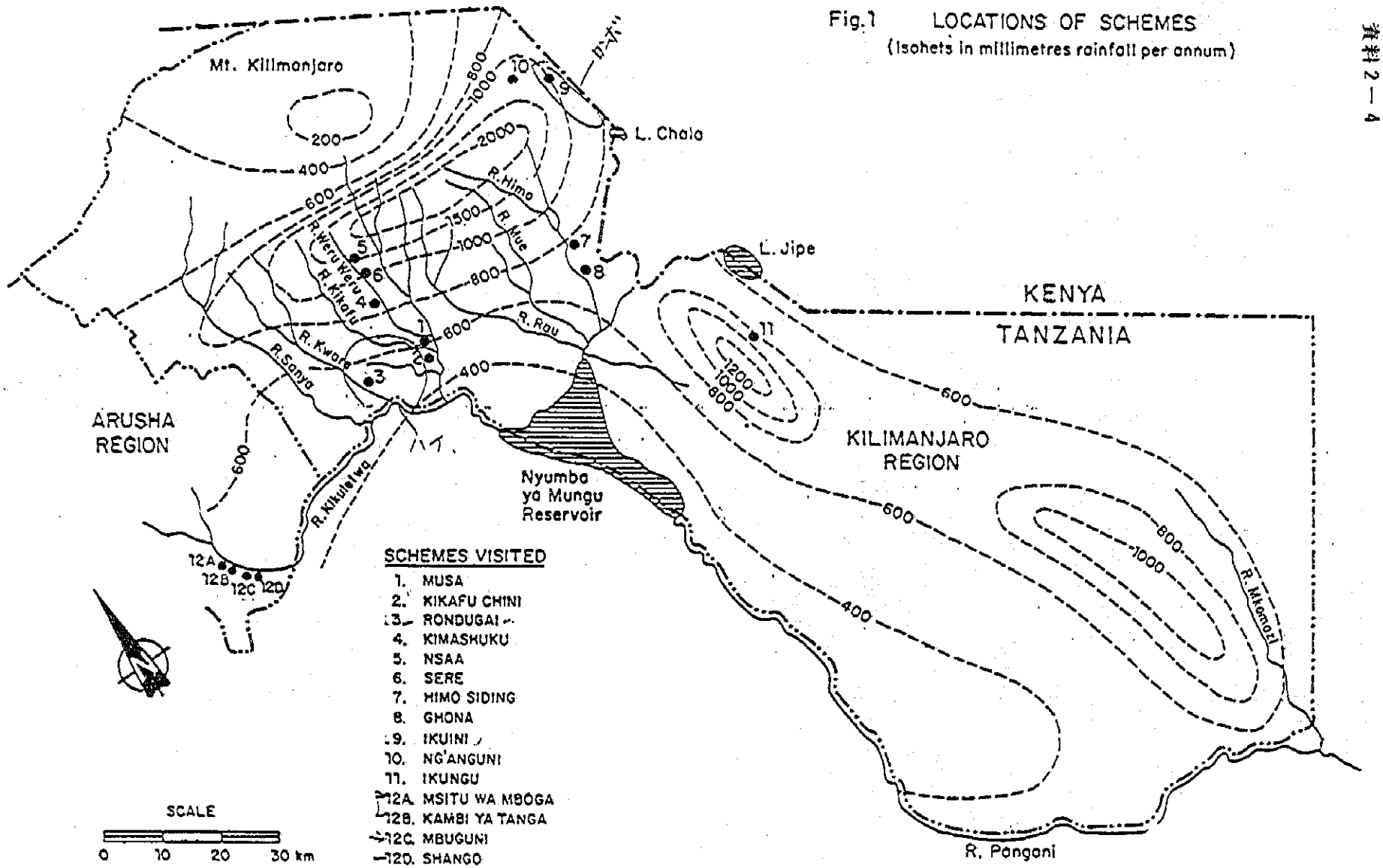
Fig.1 LOCATIONS OF SCHEMES
(Isohets in millimetres rainfall per annum)



1. MUSA MIJANGA

1. INTRODUCTION

The Musa Mijanga Scheme is shown on Figure A1 and is located in the Kikafu South Ward of Hai District. The furrow was originally built by farmers at least 50 years ago, with water diversion being effected by means of a traditional stone weir in the Weru Weru River. In 1982 the District Irrigation Officer constructed a concrete weir, but this failed in 1983, before it had been used. Repairs were carried out in early 1986, so it has not yet been possible to assess the effectiveness of the weir in improving dry season water availability.

2. PRESENT SITUATION

2.1 Irrigation System Design

The approximate layout of the present irrigation system is shown in Figure A1. Traditionally water was abstracted from the Weru Weru River by means of a traditional weir under the railway bridge, point A on the figure. This was replaced by a concrete weir and gated intake, which has still to operate, in 1982.

The main canal follows the right bank of the river in deep cut, 2-3 metres, for about 500 m. This reach of the canal is susceptible to flood damage when the river overtops its right bank and has had to be re-aligned twice in the recent past. After some 600 m the first offtake occurs in the form of an ungated intake structure on the canal right bank. This supplies the secondary canal to the Mohammed Omali area of approximately 25 ha. It is reported that there are no tertiary canals in this area, abstractions being made directly to the fields.

The major distribution box occurs approximately 1000 m from the intake, where flow is divided between the Mzee Kondo and Musa Mijanga secondary canals. This distribution box is also not supplied with gates.

The Mzee Kondo secondary canal flows across the contours in a southerly direction to terminate near the confluence of the Weru Weru and Kikafu Rivers. It was reported that, in addition to direct offtakes for individual farms, there are five tertiary canals offtaking on both sides of this secondary. None are fitted with division boxes. The area commanded by Mzee Kondo secondary is about 250 ha.

The Musa Mijanga secondary follows the course of the Weru Weru and also terminates near the Weru Weru-Kikafu confluence. In addition to direct farm offtakes it feeds five tertiary canals,

principally supplying areas on its right bank. No division structures have been installed at these tertiary offtakes. The command area of the Musa Mijanga secondary canal is about 320 ha.

All irrigation channels run below ground level and thus have no command over surrounding land. Command is gained by the farmer blocking the channel and digging a small ditch to lead water to his field. As the field is not level it is necessary to continue the ditch system through the field to supply a series of rudimentary basins. Obviously this practice is both laborious and inefficient in water use. Generally, however, it would appear that the layout of the secondary and tertiary system, with the secondaries flowing down slope and tertiaries slightly off the contour, follows normally accepted design procedure.

2.2 Present Condition

It was not possible to inspect the whole irrigation system in the time available and only those works which were inspected are described.

Main Intake: The cause of the failure of the weir in 1983 appears to have been overtopping of the left bank wing walls and erosion of the bank during a high flood. In 1986 the weir was extended to about twice in original length and now has a crest length of some 30 m. Whether this will be adequate to reduce the risk of overtopping of the wing walls significantly during high floods is not known. However, it would be prudent to protect the backfill around the wing walls and the upper slopes in the area of the wing walls with either grouted stone pitching or gabions. Erosion at the downstream end of the new left bank wing wall was already evident at the time of the visit, and additional protection to this area is necessary.

It was not possible to inspect the stilling bsin but it was reported that it had not been completed in the new section. Also the breast wall at the intake control gate was not completed and is about 1 m too low. The general quality of workmanship on the structure is poor. No scour sluice is provided and the intake will require frequent desilting.

Main Canal: For the first 100 m downstream of the intake the main canal has a masonry lining on its left bank with rock outcropping along its right bank. The bed width in this reach is approximately 1.5 m and the depth of flow 0.5 m. Downstream the canal has been re-aligned as the previous alignment was damaged by floods. The present flow section is wide (up to 3 m) and shallow (about 0.3 m). It has been excavated in soft material with the spoil dumped on the left bank to provide some protection from river flooding. The section is irregular and susceptible to damage by erosion and flooding. After about 500 m it is unlikely

that overtopping of the canal left bank by the river would occur, but the canal section to the main division box, at about 1 km from the intake, remains irregular.

Culverting of the first reach of the main canal would prevent future damage from floods and, combined with lining the remaining section to the division box, would significantly reduce seepage losses. No actual measurements of present seepage losses are available but the wide, shallow section of the canal, and the materials through which it passes, indicate that they would be considerable. Measurements on similar furrows[1] have indicated an average loss of 40 percent of inflow over a 1 km reach.

Main Canal Structures: The two principal structures on the main canal are the offtake for the Mohammed Omali secondary and the division box to the Mzee Kondo and Musa Mijanga secondaries. All need minor repair and the provision of slide gates.

2.3 Operation and Maintenance

Operation of the system is supervised by the Mzee wa Fereji, assisted by one overseer for the Mohammed Omali secondary, and two overseers each on Mzee Kondo and Musa Mijanga. All three secondaries are operational all the time and the allocation of water between them is based on long standing agreement. However, the absence of gates on the control structures must make the equitable apportionment of water difficult.

On the Mohammed Omali secondary the water is shared by two farmers during the daytime and used exclusively by one farmer at night. The irrigation interval is about three weeks. Both the Mzee Kondo and Musa Mijanga secondaries are divided into halves for operational purposes. Each "half" of the secondary is under the control of an irrigation overseer. During one week the upper half receives all the water during the day and the lower half all the water at night. In the following week the situation is reversed.

