ANNEX-D

SOIL AND LAND SUITABILITY

ANNEX - D

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ANNEX - D

SOIL AND LAND SUITABILITY

1 INTRODUCTION

This Annex details the results of the study on soil, land suitability, salinity and sodicity problems and proposed measures for soil management in the Project Area conducted under the present Study and is composed of three chapters. Chapter 1 is this introduction and explains briefly the contents of this Annex.

Chapter 2 deals with the survey methodology employed in the soil survey under the Study, the characteristics and distribution of the soils in the Study Area and the land suitability classification of the soils. The soil classification was made following the soil classification system of FAO/UNESCO defined in "the Soil Map of the World" and the soil classification defined in the previous study (JICA, 1980) was adopted after making some modifications based on the findings of the present study. The soils were classified by soil phase level. The land suitability classification for irrigated rice and upland crops was assessed following the FAO system defined in "A Framework for Land Evaluation, FAO (1976)".

In detail, the section 2.1 describes the methodology, the section 2.2 describes the soil morphological, chemical and physical characteristics of 7 soil units identified in the Study Area and their distribution and the 2.3 presents the results of land evaluation following the FAO system.

Chapter 3 discusses the results of investigations on salinity and sodicity problems made in and around the Study Area and the proposed measures for soil management in irrigated paddy farming in the Project Area.

In detail, the section 3.1 describes the results of investigations on salinity and sodicity problems made in and around the Study Area and the 3.2 proposes measures for soil management under irrigated farming for the sustainable use of land resources in the Project Area.

2 SOIL AND LAND SUITABILITY

2.1 Methodology

A soil study covering the Study Area had been conducted in 1980 under the JICA Feasibility Study on the Lower Moshi Agriculture Development Project and a semi-detailed soil map and a land suitability classification map on a scale of 1:50,000 had been prepared. In the present Study, the above soil study results were used as the base material and a review of soil and land conditions in the Area and related soil study were carried out. The primary objectives of the present soil study are:

(1) To review the semi-detailed soil map (1/50,000) covering the Study Area and to update the map based on the present conditions of soils, if deemed necessary;

(2) To review the land suitability classification map (1/50,000) prepared in accordance with the land classification system of the Bureau of Reclamation, U.S. Department of Interior, by the previous study and to evaluate land suitability for irrigation farming applying the FAO land evaluation system;

(3) To study the effects of irrigation on soil salinity and sodicity through the investigation of soil characteristics, depth and quality of subsurface groundwater and irrigation water quality, and irrigation practices proposed under the Project; and

(4) To study the soil management plan to avoid soil degradation or to improve the soil under the envisaged irrigation farming plan of the Project.

The soil survey in Phase-I was conducted by means of the excavation of test pits (19 pits) and auger boring (45 sites). Soil profiles were examined to the depth of 1 to 1.5 m or more. Some 120 soil samples were collected from major soil horizons at 32 representative soil profiles for field laboratory tests and 107 samples among them were taken for laboratory analyses. For investigating soil physical properties, a total of 30 undisturbed soil samples were taken at 10 test pits. In addition, 28 shallow groundwater samples in and around the Study Area were taken for examining water quality. Further, a survey was conducted in several traditional irrigation schemes taking water resources from the Kikuletwa river or the river having the Kikuletwa as a tributary, and some soil and water samples were taken for field laboratory analyses of chemical properties of soils. The laboratory analyses were entrusted to the Dar Es Salaam University.

In Phase-II, the supplemental soil survey was conducted in some 1,500 ha in the southern parts of the Study Area as the results of the Phase-I survey indicate the necessity of further investigation on soil salinity/sodicity status for the assessment of the soils in the areas for irrigated farming. The survey was conducted by means of auger boring to the depth of 1.5 to 2.0 m at 30 sites at a density of 1 site per 50 ha. The auger sites were located by grid system. Soil samples were collected from major soil horizons at each auger site and in total of 120 samples were taken for laboratory analyses. The items of laboratory analyses include CEC, EC of soil extracts at saturated moisture content(ECe), exchangeable cations and soluble cations of soil extracts. Based on the results of the survey, the soil and land suitability classification of the areas made in Phase-I have been reviewed and the target area has been classified into strongly salt affected area(980 ha, 65 %), slightly to moderately salt affected area(280 ha, 19 %) and not salt affected area(240 ha, 16 %). These survey and analyses were entrusted to the Dar Es Salaam University. In addition, 23 shallow groundwater samples in and around the Study Area were taken for examining water quality.

The soil classification was made following the soil classification system of FAO/UNESCO defined in "the Soil Map of the World" and the soil classification defined in the previous study (JICA, 1980) was adopted after making some modifications based on the findings of the present study. The soils were classified by soil phase level. The land suitability classification for irrigated paddy and upland crops was assessed following the FAO system defined in "A Framework for Land Evaluation, FAO (1976)".

2.2 Soil Characteristics and Distribution

2.2.1 Physical Environment and General Soil Conditions

The Study Area is extensively located in the volcanic outwash plain (old alluvial plain) on the south-eastern skirt of the Mt. Kilimanjaro, at an elevation between 715 m and 760 m. The overall land form is nearly flat with an average gradient of 1/300 and with a local slight micro-undulation.

