line to the pumping power station at a distance of approximately 4.8 km.

Pipeline

The one from the pumping power station to the reservior at a distance of 2.2 km is needed. The pipe diameter will be 500 mm (V = 2.5 m/sec), assuming that the velocity of flow in the pipe is 2 m/sec. Steel should be used as material for pipe upon consideration of water hammer, etc.

5) Reservoir

Construction of a water reservoir having sufficient capacity is needed on the top-most part of the district, for effective use of water and for emergency use in case of pump trouble.

Capacity of Reservoir

Assuming that the capacity is equal to the quantity pumped for 3 days,

$V = 0.5\ m^3 \times 60\ sec \times 60\ mm \times 20\ hours \times 3\ days = 108,000\ m^3$

In a case of water depth of 5 m, length and width are 150 m and 144 m respectively.

6) Construction cost

(a)	Improvement of access road 3 miles 10,000	30,000 shs
(b)	Pump facilities	700,000
(c)	Pump house	100,000
(d)	Pipe line (500, L = 2.2 km) 2,200 m 500	1,110,000
(e)	Storage reservoir (10,000 shs/1,000 m^3)	1,080,000
(f)	Transmission line 3 miles 25,000	75,000
(g)	Main canal system including structures	800,000
(h)	Main drainage system	400,000
(i)	Land clearing (125 shs/acre)	165,000
(j)	Land leveling (500/acre)	650,000
(k)	Setting out field units (13 shs/acre)	20,000
(l)	Field ditches and drain (13 shs/acre)	20,000
		5,150,000 shs
	contingencies	515,000
		5,665,000
	10% engineering & supervision	566,000
	Total	6,231,000 shs
	or	4,793 shs/acre

7) Operation costs of pumping station

(a) Power consumption

According to computation formula of Tanzania Electric Supply Co. (TANESCO), the following power consumption is needed for the pumping station of 173 Kw :

Power consumption/year = 173 Kw x 20 hours x 365 days = 1,262,900 KWH

Power consumption/month = 105,242 KWH

Basic fee (per month)

Up to 40 KVA	1,000 shs	
From 41 KVA to 173 KVA	133 x 20 = 2,660	

Power rate (per month)

Up to the first 10,000 KWH	@ 0.12 sh	1,200
Up to next 10,000 KWH	@ 1.11 sh	1,100
Up to next 10,000 KWH	@ 0.10 sh	8,524
Total		14,484 shs
Annual cost of power consumption		173,808 shs
		134 shs/acre

(b) Personnel expenditure

600 x 12 months x 2 persons = 14,400 shs

(c) Total operation costs

173,808 + 14,400 = 188,208 shs

Economic efficiency

(a) Investment capital

Initial year	2,000,000 shs
Second year	2,000,000 shs
Third year	2,231,000 shs

(b) Amount of increased production

The amount of production for the first year after completion of irrigation facilities will be 50% of that in the second year and forward.

(c) Internal rate of return

The internal rate of return is determined to be 16.5% on the assumption that the period of durability of pumping power station is 30 years. (Refer to the Table 4-13-1). Therefore, this project can be said satisfactorily feasible.

(3) Effectiveness

1) Unit yield

	1972 Average in Kilimanjaro	Test in Kiliya etc.	Project	Japan
Maize	120 kg	250 kg	300 kg	290 kg
Beans	96 kg		200 kg	Soja 140 kg Kidney bean 170 kg
Vegetable (cabbage)	240 kg (begetables)	3500	2500 kg	3200 kg

2) Net profit & earnings

	Unit yielf	Unit price	Gross income	Net-profit increase	Earning increase	Re-marks
Maize	300 kg	1.2 shs/kg	360 shs	$100 - \frac{266}{360} \times 100 = 27\%$	$100 - \frac{157}{360} \times 100 = 56\%$	
Beans	200	1.4	280	$100 - \frac{210}{280} \times 100 = 25\%$	$100 - \frac{145}{280} \times 100 = 48\%$	
Vegetables (cabbage)	2500	0.5	1250	$100 - \frac{408}{1250} \times 100 = 67\%$	$100 - \frac{211}{1250} \times 100 = 83\%$	

3) Production increase

Item / Crop	Planting area	Unit yielf	Yield	Unit price	Gross income	Net-profit increase		Earnings increase	
						Ratio	Sum	Ratio	Sum
	ha	kg	kg	SHS/kg	SHS		SHS		SHS
Maize	387	300	1,161,000	1.2	1,393,200	27%	376,164	56%	780,192
Beans	387	200	774,000	1.4	1,083,600	25	270,900	48	520,128
Vegetables (cabbage)	100	2500	2,500,000	0.5	1,250,000	67	837,500	83	1,037,500
Total	874	-	-	-	3,726,800	-	1,484,564	-	2,337,820

4) Reasonable investment

Annual interest: 5.5%　　　Useful life of equipment : 30 Years

$\frac{1,484,564}{0.0688} = 21,577,965$ SHS　　　4,198 SHS/10a = ¥167,920/10A

5) Appropriate limits of redemption

The following premises are to be established.

1 Size of migrants: 273 households

2 Cultivation acreage per household: 4 acres

3 Yearly living expenses (per household)

A: TSH 3600,　　B: TSH 4800,　　C: TSH 6000

Case A	3600 x 273 = 982,800	100 - (982,800 2,337,820) = 58%
Case B	4800 x 273 = 1,310,400	100 - (1,310,400 2,337,820) = 44%
Case C	6000 x 273 - 1,638,000	100 - (1,638,000 2,337,820) = 30%

Note:

Because this project is tentative one, the following items should fully be reviewed.

(1) Unit yield

The determination of unit yield adopted in the plan is not formulated on the basis of sufficient foundation, and reviews should be made through status aurveys and with the data from the research and testing institutes.

(2) Market research

Through researches and surveys are needed on the market and marketing me methods of crops especially for such perishables as vegetables and milk.

(3) Study on crops to be introduced

Studies should be initiated by theresearch and testing institute. Because of the high-cost of irrigation systems employing pumps, crops of high profitability should be introduced, and these must be studied with respect to the market situation and farming techniques.

(4) Agricultural machines and equipment

A fundamental idea for agricultural mechanization is that excessive introduction of machines at an earlier stage needs unavailingly experts of high technique and also requires the import of unnecessary machines. Orderly introduction step by by step is desired.