During the wet season not all people irrigate, and at the time of the visit (late May), irrigation water had only been used in areas growing rice. Consequently, in an average year, there is no constraint on the area cultivated during the wet season. During the dry season there is considerable competition for water and the irrigation interval can be extended far beyond the normal three weeks, depending on the number of people undertaking dry season cropping. As is usual on smallholder irrigation schemes, people with plots on the lower reaches of the supply system tend to suffer most when only limited water is available. This is

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1 JICO, October 1979. Kilimanjaro Region - Integrated Development Plan, Vol. 2, Ch. 9, Agriculture.

because plotholders on the upper reaches have first access to the water, and because considerable losses of water occur, particularly to seepage, along the canal system.

Maintenance of a routine nature, particularly cleaning of canals, is carried out four times a year by the farmers, collectively in the case of the main and secondary furrows, and individually at the tertiary and farm level. Major repairs are carried out by the district authorities although these can be subject to serious delays before funds are allocated, the three year delay in repairing the main weir being an example.

2.4 Present Farming System

Approximately 600 families use the irrigation scheme with the average family holding being 1 ha. Traditionally each adult in the family is given responsibility for a plot averaging 0.4 ha, although plot sizes range from 0.1 ha to more than 5 ha.

No reliable information is available on areas cultivated under various crops and the information provided below and on Table A1 is the best estimate that can be made from various sources.

The major wet season crop is maize, planted with the rains in March for harvest in July. The maize is normally intercropped with beans or groundnuts, which are planted after the first weeding of the maize, although beans are sometimes grown in a pure stand. These crops are basically rainfed, although the unreliability of rainfall frequently makes supplementary irrigation necessary. Vegetables, particularly tomatoes, are also grown on a small proportion of the area, planted from April onwards.

Rice is planted in seed beds in October/November for transplanting in December/January, and harvest in May/June. Most farmers try to grow some rice on small plots in depressions in the centre of the area. After harvesting rice, where adequate labour is available, beans are planted in June on residual moisture.

The main dry season crop is maize, planted in September/October for harvest in January/February. The area of this crop, which is again frequently interplanted with beans, is limited by the availability of irrigation water.

Minor crops of some importance in the March-June period are cotton and finger millet in pure stand and sunflower and sorghum, either in pure stand or as borders to the maize fields.

Extensive use is made of mechanized primary cultivation for

upland crops, but in the rice areas land preparation is usually by hand. About half the farmers use fertilizer, usually urea, but lack of cash limits applications below the recommended amounts.

2.5 Role of Irrigation

For the limited areas of dry season cropping irrigation is essential Even for the main cropping season, supplementary irrigation is claimed to double maize yields from 1800 to 3400 kg/ha. It is apparent that irrigation is necessary to supplement inadequate or unreliable rainfall, particularly at the critical tasselling stage of maize, in May.

Although the total rainfall for the period March to June at 499 mm approximately corresponds to the seasonal crop water requirement for 120 day maize of 470 mm in the average year, in a 1 in 5 year dry year the equivalent effective rainfall has been estimated at only 143 mm[1]. Consequently supplementary wet season irrigation is important.

3. REHABILITATION

3.1 Potential

A total area of some 650 ha of land could be commanded by the furrow, with no topographic constraints, if adequate water were available. With efficient irrigation and a suitable cropping pattern, this should be possible from water available in the Weru Weru. A possible constraint to development may be the tendency of the soils to develop salinity unless adequate drainage is provided. This is happening at present on the neighbouring TPC sugar estate, where installation of drainage to control groundwater levels is presently planned. In the future salinity could threaten the Musa Mijanga area and, in view of its intensive utilization and pressure on land in the Region, it is recommended that investigations be undertaken to identify preventive measures. It is probable that complete rehabilitation of the scheme, including installation of drainage and canal lining, will be necessary in the medium term.

In the shorter term it is necessary to improve the availability and control of irrigation water to allow a greater certainty of supplies for supplementary irrigation during the March-June period and to allow an increased area of cultivation during the rest of the year. There are no technical constraints to the achievement of these objectives, and they would be

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[1] JICO. October 1980. Feasibility Report on Lower Moshi Agriculture Development Project, Annex 4, Irrigation and Drainage.

welcomed by the community. However, improvement of control of the irrigation water supply does imply re-organization of the present system of scheme operation, which may meet with some opposition.

3.2 Recommendations for Rehabilitation

Subject to the suitability of its soils the complete rehabilitation of this scheme should be considered in the long term. In the short term priority should be given to ensuring a reliable supply of irrigation water, minimizing losses of water and providing means to allow the equitable apportionment of water between the three secondary canals. A lower priority is the establishment of division boxes at tertiary canal outlets and the installation of road culverts.

The most urgent item of work is the completion of the main weir and intake structure and the provision of additional protection works to ensure its long-term stability, particularly under flood conditions. To effect this, the following items of work are necessary:

- completion of stilling basin in new section
- provision of gabion protection to bed and banks downstream of the stilling basin
- provision of grouted stone pitching on upper slopes of the river banks in the area of the weir
- raising of the wing wall over the intake gate.

In its present condition the canal immediately downstream of the intake will inevitably be flooded during high river water levels, causing considerable damage and inviting the complete capture of the canal by the river. To prevent this it will be neessary to culvert the main canal until it reaches a position where flooding is not a danger, or to realign it further away from the river. For the purposes of cost estimation the option of culverting has been used, but both options should be thoroughly investigated before implementation. A further cause of damage to the canal is that flows exceeding its capacity are allowed in because of maloperation of the main gate. To minimize this risk a check and escape to the river should be installed immediately downstream of the culverted section. It is also proposed that the remainder of the canal to the main devision box be lined with either concrete, or buried butyl sheeting, to minimize seepage losses. The suitability of both alternatives should be evaluated prior to implementation, but for the purposes of budget costs concrete has been assumed. Finally, to allow easier and more effective control of irrigation water, it is suggested that gated division boxes be installed at the heads of the three main

secondary furrows. In summary, the work needed on the main canal is as follows:

- culvert first 500 m (1.0 m dia pipes assumed)
- install check and escape at ch 500 m
- lining to next 500 m (60 mm thick concrete assumed)
- trim back slopes in this section to 1:1½
- provide 3 gated division boxes.

3.3 Budget Costs

	Item		Cost (TSh)
A.	**Weir and Intake**		
1.	Completion of stilling basin		90 000
2.	Gabion protection downstream stilling basin		60 000
3.	Concrete baffles in stilling basin		20 000
4.	Completion of wing wall		10 000
5.	Grouted stone pitching		50 000
	Subtotal		230 000
B.	**Main Canal**		
6.	Excavation and backfill for culvert		150 000
7.	500 m run concrete culvert		1 500 000
8.	Check and escape structure		150 000
9.	Excavation of remainder of main furrow		175 000
10.	Lining to rest of main furrow		400 000
11.	Division boxes (3 No.) including gates		45 000
	Subtotal		2 420 000
	TOTAL		2 650 000
	Allow contingencies at 25%		465 000
	GRAND TOTAL	(say)	3 100 000

Table A1 MUSA MIJANGA

Region: Kilimanjaro District: Hai Ward: Kikafu South

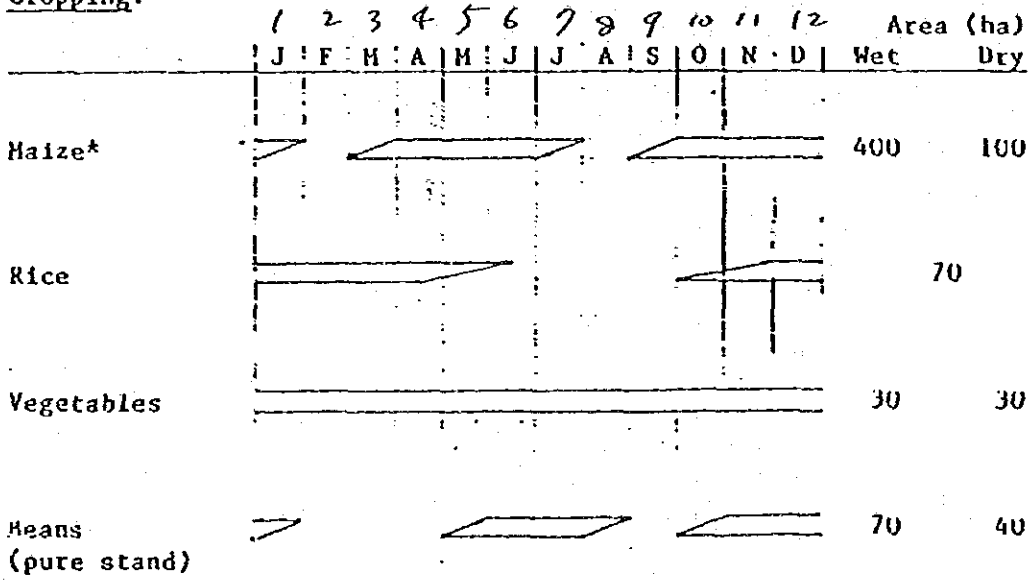
Estimated No. of Plot Holders: Approx. 1200 (600 families)

Areas cultivated: Wet season (Dec-July) 600 ha approx.
Dry season (Sept-Feb) 200 ha maximum

Annual Rainfall: Average 694 mm (Station: Kiyungi, 93.37/029)

Month	J	F	M	A	M	J	J	A	S	O	N	D
Ave. Rainfall (mm)	36	45	88	237	129	17	7	11	14	27	35	48

Cropping:



* Maize is usually intercropped with beans and groundnuts
** Areas under banana, cassava, etc., not included in the above table
*** All figures are best estimates based on various sources

Source of Irrigation Water Weru Weru River

Average monthly discharges for station 1DD5A, upstream of intake, for period 1958-63:

Month	J	F	M	A	M	J	J	A	S	O	N	D
Flow (cumec)	1.95	0.96	0.68	1.96	3.54	1.94	1.29	0.73	0.48	0.76	0.22	0.92

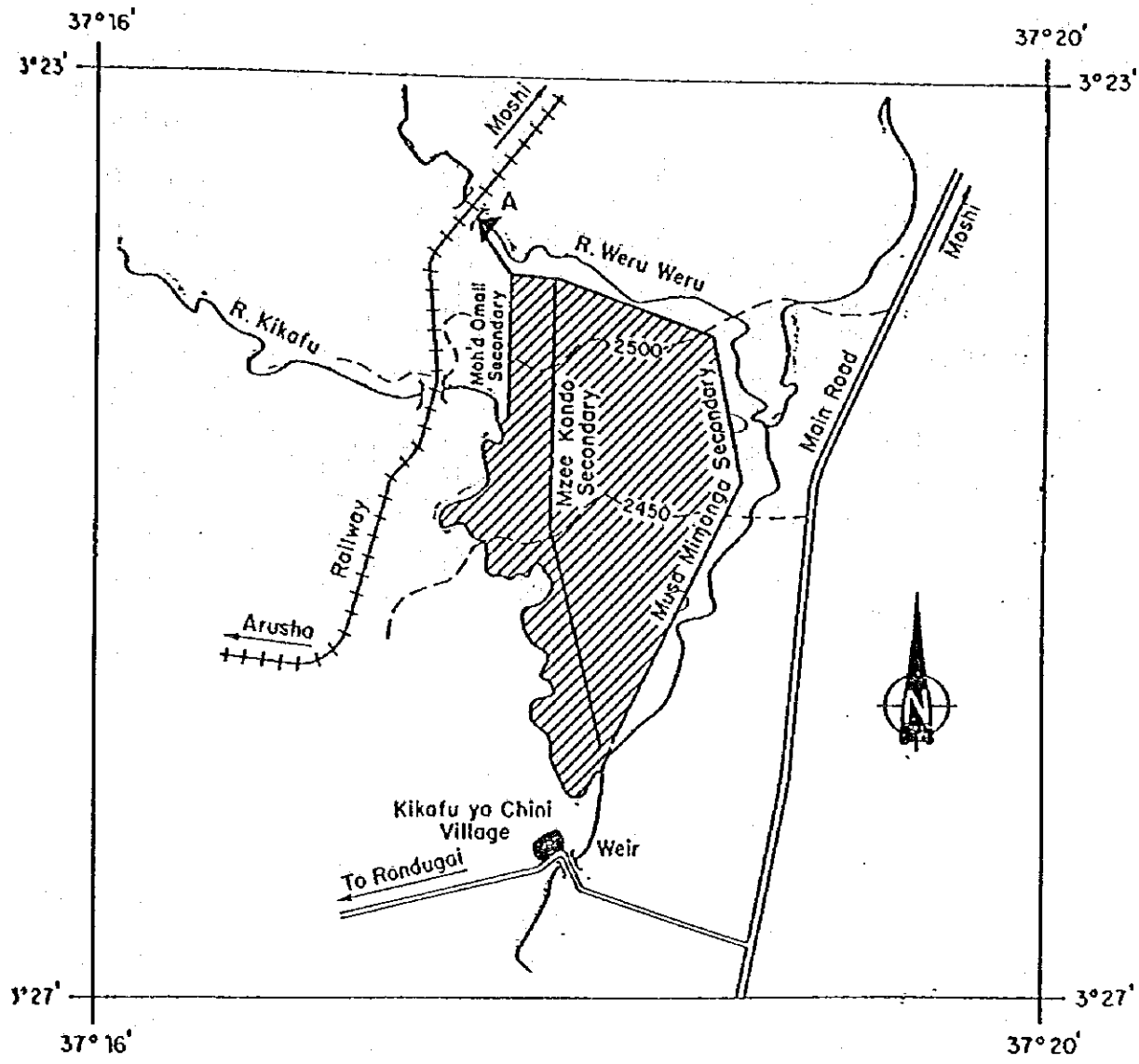


Fig. A1 APPROXIMATE LAYOUT – MUSA SCHEME

Scale 1:50,000: Reference Map Series Y742, Sheet 56/4. Contours in feet.

2. KIFAKU CHINI

1. INTRODUCTION

The Kikafu Chini village is in the Machama South Ward of Hai District. The furrow, which is shown on Figure A2, was started by the villagers in 1935 and presently irrigates some 250 ha. In 1977 proposals were submitted to the District Council for the construction of a weir and intake some 300 m upstream of the railway bridge across the river Kikafu, to allow a reliable water supply to the existing irrigated area and the extension of the area by about 200 ha. Funds were not provided for this, but instead a small pump station was built just downstream of the railway bridge. In the first year of operation the pumps were intended to irrigate 25 ha of maize but, after one month of operation, diesel supplies ran out and no further diesel was obtained. The pump station has remained idle since that time.

In order to improve water supplies to the existing area a gated intake was built further downstream on the river in 1983. However, the instability of the river in the area continues to cause problems and the District Irrigation Office has repeated the proposal of a new weir and intake upstream of the railway bridge.

2. PRESENT SITUATION

2.1 Irrigation System

The approximate alignment of the existing furrow is shown on Fig. A2. Water is abstracted from the River Kikafu by means of a gated intake structure (point A). The furrow flows south for 2.5 km until it crosses the Kikuletwa road where it turns east for about 1 km before turning south again to terminate at the Weru Weru River.

Four secondary furrows supply the area to the north of the Kikuletwa road, between the main furrow and the karonga to its west. One small secondary furrow supplies the area between the main furrow and the river in the immediate vicinity of the village. The area between the Kikuletwa road, the Weru Weru river and the karonga is supplied by four secondary furrows.

Intake Structure: The intake structure consists of a concrete headwall and gated intake, which were completed in 1983, located on a 90° bend in the Kikafu River. No weir is provided and during times of low flow the water level is raised by construction of a traditional weir. Because of its location in the river, the intake is susceptible to river bank erosion and, in 1985, the backfill to the downstream section of head wall was breached,

allowing a flood down the main canal. The structure has been extremely poorly sited, and should be replaced by a better designed and constructed installation at a tenable site.

Main Canal: Prior to the construction of the intake structure in 1983 the main canal was subject to flood damage, as no control of inflows was possible. As a result of the damage to the intake in 1985 this is still the case. Approximately the first 1 km of main canal is now badly eroded to a deeply incised, wide channel. Bank overspill in a stretch of 100 m has necessitated the construction of a masonry wall, which is presently being undermined by seepage.

Secondary Canals: Those reaches of secondary canal inspected were typical of traditional construction, being of irregular and too large a cross section and having little or no command of adjacent land. Consequently seepage losses are likely to be high and irrigation time consuming and inefficient. None of the secondary canals have control structures at their heads, nor does the main canal have any form of cross regulation.

Field Irrigation: In-field irrigation methods are predominantly basins of various sizes. In cases where cultivation is done by hand the basins are semi-permanent. Where cultivation is done by tractor the basins have to be prepared manually for every crop. At the time of the visit basins were being prepared for beans, following rice or maize. The standard of preparation was comparatively good, although basin sizes were too large (300-400 m^2) for effective water control, particularly on unlevelled land.

Drainage: No drainage system is installed and the karonga forming the western boundary of the presently irrigated area provides the natural drainage of the area. Occasional patches of surface salinity were reported in the northern part of the area and this was considered a problem by the farmers, although it has not yet caused the abandonment of any land. The presence of a high water table and some waterlogging in the wet season was considered by the farmers to be responsible for the lower maize yields achieved for the wet season crop, when compared with the dry season crop.

Other: Access through the area is made difficult by a number of broken culverts on both the main and secondary furrows. Four minor culverts and one large culvert need replacement.

2.2 Operation and Maintenance

A furrow committee of seven members supervises operation and maintenance of the scheme. Although all the branch furrows theoretically operate all the time, the system of operation is flexible and a weekly meeting is held by each branch to arrange the following weeks irrigation schedule. The actual distribution

of water between the various branches is difficult without control structures, but is carried out by appointed water askaris. Irrigation is often carried out at night and the irrigation interval is 2-3 weeks.

Routine maintenance, consisting of cleaning the furrows, is done twice a year in March and June. Major repairs needed are reported to the District Council.

2.3 Farming System

The main crop is maize which is usually grown in pure stand. In March about 250 ha are planted, of which 100 ha is not commanded by the irrigation system. This crop is harvested in June/July and a second, irrigated, maize crop is planted in September on 85 ha for harvest in January. Between the two maize crops, beans are planted, also in pure stand. However, presumably because of labour and time constraints only 40 ha of beans are planted on average. The other major crop is rice, which is planted in seed beds during September and transplanted in October/November for harvest in May/June. The area of rice grown is about 40 ha. A small area, about 15 ha, of vegetables is planted in July and minor crops include cotton, sorghum, groundnuts and finger millet. A large part of the area, some 80 ha, is taken up by bananas.

Usually a single cultivation by tractor is paid for by the farmers at a cost of TSh. 1500 per hectare. Fertilizer and other inputs are not widely used. Quoted yields are good in comparison with other areas, possible because of the usual adequacy of irrigation water, but also because the figures are not distorted by intercropping. Yield levels claimed are as follows:

Maize (wet season)	2300 kg/ha
Maize (dry season)	3000 kg/ha
Paddy (without fertilizer)	2500 kg/ha
Paddy (with fertilizer)	3700 kg/ha
Beans	2200 kg/ha

2.4 Role of Irrigation

Although average rainfall in the period March to June is theoretically adequate to support a maize crop, supplementary irrigation is important if acceptable yields are to be achieved in years of low or erratic rainfall. The September planted maize is almost an entirely irrigated crop, as are the beans and vegetables planted in July. Although it would be possible to grow some rainfed rice in the immediate area of the karonga, the present area of rice cultivation and present yield levels are only possible because of irrigation.