The climate in the Study Area is characterised as "Semi-arid Monsoon Tierra Templada (Tt/Tp.c; mo) according to the zonal climatic classification system by J. Papadakis. The mean annual rainfall is around 600 mm and the annual potential evaporation is about 2,000 mm. The rainfall pattern shows the existence of rainy seasons, the main rainy season from March to May and the light rainy season from November to February. The potential evaporation exceeds rainfall except in April and May. The temperatures are fairly constant throughout the year with an annual variation of mean temperature of 20 to 25 ℃.

The Study Area can be classified into three geomorphologic units of old alluvial plain, colluvial plain, and recent alluvial plain. The areal extents of the latter two are limited and nearly 90 % of the Area lies in the old alluvial plain.

(1) Old Alluvial Plain

The old alluvial plain has a nearly flat topography with fine to medium textured old alluvial deposits and is almost entirely used as farmland except for the area with grass and shrub vegetation located in the southern part of the area. The majority of the soils in the plain have been under the soil forming processes with the oxidation weathering under the semi-arid monsoon climate and have a weakly developed cambic profile in subsoil. However, the soils in the southern part of the low lying plain might have undergone saline and sodic soil forming processes affected by brackish shallow groundwater. The soils in the plain are classified into: 1) Eutric Cambisols, Phreatic Phase, 2) Eutric Cambisols, Saline/Sodic Phase and 3) Eutric Cambisols, Slight to Moderate Saline Phase.

(2) Colluvial Plain

The colluvial plain having a very gentle topography lies in the north-eastern end of the Study Area (mainly in paddy fields in Kaloleni) and most of the area have been developed for small patches of flat paddy fields or low terraced paddy fields. The soils in the area are derived from fine textured colluvial deposits transported from the upper hills. They have vertic properties and are classified as Vertic Cambisols.

(3) Recent Alluvial Plain

The area consists of slightly depressed lands and narrow natural levees along the Rau river. The former in the Study Area have mostly developed for paddy fields and the latter have generally been used for upland farming. The soils in the area are generally derived from fine textured alluvial deposits and classified into: 1) Eutric Fluvisols, 2) Mollic Gleysols and 3) Eutric Gleysols.

2.2.2 Soil Characteristics and Distribution

The soils are broadly classified into Cambisols and Fluvisols developed in moderately to well drained areas, Cambisols affected by shallow brackish groundwater and Gleysols and Vertic soils developed in poorly drained areas, while the areal extents of distribution of soils other than Cambisols are limited. The Cambisols are classified into four soil units (phases) and the Gleysols into two. Seven soil units in total are distributed in the Study Area as shown in Table D.2.1, Figure D.2.1 and summarised in the following table.

Mapping Unit	Soil Unit (Soil Phase)	Areal Extent (%)	
Cm - 1	Eutric Cambisols, Phreatic Phase	6,044 ha	(72)
Cm - 2	Eutric Cambisols, Saline/Sodic Phase	980 ha	(12)
Cm - 3	Eutric Cambisols, Slight to Moderate Saline Phase	280 ha	(3)
Cm - 4	Vertic Cambisols, Poorly Drained Phase	160 ha	(2)
Gy - 1	Mollic Gleysols	430 ha	(5)
Gy - 2	Typic Eutric Gleysols, Poorly Drained Phase	360 ha	(4)
Fl	Eutric Fluvisols	190 ha	(2)
	Total	8,444 ha	(100)

The soils in the Study Area generally have high contents of available phosphate and potassium and the mineral fertility status of the soils are assessed high as shown in chemical and physical properties of the soils(results of laboratory analyses) presented in Table D.2.2 and D.2.3. Major characteristics including morphological, chemical and physical characteristics of the soil units and the land suitability of the soils distributed in the Area are explained in the following section. In the assessment of soil fertility status in the characterisation, the following criteria for the assessment have been applied.

Criteria for Fertility Assessment

	High	Medium	Low
N %	> 0.5	0.2 - 0.5	< 0.2
C %	> 10	4 - 10	< 4
Av. P2O5(ppm) 1/	> 50	15 - 50	< 15
Av. P2O5(ppm) 2/	> 15	5 - 15	< 5
Ex. K(meq/100g soil)	> 0.5	0.25 - 0.5	< 0.25

1/: when soil pH <7.0(Bray method); 2/: when soil pH >7.0(Olsen method)

Note: Adopted from Booker Tropical Soil Manual, 1991

(1) Eutric Cambisols, Phreatic Phase (Soil Mapping Unit Cm-1: 6,044 ha / 72 %)

The soils are extensively distributed in nearly flat lands in the Study Area and are almost entirely used for crop cultivation (maize and paddy) except for some areas occupied by village yards or housing yards. The soils are formed by old alluvium deposited by the Rau river and generally have clayey soil textures. The soils have a cambic B horizon weakly developed under the ochric surface horizon. The soils are underlain by a gravel layer or gravel-rich layer in the subsoil at a depth generally below 100 cm from the surface. The description of representative profiles are presented in Table D.2.4.

The soils generally have a clayey surface horizon with sandy fractions and a clay to sandy clay subsoil with or without coarse fragments and gravel. Silt content in the soils is rather low in the entire profile and generally below 20 %.

The soils are none-saline and none-sodic having neutral to slightly alkali reaction, pH (H2O, 1:2.5) ranging from 6.0 to 7.5, throughout the entire profile and ECe less than 0.5 mS/cm. CEC is generally higher than 15 meq per 100g of soil, and ESP is usually below 2 % in the entire profile. Contents of both organic carbon and total nitrogen in the surface soils are very low. However, contents of available potassium (exchangeable K) and phosphate are generally high to very high in the entire profile.

Spatial variation of physical properties of the soils is rather high and major properties are in the following ranges:

Surface soil:	pore space 40 - 50 %,	solid space 50 - 60 %,	AWC 10 - 15 %
Subsoil:	pore space 30 - 50 %,	solid space 50 - 70 %,	AWC 10 - 15 %

Note: surface soil 0-20 cm, subsoil > 20 cm, AWC = available water capacity

The soils have good permeability and have no serious limitation for irrigated farming and are assessed moderately suitable for both paddy and upland crops cultivation. However, proper soil and water management to avoid salinity/sodicity problems under irrigation farming are essential for sustainability of crop production in the area.

(2) Eutric Cambisols, Saline/Sodic Phase (Soil Mapping Unit Cm-2: 980 ha / 12 %)

The soils are found in the low lying flat lands in the southern end of the Study Area along the NAFCO irrigation canal. The soils usually have strong saline properties at the surface and strong saline cum slight to very strong sodic properties in the subsoil. Most of the lands covered by these soils have vegetation of indicator plants for salt accumulation and are not used for crop cultivation and are left waste or used for grazing. The description of representative profile is presented in Table D.2.4.

The soils are formed by old alluvium and have sandy clay loam to clay surface soils and clayey subsoil. The soils have a gravel layer or gravel-rich layer in the subsoil at a depth generally below 100 cm from the surface and are affected by relatively shallow groundwater having moderate to high salt contents. At the end of the wet season (May 1997) groundwater was encountered within 2 m from the surface and has strong salinity: EC 5 to 35 mS/cm and pH 7.2 to 8.9. The sources of accumulated salts in the soils might have been supplied from this brackish water during soil formation processes.

The soils have neutral reaction and high accumulation of salts (ECe 20 - 50 mS/cm) in the 40 cm surface layer. Sodicity of soils tends to increase toward lower horizons and become strong to very strong in subsurface horizon(40 - 60 cm). Soil reaction is higher than pH 7.5 generally at a depth of 80 to 100 cm. Degrees of salt accumulation in the area vary depending on location and they generally increase towards the south to south-western direction. Main exchangeable and soluble cation in both the surface and subsoil is Ca and main soluble anion is Cl.

Contents of both organic carbon and total nitrogen in the surface soils are very low. However, contents of available potassium (exchangeable K) and phosphate are generally very high in the entire profile. Major physical properties of the representative profile are: pore space 50 %, solid space 50 %, AWC 13.5 % in the surface horizon, and pore space 35-45 %, solid space 55-65 %, AWC 13-20 % in the subsoil. Major limitations of the soils for irrigated farming are soil salinity and existence of shallow to moderately deep aquifers containing groundwater with moderate to high soluble salt contents.

The soils are assessed not suitable for irrigated paddy and upland crop cultivation because of strong salinity in the entire soil profile and strong to very strong sodicity in lower horizons.

(3) Eutric Cambisols, Slight to Moderate Saline Phase(Soil Mapping Unit Cm-3: 280 ha/3%)

The soils are found bordering the Saline/Sodic Phase in the southern part of the New Extension Area and usually have slight to moderate saline properties at the surface and slight to strong saline/sodic properties in the subsoil. Most of the lands covered by these soils are used for upland crop cultivation. The soils have similar profile characteristics to Cm-2.

The soils are formed by old alluvium and have sandy clay loam to clay surface soils and clayey subsoil. The soils have a gravel layer or gravel-rich layer in the subsoil at a depth generally below 100 cm from the surface. The area covered with the soils generally have aquifers with high salt content at a depth of around 3m in the dry season.

The soils have neutral reaction and moderate to high accumulation of salts (ECe 4 - < 15 mS/cm) in the 40 cm surface layer. Salinity of the soils tends to increase toward lower horizons.

The soils have good permeability and have no serious limitation for irrigated paddy cultivation and are assessed moderately suitable. However, the suitability for upland crops is assessed marginal because of current salinity and danger of further salt accumulation by upland irrigation. Proper soil and water management to avoid salinity/sodicity problems under irrigation farming are essential for sustainability of crop production in the area.

(4) Vertic Cambisols, Poorly Drained Phase (Soil Mapping Unit Cm-4: 160 ha / 2 %)

The soils are mainly distributed to a limited extent in paddy fields in Kaloleni at the northern end of the Study Area. The original land forms of the area covered with this type of the soils are slightly sloping to flat and low terraced paddy fields are developed in the upper part of the area. The soils are derived from clayey colluvium deposited with the fan formation. Generally, the soils have a diagnostic horizon sequence of A/Bw/C. Vertical and horizontal cracking when dry is the main profile feature of the soils. The description of representative profile is presented in Table D.2.4.