2.5 Present Problems

At present, considered as a traditional irrigation scheme, Kikafu Chini appears to operate with reasonable success. To a large degree this is probably due to the aedequate water supply available throughout the year from the river Kikafu. However, the major immediate problem facing the scheme is the inadequacy of the present intake structure and the consequent severe flood damage suffered by the main canal. The long standing proposal to construct a new intake at a more favourable site, which would allow significant expansion of the area irrigated, should therefore be further considered.

Other immediate problems requiring attention are:

- lack of control structures at secondary canal heads,
- severe damage to road culverts.

A longer term, but important, problem facing the scheme is that of waterlogging and salinity. Experience elsewhere (TPC Estate, Rondugai; Kahe) has indicated that this is potentially a threat to future productivity of the area.

3. REHABILITATION

3.1 Potential

The Kikafu Chini scheme has access to an adequate resource of good quality water, in the Kikafu River, to support an irrigated area much larger than that presently in use. The water right of 0.63 cumec was requested and approved when extension of the scheme to 600 ha was originally planned and, with reasonable efficiency of water use, should be adequate for an area of that size.

Preliminery inspection indicates that about 200 ha of the proposed extension area would be topographically suitable for surface irrigation. The major unknown factor is the quality of the soils and their susceptibility to gradual salinization, as is happening in parts of the presently irrigated area.

3.2 Requirements for Rehabilitation

The existing intake and headreach of the main canal require replacement if a water supply to the scheme is to be assured and further flood damage prevented. The location of the new intake depends on the command required, which is in turn dependent upon the technical and economic feasibility of extending the scheme. In view of experience with the present intake, the new one should be located at a stable site. The site selected by the District

Irrigation Office meets this criterion and, subject to further study, has been used for the purpose of cost estimation.

The main canal from this site must pass under the railway bridge across the Kikafu River and the railway authorities have approved this, provided that the canal is culverted under the bridge itself. In order to avoid possible flooding of the reach of canal between the intake and the bridge, it would be advisable to culvert the whole reach, about 250 m long. The main canal would then follow the contour for approximately 1 km, before dividing to supply the existing area and the extension area. In this reach the canal should be lined to prevent unacceptable seepage losses, and two cross drainage structures will be needed, together with remedial treatment of gully erosion.

From the bifurcation a branch canal would be required to join the existing furrow about 1 km downstream of the present intake, making a total length of 1.5 km. Within the existing irrigation area, control structures are required at the heads of all secondary canal offtakes and the repair or replacement of existing culverts is necessary.

In order to identify the extent and degree of the drainage problem and to propose remedial works, detailed investigations of the soils and behaviour of the water table will be necessary, together with topographic mapping. It is probable that remedial works will include canal lining and the installation of a drainage system but the extent of these works cannot now be identified.

As the extension area can be expected to face similar problems in the long term it will be necessary that its design takes this into account. It is therefore suggested that the design of the extension area be undertaken on the basis of detailed topographic and soil mapping to allow gradual implementation, initially of the main and secondary canal system to be followed by the main and secondary drainage system, and subsequently be the tertiary system and land development.

3.3 Budget Costs

The cost estimates presented below assume that the new intake will be built upstream of the railway bridge to command the presently irrigated area and the extension area. No costs are included for the development of the extension area, nor for remedial works to prevent salinization of the existing area, as both require further investigation. In the event that the extension area is not to be developed, it will be necessary to review the siting of the new intake.

	Item	Cost (TSh)
1.	Weir, intake and scour sluice	3 000 000
2.	Box culvert 500 m long	1 285 000
3.	Escape and check	50 000
4.	Lined main canal to division box	1 180 000
5.	Branch canal to existing area	1 245 000
6.	8 No. division boxes in existing area	160 000
7.	5 No. culverts	140 000
		7 060 000
	Contingencies at 25%	1 760 000
	TOTAL (say)	10 000 000

Table A2 KIKAFU CHINI

Region: Kilimanjaro District: Hai Ward: Machame South

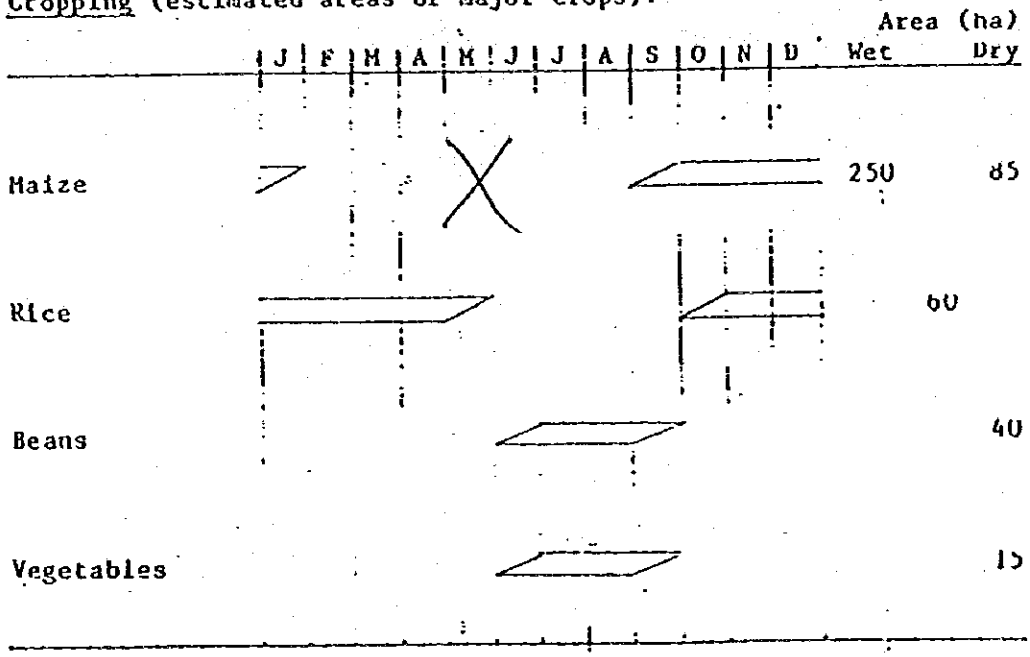
Estimated No. of Plot Holders: 310 farm families

Areas cultivated: 250 ha irrigated, 200 ha rainfed

Annual Rainfall: 624 mm (Station 93.37/122)

Month	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall (mm)	43	33	104	199	86	12	8	5	13	27	48	46

Cropping (estimated areas of major crops):



Perennial crops include bananas (80 ha) and coffee (5 ha). Minor crops include cotton, sorghum, groundnuts and finger millet.

Source of Irrigation Water River Kikafu

Discharge data for period 1954-63 for Station 100 8, upstream of intake:

Month	J	F	M	A	M	J	J	A	S	O	N	D
Ave. Flow m^3/s	2.86	2.31	1.57	12.42	18.07	7.41	4.75	2.83	1.46	1.46	1.78	2.70