The soils have neutral reaction in the surface soil and slightly alkaline reaction in the subsoil. EC (1:2.5) is lower than 0.5 mS/cm in the entire profile. CEC is higher than 15 meq/100g of soil and ESP is usually below 3 % in the entire profile. Contents of organic carbon and total nitrogen in the surface soil are very low. Content of available potassium (exchangeable K)in the surface layer is high but that of available phosphate is very low.

The soils have no serious limitation for irrigated paddy farming and are assessed moderately suitable for paddy. However, poor drainage conditions of the area covered with these soils will present some limitation for upland crop cultivation. Further, mechanisation of land preparation will be restricted due to drainage conditions.

(5) Mollic Gleysols (Soil Mapping Unit Gy-1: 430 ha / 5 %)

The soils develop mainly on narrow depressions along the Rau river and have a thick mollic horizon at the soil surface and a mottled horizon at a relatively shallow profile in the subsoil. The low-lying area extends in paddy fields at the north-eastern end of the Study Area. The soils are derived from recent fine texture alluvium deposited by the Rau River and have clay loam to clay surface soils and clay subsoil underlain by gravel-rich layers. The description of representative profile is presented in Table D.2.4.

The soils have neutral reaction in the surface soil and neutral to slightly alkaline reaction in the subsoil. EC (1:2.5) is lower than 0.5 mS/cm in the entire profile. CEC is higher than 15 meq/100g of soil and ESP is below 3 % in the surface soil and 4 % in the subsoil. Contents of organic carbon and total nitrogen in the surface soil are very low. Contents of available potassium (exchangeable K) and phosphate are high. Major physical properties of the representative profile are: pore space 41 %, solid space 59 %, AWC 12.8 % in the surface horizon, and pore space 34-38 %, solid space 62-66 %, AWC 8-10 % in the subsoil.

The soils have no serious limitation for irrigated farming and are assessed moderately suitable for both paddy and upland crops cultivation.

(6) Typic Eutric Gleysols, Poorly Drained Phase (Soil Mapping Unit Gy-2: 360 ha / 4 %)

The soils are found mainly in low-lying areas extending in paddy fields at the north-eastern end of the Study Area. The soils are derived from recent fine texture alluvium deposited by the Rau river and have clay to clay loam surface soils and clay subsoil. The soils have iron mottling from surface soil to subsoil and gleyzation in the upper soil layers is observed under paddy cultivation. The description of representative profile is presented in Table D.2.4.

The soils have neutral reaction and EC (1:2.5) lower than 0.5 mS/cm in the surface soil. The subsoil has some salt accumulation compared with the surface soils and indicate moderate sodicity. CEC of the surface soil is higher than 20 meq/100g of soil. Contents of organic carbon and total nitrogen in the surface soil are very low. Contents of available potassium (exchangeable K) and phosphate are generally high.

The soils have no serious limitation for irrigated farming and are assessed moderately suitable for paddy and marginally suitable for upland crops. Poor drainage conditions and resultant restriction on mechanisation of land preparation will present some limitation for crop cultivation, especially in the case of upland crops. Salinity/sodicity of subsoil will not bring about any harmful effects if the leaching fraction of irrigation water is sufficient to prevent accumulations of salts in the surface layer.

(7) Eutric Fluvisols (Soil Mapping Unit Fl: 190 ha / 2 %)

The soils develop on the slightly depressed land and narrow natural levee along the Rau river. In paddy fields, the soils have substantial mottles at the soil surface and a mottled horizon at relatively shallow profile in the subsoil. However, in upland fields no diagnostic profile features are observed. The soils are derived from recent fine texture alluvium deposited by the Rau river and have clayey texture in the entire profile. The description of representative profile is presented in Table D.2.4.

The soils usually have neutral to slightly alkaline reaction in the surface soil and slight alkaline reaction in the subsoil. Sodicity of the surface soil is slight (ESP 2 - 4 %) and EC (1:2.5) is generally lower than 0.5 mS/cm in the entire profile. Contents of organic carbon and total nitrogen in the surface soils are low to very low. Contents of available potassium (exchangeable K) and phosphate are high to very high.

The soils have no serious limitation for irrigated farming and are assessed moderately suitable for both paddy and upland crops cultivation.

2.3 Land Suitability Classification

(1) Evaluation System

The evaluation of the soils in the Study Area has been made for irrigated paddy and upland crop cultivation by applying selected land qualities and assessment criteria shown in Table D.2.5, in accordance with the system proposed in the FAO system, "A Framework for Land Evaluation, FAO Soils Bulletin No. 32". The classification has been made at a subclass level by adding subclass symbols indicating kinds of limitations. The land suitability classes and examples of subclasses employed are as follows:

Suitability Class	Definition	Subclass (limitation)
Class S1 Highly Suitable	Land having no significant or only minor limitations to sustained application of a given use	-
Class S2 Moderately Suitable	Land having limitations which in aggregate are moderately severe for sustained application of a given use	S2d (drainage)
Class S3 Marginally Suitable	Land having limitations which in aggregate are severe for sustained application of a given use	S3f (flooding)
Class CS Conditionally Suitable	Land having limitations which in aggregate prohibit a given use under the management specified, but suitable if certain conditions are fulfilled	Css (salinity)
Class N Currently Not Suitable	Land having limitations which cannot be corrected with existing knowledge at a currently acceptable cost	Nt (soil texture)

(2) Land Suitability Classes

The results of land classification are shown in Table D.2.6 and Figure D.2.1, and summarised in the following table.

Soil Unit (Soil Phase)	Suitability Classes for Irrigated Paddy	Suitability Classes for Irrigated Upland Crops	Areal Extent (%)
Eutric Cambisols, Phreatic Phase	S2e	S2e	6,044 ha (72)
Eutric Cambisols, Saline/Sodic Phase	Ns	Ns	980 ha (12)
Eutric Cambisols, Slight to Moderate Saline Phase	S2esz	S3s	280 ha (3)
Vertic Cambisols, Poorly Drained Phase	S2ew	S3w	160 ha (2)
Mollic Gleysols	S2e	S2e	430 ha (5)
Typic Eutric Gleysols, Poorly Drained Phase	S2ew	S3w	360 ha (4)
Eutric Fluvisols	S2e	S2e	190 ha (2)
Total			8,444 ha (100)

As shown in the table, the soils in the Area except for strongly salt affected Eutric Cambisols are assessed suitable both for irrigated paddy and upland crops and they are generally more suitable for paddy and higher degrees of limitations for upland crop cultivation will be encountered, especially due to soil salinity and drainage conditions. The results of land suitability classification are summarised below:

(a) Suitability for Irrigated Paddy

All the soils in the Area except for one soil unit are classified as moderately suitable for irrigated paddy (S2: 7,464 ha, 88 %) with slight to moderate limitations on soil nutrient holding capacity (CEC) and with or without slight to moderate limitations on drainability of soil or salinity. Eutric Cambisols, Saline/Sodic Phase is classified as currently not suitable(Ns: 980 ha, 12 %) because of high salt accumulation in the soils and subsurface soil sodicity problems.

(b) Suitability for Irrigated Upland Crops

Nearly eighty percent (79 %) or some 6,664 ha of the soils in the Area are evaluated as moderately suitable for irrigated upland crops with slight to moderate limitation on soil nutrient holding capacity (CEC). 800 ha or 9 % of the Area are assessed marginally suitable (S3) because of poor drainability or salinity of soils. Eutric Cambisols, Saline/Sodic Phase is as currently not suitable(Ns: 980 ha, 12 %) because of high salt accumulation in the soils and subsurface soil sodicity problems.

3 PROPOSED MEASURES FOR SOIL MANAGEMENT

3.1 Soil Salinity/Sodicity Problems

At the southern end of the Study Area, substantial distribution of salt-accumulated soils has been identified. However, the salinity level and sodic conditions are not permanent characteristics of the soil and their presence may not be very significant to irrigation development if leaching conditions are favourable because salts are mobile and can be removed by leaching when drainage conditions are satisfactory. On the other hand, the development of the unfavourable properties of saline and sodic soils is a continuing hazard in irrigation which can be prevented by adequate irrigation/drainage and soil management practices. Important factors to be considered in the evaluation of salinity and sodicity problems include: irrigation water quality, infiltration and permeability rate of soils, levelling required to provide suitable land surface for leaching, ability of substrata to transmit necessary leaching water, level of salinity or sodic conditions and availability of gypsum to replace sodium in sodic soils and cropping system.

With a view to investigating soil salinity and sodicity problems and to study soil management measures under the Project, the following investigations have been made in the present Study.

- Survey of groundwater depth and water quality of shallow wells in and around the Study Area;
- Soil sampling and analysis for examining effects of irrigation in the past in the Existing Lower Moshi Project Area; and
- Field survey in irrigated paddy fields taking water resources from the Kikuletwa River for examining possible adverse effects of irrigation water on paddy growth and soil properties.

(1) Groundwater Depth and Water Quality

Groundwater depth and water quality have been surveyed at 25 shallow wells and at 3 soil sampling sites in the Phase-I survey and at 23 shallow wells in the Phase-II survey as shown in Figure D.2.1. The results of the survey are presented in Table D.3.1. As shown in the table, most of the water samples indicate moderately high to high electric conductivity (EC) and Na ion content although the groundwater depths are generally below 2 m. It is reported that the groundwater table is deepest around the end of May and in the dry season the water surface drops for about 1m from the present level. However, in the southern parts of the Study Area, the existence of groundwater rich in soluble salts at a shallow depth from the surface has been detected. The distribution of salt accumulated soils is generally consistent with the distribution of shallow groundwater table. Inadequate drainage and a rising water table after a few years of irrigation may lead to the entry of saline water into the root zone. The introduction of proper irrigation/drainage water management and soil management in the areas with a shallow groundwater table is essential for the reclamation of such areas and to prevent further accumulation of salts in the root zone under irrigation.

(2) Effects of Irrigation on Soil Properties in Existing Lower Moshi Project Area

In order to investigate effects of the past irrigation on soil chemical properties in the Existing Lower Moshi Project Area, soil samples were taken from paddy fields where irrigated paddy cultivation started between 1985 to 1987 and upland fields where no irrigation was practised in the past (sampling locations are shown in Figure D.2.1). The results of chemical analyses are presented in Table D.3.2. As shown in the table, there is no tendency of salt accumulation and increase of ESP in paddy fields. On the contrary, the two soils (Pa-5s & Pa-6s) in upland fields adjacent to paddy fields show accumulation of salts compared with the soils in the adjacent paddy fields, which might have resulted from the rising of the groundwater table due to irrigation in paddy fields or from leaching of salts occurred during paddy cultivation the paddy fields. In any case, it could be assessed that there was no salt accumulation and increase of ESP in the paddy fields due to irrigated paddy cultivation for a period of some ten years in the past.