EC of river water: 79 µs/cm

Water right: 0.63 m^3/s

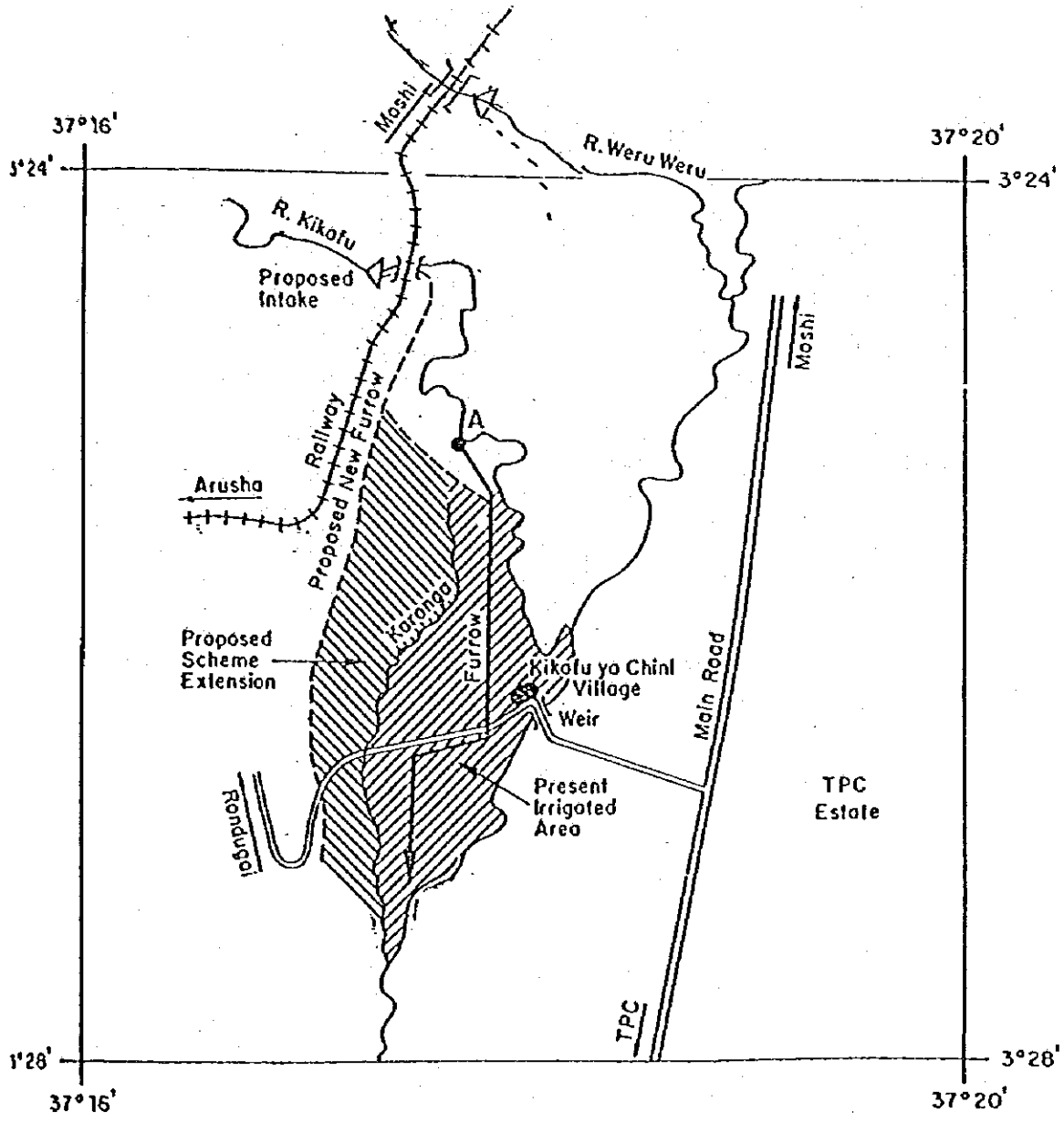


Fig. A2 APPROXIMATE LAYOUT – KIKAFU CHINI SCHEME
Scale 1:50,000 : Reference Map Series Y742, Sheet 56/3.

3. RONDUGAI

1. INTRODUCTION

The Rondugai furrow is in the Masama South ward of Hai District and is used by Rondugai and Kawaya villages. The furrow was started in 1949 to supply farmers from Rondugai village and was extended into the area of Kawaya village in 1954. Until 1972, when the present concrete weir and intake were constructed, abstractions were made from the River Kware by means of a traditional weir. In 1982 a second concrete weir and intake were installed, a short distance downstream of the first, to supplement irrigation water suplies to the scheme.

The required rehabilitation works, as identified by the District Irrigation Officer, are as follows:

- maintenance of intakes, installation of control gate
- repair of river bed, downstream of intake
- improvement of main canal
- detailed topographic survey and design for potential irrigated area
- construction of distribution channels, field channels and distribution boxes
- land levelling
- construction of drainage systems
- crop pattern and intensity.

2. PRESENT SITUATION

2.1 Irrigation System

The approximate layout of the present water distribution system is shown on Figure A3. This layout is based on 1:70 000 scale aerial photography on which the furrows cannot always be distinguished, supplemented by information from farmers and spot checks in the field. Consequently the information presented is subject to error.

The main weir and intake structure (A on Figure A3) are located on the River Kware about 700 m downstream of the railway bridge. The intake supplies the main canal which is 400 m long to the main division box at point B on the figure. At the division box the canal divides into three major branches. The Kikuletwa Branch supplies areas to the south along the Kware River. Since 1982 this branch has been supplied from the second intake on the Kware, known as the Ismaili intake (C on Fig. A3), and not from the main Rondugai intake.

The largest branch is the Kawaya Branch which supplies

parts of Kondugai and most of Kawaya. This branch subdivides at point D on Fig. A3, the major offtake being known as the Longoi Branch.

The smallest branch from distribution box B is the Chekerini Branch which supplies the northern part of the area and runs parallel to the railway.

The command areas of the individual branches, and the scheme as a whole, are difficult to determine. From the available topographic maps it would appear that more than 2000 ha could be commanded, when enough water is available. Local government officials claim that, when water in the Kware is adequate, 1000 ha are supplied, but during low flows in the river, only 450 ha can be irrigated.

Intake Works: The main Rondugai intake is a sophisticated structure comprising a 3 m high concrete weir of crest length approximately 15 m. The inlet works comprise a gated orifice into a 4 m wide concrete channel, the right wall of which is an escape spillway, discharging into and just downstream of the main weir stilling basin. The downstream end of this concrete channel is a concrete wall incorporating a second orifice. The main weir also incporates a desilting gate at its centre. Due to flood damage the main inlet gate and desilting gate are no longer operable, and the inlet gate has been removed. Because of the absence of a gate on the orifice at the downstream end of the overspill section it has been impossible to control flows into the furrow and this has resulted in washouts of the main furrow. The stilling basin to the weir is not long enough and has been reportedly undercut and there is considerable erosion to the river channel immediately downstream.

The Ismaili intake is of simpler design, comprising a 15 m long concrete weir with a gated inlet. The inlet gate is missing and, as the stilling basin is not long enough, there is considerable erosion in the channel downstream.

Canal Headreaches: The headreach of the main furrow from the intake to the distribution box has been subject to considerable erosion, of both banks and bed, and repeated breaches of its right bank due to inflows exceeding its capacity. At the time of the visit the right bank had once again been breached and until this is repaired, no irrigation water will be available to the scheme. At present the furrow has a bed width of 4-5 m and has eroded to some 2 m below ground level, where its bed is cobbles and rock or boulder outcrops.

Similar evidence of erosion, although not to the same extent, occurs on the furrow from the Ismaili intake to the Kikuletwa Branch. Because of the lack of escape facilities at this intake it can be expected that the headreach will suffer further damage in the future.

Secondary Canal System: The secondary canal system starts at the main distribution box (B on Figure A3) which is in extremely poor condition and has no gates. Consequently effective allocation of water to the branches is impossible. It was not possible to inspect the total length of the secondary system but spot checks showed the canals to be of irregular cross section with little command.

On the Kikuletwa Branch there are three tertiary branch offtakes, on the Kawaya Branch eight tertiaries and on Chekerini Branch two tertiary offtakes. None of these are controlled by division boxes.

Field Irrigation: At the time of the visit there was no evidence of field irrigation systems except in areas growing rice. Apparently for upland crops a rudimentary basin system is installed every year, after mechanized land preparation. However, in the rice areas it appeared that the basins were permanent and land preparation is done manually or by oxen. Water is supplied from the secondary or tertiary furrow into the upper basin and then passes downslope through a series of basins. No land levelling has been done and field irrigation methods are consequently time consuming and very ineffficient.

Drainage: No drainage system has been installed. At the time of the visit the rice areas were being drained for harvest and the drainage water was being discharged into the canal system where it was lying stagnant. The appearance of the drainage water, which was light brown, and the dark brown mottling of the topsoils in parts of the rice area, indicate problems with salinity and alkalinity. This was confirmed by the farmers who reported that over 40 ha of rice land have been abandoned because of salinity/alkalinity.

In the north of the area, along the railway, extensive surface deposits of white salts are evident indicating a serious salinity/alkalinity problem. According to the farmers this has caused the abandonment of 50 ha of land in the Chekerini area.

2.2 Operation and Maintenance

Operation and maintenance of the system is supervised by a furrow committee comprising a chairman and members from the major secondary and tertiary branches.

The three main secondary branches flow all the time but the manner of allocation of water to tertiary branches varies. Both tertiary branches in the Chekerini command flow all the time. Of the three tertiaries in the Kikuletwa system, two flow all the time and the third, which irrigates an area of bananas, is only used twice a year. Operation of the Kawaya system is more complex

with the smaller branches receiving water for alternate 3 day periods and the larger ones all the time.

Irrigation takes place during both day and night. During the daytime the water is used for upland crops and at night for rice. In the area of Rondugai village, where farms are larger, each farmer is allocated water for twelve hours, in Kawaya the allocation is for six hours.

Routine maintenanc of the main furrow is carried out by all the farmers and organized by the main committee. For the individual branches maintenance is organized by the branch leaders. Because of the presence of waterlilies it is necessary to clean the canals every three months.

2.3 Farming System

The major crops are maize and rice. The main maize crop is planted with the rains in March/April for harvest in July and is essentially a rainfed crop, although supplementary irrigation is occasionally provided. A second maize crop is planted in September for harvest in December. Maize is usually intercropped with beans, groundnuts or finger millet. Land preparation for the maize is usually by tractor, but other inputs such as fertilizer are rarely used, yields are estimated at 1200 kg/ha.

Seed beds for the rice are started in October and November for transplanting in December/January. The crop is harvested in June. Land preparation for rice is usually done manually and fertilizer is only rarely used. Local varieties are grown and paddy yields were claimed to be 3000 kg/ha.

Small areas of vegetables (about 40 ha) are grown throughout the year and annual crops are bananas (60 ha) and coffee (10 ha).

Farm sizes vary between the two villages. The Rondugai area, being less densely populated, has a range of farm sizes from 1 to 4 ha, with an average of 2 ha. In Kawaya the average holding is about 1.5 ha. Most farmers try to grow both paddy and maize which in many cases results in split holdings.

The distance of the Rondugai/Kawaya area from the coffee belt precludes large scale commuting from that area and the majority of the farmers are permanent residents.

2.4 Role of Irrigation

Irrigation provides an essential supplementary source of water to the rice crop and supplies the total water requirement

of the dry season maize and vegetable crops. While rainfall is usually adequate for the present low standard of wet season cropping, supplementary irrigation is occasionally necessary to guarantee a yield in years of poor rainfall.