(3) Findings of Field Survey in Paddy Fields in The Downstream of Kikuletwa River

Some findings of the field survey in irrigated paddy fields located in the downstream of the Kikuletwa river and taking water sources from the Kikuletwa river or the Pangani river which has the Kikuletwa as a tributary are presented in Table D.3.3. Water resources of both the Kikuletwa and Pangani river showed alkali reaction with pH over 8 and the adverse effects of such water with high pH on paddy growth and soils were apprehended. However, as shown in the table, no specific hazards of the use of such water for irrigated paddy cultivation were reported by farmers and extension officers in the areas and normal growth of paddy was observed in the two paddy fields.

3.2 Proposed Measures for Soil Management

The chances of salt accumulation is generally a continuing hazard in irrigation and the development of the unfavourable properties of saline and sodic soils under irrigation should be prevented by adequate irrigation/drainage and soil management practices. These practices include: 1) adequate irrigation to leach soluble salts below the root zone, 2) maintaining soil permeability in good conditions, 3) efficient distribution of water to prevent excessive deep percolation and water stagnation and 4) construction of a good surface drainage system to remove runoff water from each field. Among those practices, the maintaining of good soil permeability or the improvement of same is essential soil management practices to avoid soil degradation due to continuous irrigation. Further, application of gypsum or other soil ameliorates should be examined where necessary to prevent or to correct unfavourable sodic conditions.

The assessments of the qualities of water resources for irrigation under the Project indicate: 1) Kikuletwa river - slight to moderate restriction due to salinity and infiltration hazard, 2) Njoro river - no restriction with salinity hazard and slight to moderate restriction due to infiltration hazard and 3) Rau river - no restriction with salinity hazard and severe restriction due to infiltration hazard. Although the chances of the development of salinity hazard under irrigated paddy farming is limited, special attention for maintaining soil permeability is needed to prevent infiltration hazard. The soils in the Project Area generally have clayey textures in the surface and subsurface layers. However, the permeability the soils is good attributed to higher sandy fraction and lower silt fraction of the soils. The maintaining of good soil permeability is essential soil management measures to avoid soil degradation due to continuous irrigation in the Project Area.

The soils in the Project Area generally have high content of available phosphate and exchangeable potassium and successful paddy production has been done for over 10 years without an application of phosphate and potassium fertilisers. In addition, the water resources for irrigation in the Project have high contents of potassium roughly equivalent to supply of 75 to over 200 kg/ha of K_2O per cropping season. While, unexpectedly poor response of paddy plants to Urea application are also reported in the Area. The review of fertilisation practices is considered essential for sustainablity of paddy farming in the Project Area.

The proposed measures for soil management in the Project Area to prevent soil degradation due to irrigation and the proposed approaches to fertilisation issues are as follows;

(1) Introduction of Soil Amelioration Crops

For the maintaining or improvement of soil permeability, the introduction of soil amelioration crops having deep rooting characteristics and/or having characteristics to promote formation of soil structures is one essential soil management practice. In paddy farming under the Project, direct puddling method for land preparation by rotary tiller is practised and surface soil structures will be destroyed in every paddy cropping season. The introduction of pasture grasses having characteristics of promoting formation of soil structures through their root development is not effective and, therefore, the introduction of alfalfa having deep rooting characteristics in rotation with paddy is proposed aiming at the maintaining or improvement of permeability of subsurface soils. In the proposed cropping pattern, the cultivation of the crop in rotation with paddy in the late dry season in 20 % of the entire area is planned. Alfalfa products should better be used for animal feeding to improve feed quality and for the enhancement of livestock productivity in the Project Area.

(2) Application of Organic Matters

The other practice for the maintaining or improvement of soil permeability is continuous application of organic matters through the incorporation of crop residues into soils or as farmyard manure or composts. The proposed practices, therefore, are: 1) spreading paddy straws after harvesting, being left to rot in fields and incorporate them into soils at the time of land preparation and 2) preparation of composts or farmyard manure by utilising paddy straws and dressing of them prior to land preparation. The application of organic matters in the form of farmyard manure is more preferable measures as it means the use of crop residues for the improvement of animal feeding system in the Project Area .

(3) Monitoring of Effects of Proposed Soil Management Practices and Soil Salinity and Sodicity Status

The introduction of the proposed soil management practices should be started prior to the introduction in farmers fields through the verification and demonstration activities of the practices and the effects of the practices on permeability and soil nutritional status should be monitored continuously. In addition, the periodical monitoring of salinity and sodicity status of the soils in the entire Project Area should be done as an important routine activity of the Agronomy Section of KADP. Such monitoring should include the periodical measurements of soil pH and EC after every cropping seasons and of pH and EC of irrigation water in monthly basis. In case when noticeable changes in soil conditions or water quality are observed in such monitoring activities, detail analyses of soil or water samples should be made and the counter measures should be discussed with the research institutes and introduced, if deemed necessary.

(4) Fertilisation

As discussed earlier, the review of fertilisation practices will be necessary in the Project Area. For the review, fertiliser trials on: 1) effects of phosphate fertilisation, 2) comparative trial on nitrogen sources, Urea and Ammonium Sulphate and 3) effects of potassium fertilisation in fields having different water resources; are to be implemented from the initial stage of the development of the Project.

Tables

Table D.2.1 Soil Distribution and Land Suitability Classification

Soil Classification/ Soil Unit		Land Suitability Classification 1/		Areal Extent		
Soil Unit	Mapping Symbol	for Irrigated Paddy Filed	for Irrigated Upland Crops	(ha)	(%)	Distribution
Dystric Cambisols, Phreatic Phase	Cm - 1	S2e	S2e	6,044	72	Entire New Extension Area except for southern part
Eutric Cambisols, Saline/Sodic Phase	Cm - 2	Ns	Ns	980	12	Southern part of New Extension Area
Eutric Cambisols, Slight to Moderate Saline Phase	Cm - 3	S2esz	S3s	280	3	Southern end of Study Area along NAFCO canal
Vertic Cambisols, Poorly Drained Phase	Cm - 4	S2ew	S3w	160	2	Majority in Kaloleni
Mollic Gleysols	Gy - 1	S2e	S2e	430	5	Rau Ya Kati/Oria along Rau River
Typic Eutric Gleysols, Poorly Drained Phase	Gy - 2	S2ew	S3w	360	4	Expanded Area(Mandaka) & Upper Mabogini
Typic Eutric Fluvisols	Fl	S2e	S2e	190	2	Expanded Area(Mandaka) & Rau Ya Kati/Oria
Study Area Total				8,444	100	

1/: S2 Moderately suitable, S3 Marginally suitable, N Currently not suitable

File: DT-1

Table D.2.2 Chemical and Physical Properties of Soils(Representative Soil Profiles)-1/4

Site No. Soil Unit Location Land Use	Horizon (cm)	Chemical Properties																		Physical Properties						
		pH (1:2.5) H2O	pH (1:2.5) KCl	EC (1:2.5) uS	ECe uS	C %	N %	Av. P2O5 ppm	CEC meq/100g	Exchangeable Cations meq/100g soil K	Na	Ca	Mg	ESP %	Soluble Cations meq/100g soil K	Na	Ca	Mg	Texture (%) Clay	Silt	Sand	Texture	Bulk Density	Real Density	Porosity (%)	Solid Phase (%)	Field Capacity (%)	Wilting Point (%)	Av. Water Capacity (%)
Pa-1	I 0 - 15	6.0	4.8	50	160	1.34	0.08	50.8	16.0	1.5	0.2	5.8	3.3	1.3	0.0	0.0	0.0	0.0	54	18	28	C							
Cm-1	II 15 - 30	7.0	5.6	60	180	0.42	0.05	70.5	15.1	2.3	0.4	7.4	5.3	2.6	0.0	0.1	0.0	0.0	60	16	24	C							
L. Mabogini	III 30 - 50	6.3	4.8	50	90	2.32	0.15	77.0	15.7	2.1	0.5	4.2	4.2	3.2	0.0	0.1	0.0	0.0	66	14	20	C							
Paddy Field	IV 50 - 100	7.1		70																									
Pa-2	I 0 - 15	6.8	5.6	60		0.74	0.09	121.3	16.4	3.0	0.2	8.3	4.0	1.2					42	16	42	C							
Cm-1	II 15 - 40	6.3	4.9	60		0.38	0.05	86.9	19.2	3.1	0.1	8.1	3.3	0.5					52	14	34	SC/C							
L. Mabogini Upland Field	III 40 - 100	6.4	5.2	80		0.38	0.00	78.6	16.6	2.3	0.1	7.2	4.0	0.6					52	32	16	C							
Pa - 3	I 0 - 18	6.4	5.0	40	90	0.72	0.08	33.2	14.9	1.1	0.2	6.3	4.3	1.3	0.0	0.0	0.0	0.0	42	18	40	C	1.48	2.73	45.2	54.8	31.2	20.1	11.1
Cm-1	II 18 - 50	7.4	5.9	60	90	0.22	0.03	554.7	14.0	1.9	0.4	8.7	5.1	2.9	0.0	0.0	0.0	0.0	56	12	32	C	1.48	2.22	33.3	66.7	35.1	20.6	14.6
L. Mabogini Paddy Field	III 50 - 90	7.2	5.7	60	130	0.12	0.01	221.6	15.9	2.1	0.5	10.3	4.4	3.1	0.0	0.0	0.0	0.0	52	8	40	C	1.38	2.83	51.5	48.6	35.9	26.0	10.0
Pa - 4	I 0 - 15	6.6	5.5	90	130	0.87	0.05	183.8	19.2	3.7	0.1	8.5	4.6	0.5	0.1	0.0	0.0	0.0	46	14	40	C	1.38	2.12	34.8	65.2	28.9	20.1	8.8
Cm-1	II 15 - 45	6.4	5.1	70	110	0.63	0.04	104.5	18.8	2.6	0.2	8.8	4.0	1.1	0.0	0.0	0.0	0.0	56	14	30	C	1.43	2.66	46.2	53.8	32.1	20.7	11.5
L. Mabogini	III 45 - 65	6.0	4.6	70	150	0.25	0.02	112.2	20.6	2.2	0.3	7.4	4.1	1.5	0.0	0.1	0.0	0.0	58	16	26	C	1.43	2.44	41.4	58.6	34.2	24.3	10.0
Upland Field	IV 65 - 110	5.9	4.3	90	100	0.18	0.02	86.9	23.2	2.3	0.4	7.2	4.7	1.7	0.0	0.1	0.0	0.0	62	14	24	C	1.44	2.41	40.0	60.0	37.0	23.0	14.0
Pa-5	I 0 - 20	6.5	5.1	50	160	1.13	0.15	67.7	19.6	1.4	0.5	9.4	5.1	2.6	0.0	0.0	0.0	0.0	46	16	38	C							
Cm-1	II 20 - 40	7.2	5.7	60	160	0.50	0.03	243.2	15.8	1.7	0.4	9.4	5.7	2.5	0.0	0.0	0.0	0.0	48	12	40	C							
Chekereni	III 40 - 60	6.8		110																									
Paddy Field	IV 60 - 100	6.8		120																									
Pa-6	I 0 - 20	6.8	5.6	60	220	0.88	0.06	4.1	16.1	1.4	0.3	8.3	5.1	1.9	0.0	0.1	0.0	0.1	34	12	54	SCL							
Cm-1	II 20 - 35	7.4	6.2	80	310	0.81	0.06	129.6	16.1	1.9	0.4	11.0	5.3	2.5	0.0	0.1	0.0	0.1	38	16	46	SC							
Chekereni	III 35 - 60	7.4		150																									
Paddy Field	IV 60 - 80	7.5		150																									
Pa-7	I 0 - 20	7.4	6.3	110	330	0.96	0.08	278.6	17.8	3.9	0.2	11.3	4.7	1.1	0.1	0.0	0.0	0.0	40	18	42	CL							
Cm-1	II 20 - 40	7.1	6.1	200	900	0.58	0.03	239.6	16.9	3.2	0.2	10.1	4.3	1.2	0.1	0.1	0.2	0.1	46	18	36	C							
Chekereni	III 40 - 60	7.2	6.0	80	280	0.33	0.02	277.5	16.2	3.0	0.2	9.0	5.0	1.2	0.1	0.0	0.0	0.0	52	14	34	C							
Upland Field	IV 60 - 100	6.6		120																									
Pa-9	I 0 - 15	6.4	4.9	60		1.04	0.15	17.3	18.7	0.9	0.8	9.4	4.8	4.3					52	14	34	C							
Cm-1	II 15 - 40	7.6	5.9	70		0.37	0.02	353.6	14.6	1.1	0.8	10.3	5.3	5.5					52	14	34	C							
U. Mabogini Paddy Field	III 40 - 70	7.6	6.0	70		0.20	0.02	157.1	14.5	1.2	0.7	9.3	5.4	4.8					50	14	36	C							