2.5 Present Problems

In its present form the Rondugai scheme has the following problems:

- erosion damage to both intake structures
- severe damage to both canal headreaches due to lack of control of inflows
- inequitable distribution of water to secondary and tertiary branches due to lack of gated control structures
- poor irrigation efficiencies due to lack of control structures, lack of a properly designed irrigation system, no land levelling and poor water management
- seepage losses from canal system, leading to water shortages and high groundwater table
- lack of a drainage system which, combined with the high groundwater table, is causing the gradual salinization of many areas.

3. REHABILITATION

3.1 Potential

Although the River Kware is usually dry from July to November, the main source of water to the scheme is the Rondugai Springs which have a reportedly reliable flow in excess of 1 m^3/s. With an appropriate cropping pattern and an efficient irrigation system this should be adequate to support 1000 ha. Topographically the area is suited to a scheme of at least this size, but the major constraint would be the soils.

Although no soil survey has been carried out it is apparent that salinity and alkalinity are a serious problem in many parts of the area. Seepage losses from the present irrigation system over the years have progressively raised groundwater levels and, although the irrigation water is of good quality, salts in the subsoil have been brought to the surface through capillary rise and evaporation from the raised water table.

Reclamation of badly affected saline, and particularly

saline/alkaline areas, is expensive and not usually economically viable for smallholder irrigation schemes. However, a considerable number of people rely on the Rondugai scheme and it would be appropriate to investigate means of arresting the deterioration of the soils in those areas which have not yet been seriously affected. Initially this would require detailed topographic and soils mapping, investigations of depth and permeability of the soils and observation of groundwater levels and quality throughout the area. In the longer term the works required would include a properly designed irrigation system with lined canals, a comprehensive drainage system and careful operation of the scheme. At present day levels these works would cost in excess of US$ 10 000 per hectare.

The social and economic merits of undertaking works of this nature cannot be evaluated at this time but the scheme also suffers from immediate problems which should be corrected.

3.2 Rehabilitation Works

The rehabilitation works immediately required at the scheme are aimed at ensuring an irrigation water supply, and are concentrated on the intakes and main canal headreaches. No works are proposed on the existing secondary and tertiary distribution system as long term rehabilitation may require the complete realignment of these systems. The immediate rehabilitation works proposed are as follows:

- Repairs to main intake, including provision of gates at inlet and orifice downstream of overspill section, extension of stilling basin, provision of gabion revetement to river channel downstream of stilling basin and minor repairs.

- Repairs to Ismaili intake, including provision of gate at inlet, installation of a second gated orifice and overspill section, extension of stilling basin, provision of gabion revetement to river channel downstream and minor repairs.

- Rondugai furrow headreach to be flumed in concrete/masonry to division box.

- Ismaili furrow headreach to be flumed in concrete/masonry to junction with Kikuletwa Branch.

- Main division box to be replaced with gated structure.

3.3 Budget Costs

	Item	Cost (TSh)
1.	Repairs to Rondugai Intake Structure	418 000
2.	Repairs to Ismaili Intake Structure	416 000
3.	Rondugai headreach	1 576 000
4.	Ismaili headreach	394 000
5.	Division box	33 000
	Subtotal	2 837 000
	Contingencies at 25%	713 000
	TOTAL (say)	3 600 000

Table A3

RONDUGAI

Region: Kilimanjaro District: Hai Ward: Masama South

Villages: Rondugai (est. pop. 4600), Kawaya (est. pop 3900)

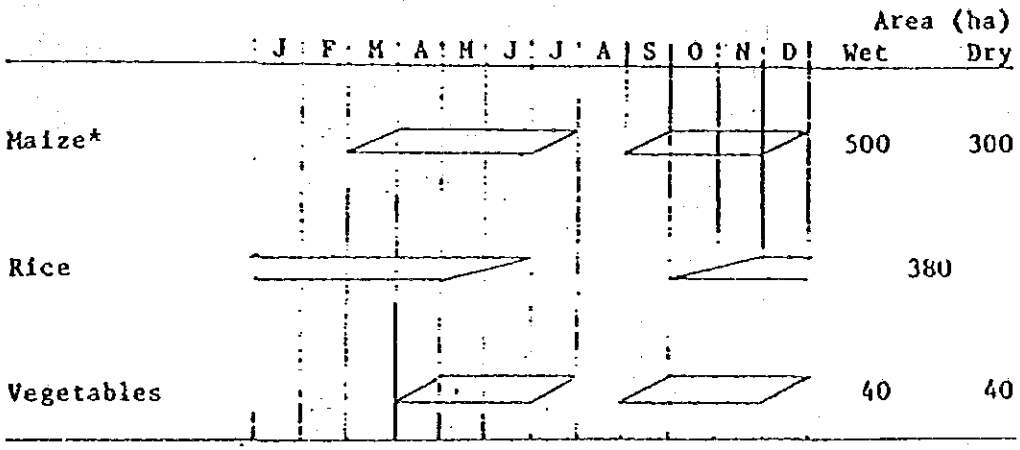
Area supplied by Furrow: Wet season approx 1000 ha
Dry season approx. 450 ha

Estimated Number of Farmers: 460 families

Annual Rainfall: Approx. 600 mm. Rainfall distribution based on Station 93.37/029

Month	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall (mm)	31	38	75	204	115	15	6	10	12	23	30	41

Cropping:



* Maize is usually intercropped with beans, groundnuts or finger millet. 60 ha are under bananas and 10 ha under coffee.

Source of Irrigation Water Rondugai Springs on Kware River

No relevant records of discharge exist, although Rondugai Springs are reported to have a reliable flow in excess of 1 m^3/s.

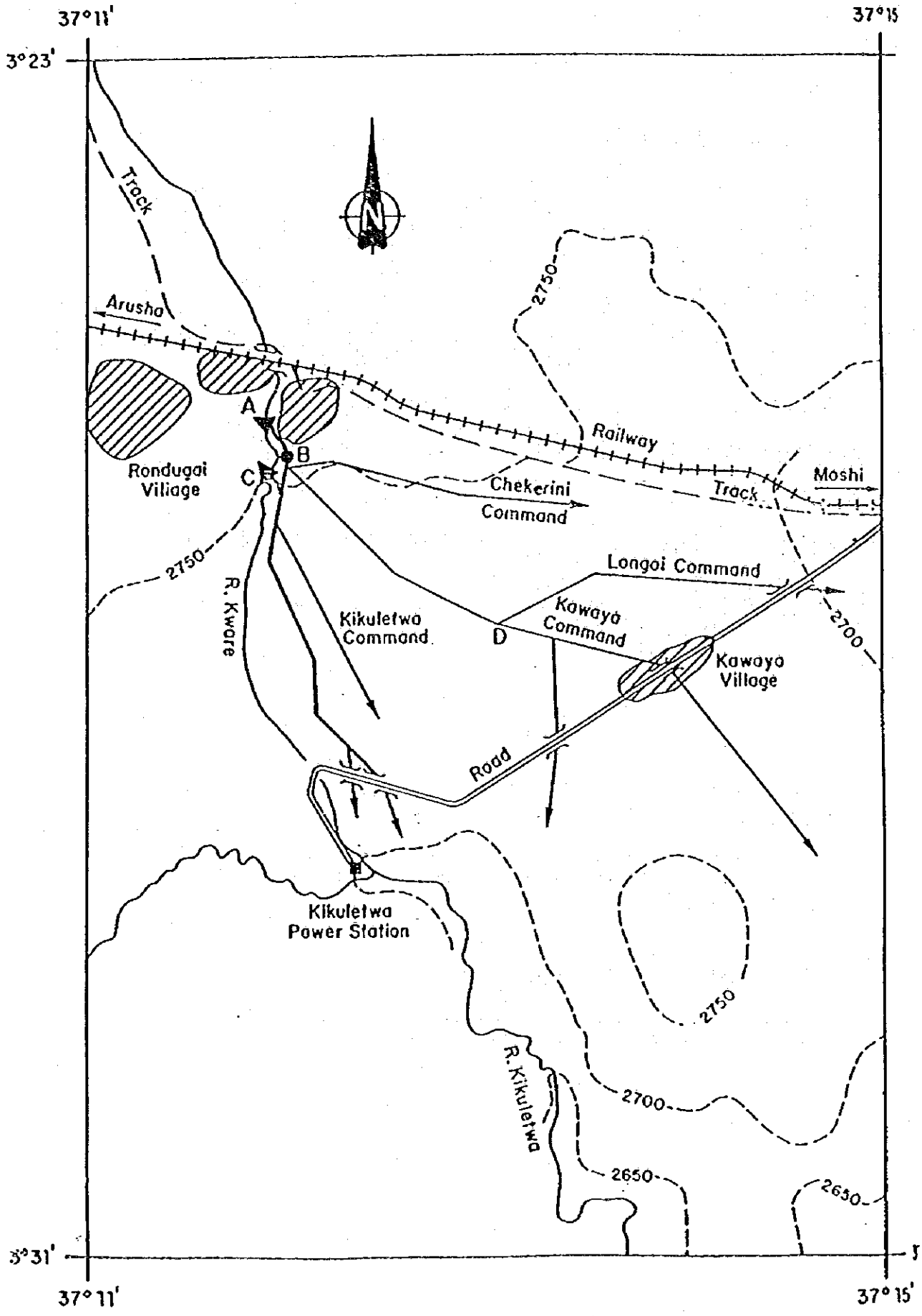


Fig. A3 APPROXIMATE LAYOUT – RONDUGAI SCHEME

9. IKUINI

1. INTRODUCTION

The Ikuini furrow in Rombo District abstracts water from springs on the River Ungwasi to supply farmers in Ikuini and Ibukoni villages. The furrow was started in 1955 by the present chairman of the furrow committee. A weir and gated intake were built by the Ministry of Agriculture and the furrow extended to supply Ibukoni Village between 1972 and 1975. A night storage dam was completed in 1980.

It is estimated tht 330 farmers in both village use the furrow but, because of inadequacy of water, can only irrigate a part of their holdings. Increasing pressure on land in the uplands is forcing large numbers of people to either commute to, or settle in, the two villages for production of cereal crops. This has caused the area of cultivation to be extended towards the drier, lower areas in the east.

The District Irrigation Office have proposed remedial works to allow more efficient operation of the furrow, in particular:

- lining of the main furrow
- inverted siphon on Ibukoni Branch at River Motale
- road culvert on lower Mombo Road
- distribution control structures.

2. PRESENT SITUATION

2.1 Irrigation System

Water is abstracted by means of a weir and gated intake from the River Ungwasi (point A on Figure A9) to supply the main furrow, which initially follows a course of the river for about 350 m, before emerging from the river valley to flow downslope, for a further 550 m to the night storage reservoir (B on Figure A9). Immediately upstream of the reservoir a gated division box allows flow to be directed into the reservoir or along the main furrow. The main furrow continues round the reservoir, with one uncontrolled abstraction, supplying the northern part of Ibukoni village, to join the outlet channel from the reservoir at the main distribution structure. At this point branch canals supply Ikuini and the lower part of Ibukoni offtake.

The Ikuini branch has six uncontrolled tertiary offtakes upstream of the lower Rombo road. Occasionally areas to the east of the road are irrigated by excavating a channel across the road. The lower Ibukoni branch divides into two tertiary branches. The division is uncontrolled.

Intake Structure: The river water level is controlled by a low weir of triangular cross section built on rock outcrops. Some seepage occurs under the structure but its stability is not threatened. The gated intake structure to the furrow is in satisfactory condition.

Main Furrow: The stretch of the main furrow along the river bank is shallow and of irregular cross section with frequent small outcrops of rock. Washouts of its left bank had occurred in the past and in these sections masonry walls have been constructed. There are considerable seepage losses over this section. The remainder of the furrow to the reservoir is steep and of irregular cross section. Seepage losses are evident where it is in fill, immediately upstream of the reservoir.

Reservoir: The reservoir is constructed on a slope, excavation from the upper slope being used for compacted earthfill to the embankments. The embankments appear in good condition with no evidence of seepage. The storage capacity is estimated to be about 5000 m^3. Stilling arrangements at the intake are satisfactory but the outlet is controlled by a single sluice gate with no flow measurement device. It is therefore difficult to control the outlet discharge. No escape is provided, surplus water flows over the top of the outlet gate. The channel from the reservoir to the main division box is very steep and badly eroded.

Main Division Box: This structure is a concrete box about 2 m square with two pipe inlets, from the reservoir and main furrow, and two pipe outlets, to the Ikuini and lower Ibukoni branches. No gates are installed and effective control is impossible.

Branch Canals: The Ikuini Branch has six offtakes, none of which are controlled, and irrigation to the east of the lower Rombo road is difficult because there is no road culvert. The upper Ibukoni Branch discharges into the Motale River, at a point where a weir has been built to retain the water. On the other bank an uncontrolled intake abstracts the water. This arrangement is extremely inefficient and the abstracting furrow suffers frequent flood damage. The lower Ibukoni Branch crosses the River Motale in an inverted siphon and divides to two uncontrolled tertiary branches.

2.2 Operation and Maintenance

Each village has a furrow committee, comprising a chairman and five members, to supervise operation and maintenance of the irrigation system. The Ikuini and lower Ibukoni branches receive water all the time, but supplies to the upper Ibukoni branch are intermittent. Allocation of supplies from the main branches is complex and could not be satisfactorily explained, but apparently results in 8 farmers simultaneously receiving water for 6 hours at

a time in each village. This infers an irrigation interval of 10 days but, because of the low quantity of water available to each farmer, less than half the farm can be irrigated at a time.

Because of the night storage reservoir it is not necessary to irrigate at night. The reservoir is operated by a labourer paid by the District Irrigation Office. It would appear that its operation leaves something to be desired, as water is usually diverted into it during both day and night, with the intention of preventing it being drawn down. This would appear to largely defeat the objective of the reservoir. However, as its capacity was decided without any consideration of inflow and outflow, operation is largely by trial and error. Apparently no effort is made to regulate outflows by progressive opening of the outlet gate as the reservoir is drawn down.

Routine maintenance of the individual branches is the responsibility of the respective village irrigation committees. They combine to carry out maintenance of the main furrow and reservoir, although desilting of the reservoir has not been done since it was built. More major items of maintenance are done by the District Irrigation Office, when they can get funds. No funds for maintenance are allocated by the District Council.

2.3 Farming System

The major cropping season is the period of the short rains from October to February. Maize, usually intercropped with beans, cowpeas and pigeon peas, is grown at this time. Maize, cowpeas and beans are harvested in January and pigeon peas in August. When intercropped 1000 kg of maize and 500 kg of beans are obtained per ha. Pure stand maize yields 1600 kg/ha. These yields are claimed to increase by up to 50 percent for farmers with access to irrigation water.

The other major crop is finger millet, planted in February/March for harvest in June/July. This crop is grown in pure stand and yields about 1000 kg/ha. Minor crops are sunflower and vegetables, planted during both seasons.

Most of the farmers resident in Ikuini and Ibukoni have a holding of about 1 ha. In addition farmers from the coffee zone to the west commute to the area to grow cereals and have an average holding of 0.3 ha.

Minimal use is made of fertilizer and other inputs, although mechanized primary cultivation is increasing as a result of the Region's agricultural mechanization programme.

2.4 Role of Irrigation

Irrigation in this area is entirely supplementary, particularly for the maize crop during its crucial tasselling stage in December/January. At present it is estimated that only 85 ha of land are provided with supplementary irrigation. However, rainfall decreases from an annual average of 1390 mm at Haruma Convert to the west of Ikuini to approximately 700 mm at the Kenya border. The lower, drier eastern areas are being more extensively cultivated as pressure on land increases and irrigation of these areas will be necessary to ensure reliable yields.

3. REHABILITATION

3.1 Potential

The irrigation potential of the area is limited by availability of water in the River Ungwasi. No discharge records are available for the river but it is reported that, downstream of the springs, the river has only been dry on two occasions, in August/September of 1974 and 1984. During this period, with the present cropping pattern, irrigation is not required.

The improvements proposed by the District Irrigation Office are aimed at making more efficient use of the available water and could increase water availability by up to 30 percent. However further significant increases in efficiency may be achieved by reviewing the manner of operation of the irrigation system, and particularly the night storge reservoir.

3.2 Rehabilitation Works

The major items of rehabilitation works proposed are as follows:

- flume main canal for first 350 m
- line main canal for next 550 m
- line main canal around night storage reservoir
- provide stilling basin, measuement structure and flume on outlet from night storage reservoir
- replace present main division box with gated structure
- provide gated control for upper Ibukoni branch
- provide inverted siphon on upper Ibukoni branch crossing of River Motale

- provide eight gated division boxes

- install road culvert at Ikuini branch crossing of lower Rombo road.

3.3 Budget Costs

	Item	Cost (TSh)
1.	Main canal flume	588 000
2.	Main canal lining	355 000
3.	Outlet works to night storage reservoir	150 000
4.	Main division box	77 000
5.	Control, Upper Ibukoni Branch	30 000
6.	Inverted siphon, Upper Ibukoni Branch	55 000
7.	8 No. minor division boxes	120 000
8.	Culvert on Lower Rombo Road	25 000
	Subtotal	1 400 000
	Contingencies at 25%	350 000
	TOTAL (say)	1 800 000

Table A9 IKUINI

Region: Kilimanjaro District: Rombo Ward:

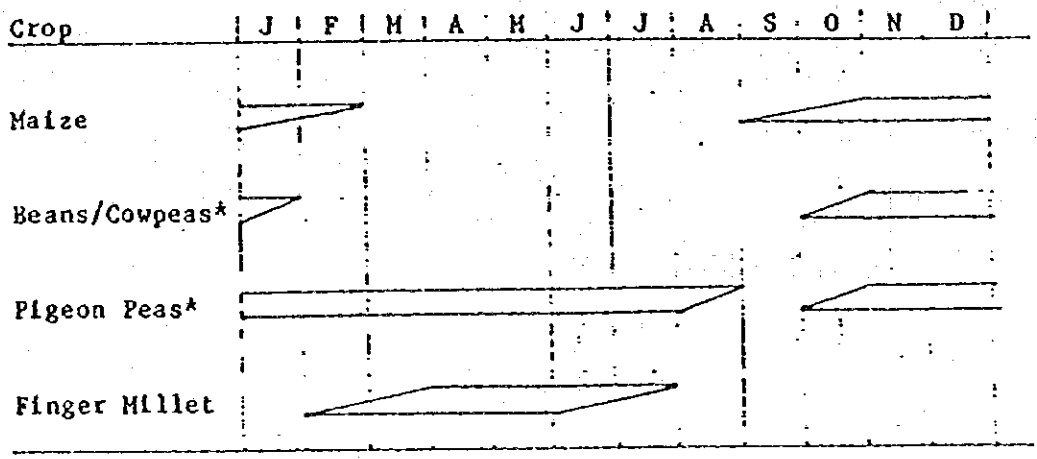
Village: Ikuini (pop. approx. 1900), Ibukoni (pop. approx. 3500)

No. of Furrow Users: 330 farmers

Annual Rainfall: 1372 mm (Haruma Convent)

Month	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall (mm)	97	105	172	284	70	29	25	21	58	94	292	145

Cropping: (Main Crops)



* Interplanted with maize

No reliable information on total areas cultivated is available, but estimated that 85 ha receive supplementary irrigation.

Source of Irrigation Water: Springs on River Ungwasi. No data available

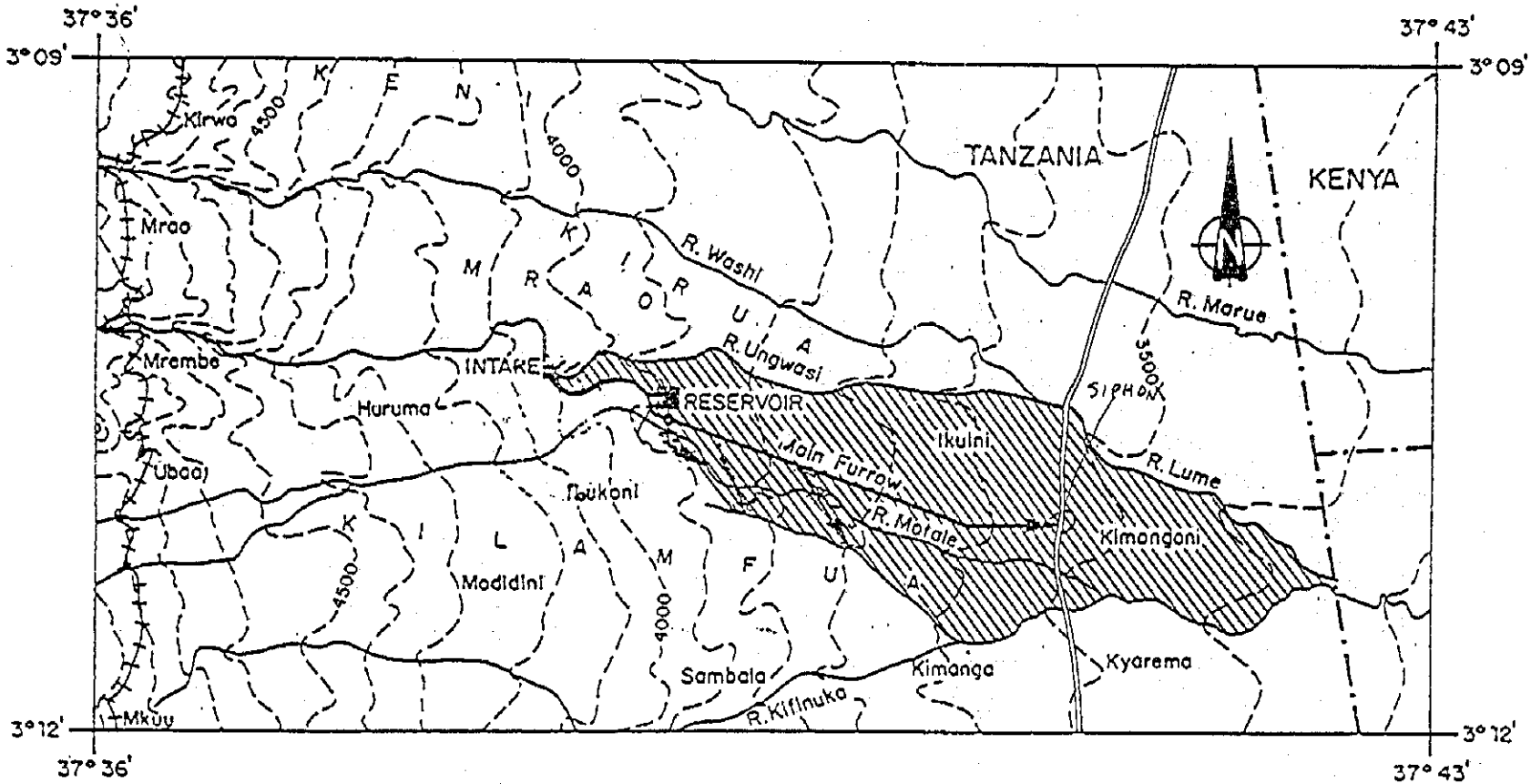


Fig. A9

APPROXIMATE LAYOUT–IKUINI FURROW

Scale 1:50,000 : Reference Map Series Y742, Sheet 57/1. Contours in feet.

資料２－５

COMMENTS ON SCOPE OF WORK FOR THE FEASIBILITY STUDY ON LOWER MAI AND LOWER ROMBO AGRICULTURAL DEVELOPMENT PROJECT.

CLAUSE III - 2- (1) AERIAL PHOTOGRAPHY

It is recommended that scale be changed from 1 : 20,000 to 1:10,000 as the later scale will clarify features in the photographs.

CLAUSE VI - 1: It is recommended that the following sentences read as follows:

2: To permit the members of the Japanese study team to enter, leave and sojourn in the United Republic of Tanzania for the duration of their assignment therein in accordance with existing regulations.

5. To provide necessary facilities to the Japanese study team for the remittance as well as the utilisation of funds introduced into the United Republic of Tanzania from Japan in connection with the implementation of the study as will be applicable.

CLAUSE VII: The following additional undertakings are recommended:

3. To provide vehicles and study equipment.

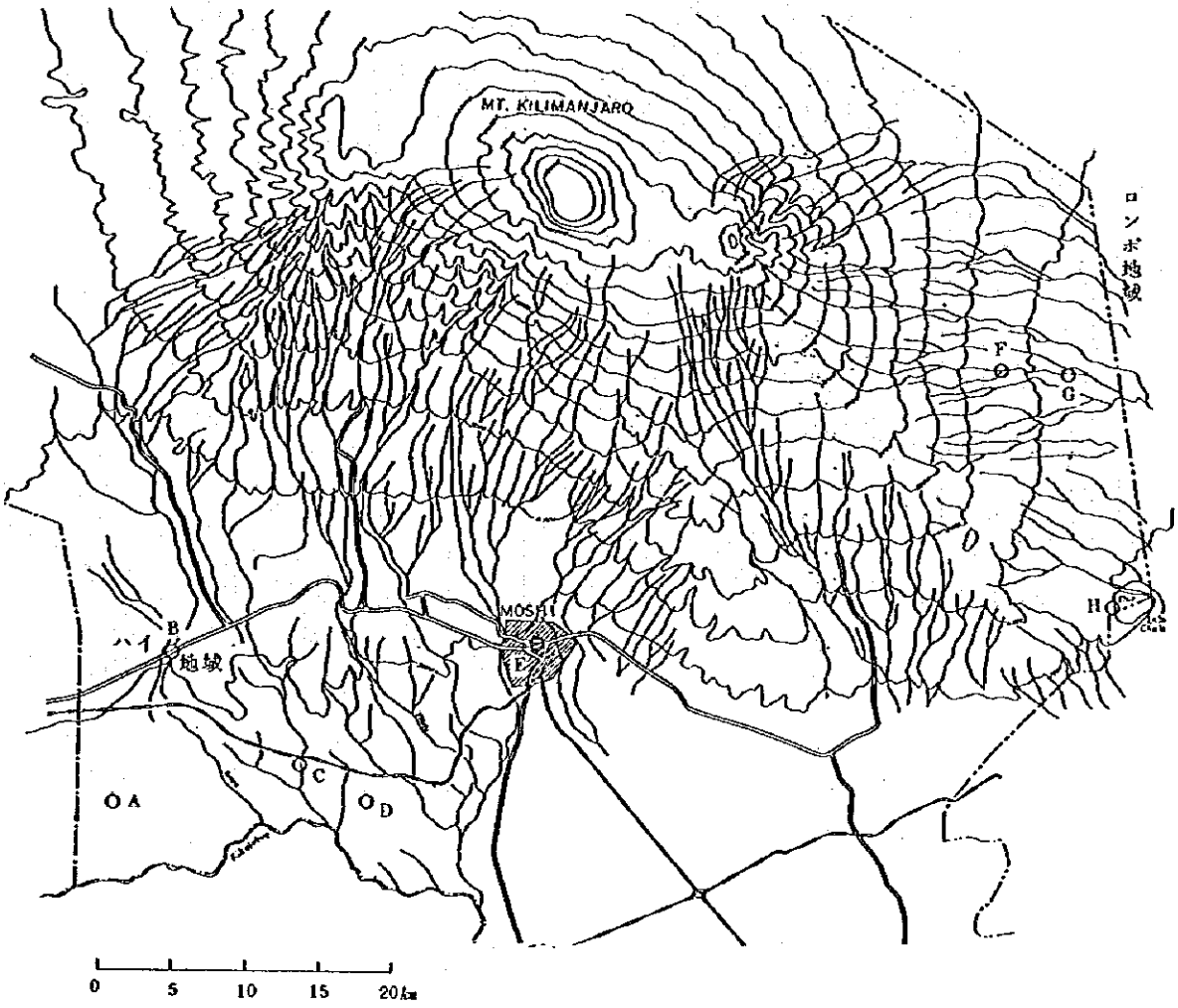
4. To supply spare parts for 1 unit TONE drilling Rig.

GENERAL:

If possible, counterpart staff should participate fully at all stages of project development as:

1. The partcipation shall enable counterpart staff get thoroughly acquainted with all aspects of project development.

2. Transfer of Technology shall be more effective.



資料2－6

水 質 地 図

地　名	状　態	電導度（μS/cm）	温度（℃）
A	井戸水	1464	28
B　Sanya川	流　水	1050	29
C　Rundugai	湧　水	400	24
D	水田の水	655	28
E　MOSHI HOTEL	水道水	172.5	30
F　Komdo	流　水	67.5	23
G　Ungwasi	流　水	88.4	28
H　Chala湖	湖　水	28.5	29