Table D.2.2 Chemical and Physical Properties of Soils(Representative Soil Profiles)-2/4

Site No. / Soil Unit / Location / Land Use	Horizon (cm)	Chemical Properties																		Physical Properties									
		pH (1:2.5) H2O	pH (1:2.5) KCl	EC (1:2.5) uS	ECe uS	C %	N %	Av. P2O5 ppm	CEC meq/100g	Exchangeable Cations meq/100g soil				ESP %	Soluble Cations meq/100g soil				Texture (%)				Bulk Density	Real Density	Porosity (%)	Solid Phase (%)	Field Capacity (%)	Wilting Point (%)	Av. Water Capacity (%)
										K	Na	Ca	Mg		K	Na	Ca	Mg	Clay	Silt	Sand	Texture							
Pa-12	I 0 - 20	7.9	6.9	190	640	1.46	0.12	149.3	24.8	6.6	0.2	16.6	7.8	0.8	0.2	0.0	0.0	0.1	36	24	40	CL							
Cm-1	II 20 - 35	7.6	6.8	390	1,680	1.00	0.12	715.5	27.3	5.6	0.3	14.4	5.9	1.1	0.3	0.1	0.3	0.2	44	18	38	C							
Oria Upland Field	III 35 - 70	7.2	6.4	710	3,600	0.23	0.02	226.5	25.8	4.5	0.4	16.7	5.5	1.6	0.2	0.2	1.0	0.6	46	16	38	C							
Pa - 13	I 0 - 15	6.3	5.0	70		1.29	0.13	34.4	21.6	1.1	0.3	10.8	4.2	1.4					42	16	42	C	1.28	2.51	49.0	51.0	36.6	23.0	13.6
Cm-1	II 15 - 30	7.2	5.9	70		1.07	0.12	201.7	20.7	1.3	0.3	13.7	6.6	1.4					44	16	40	C	1.41	1.93	27.0	73.0	38.2	25.4	12.9
Rau Ya Kati	III 30 - 60	7.5	6.0	50		0.50	0.03	245.0	16.5	1.4	0.4	10.0	7.8	2.4					52	16	32	C	1.38	2.72	49.3	50.7	33.5	25.3	8.2
Paddy Field	IV 60 - 100	7.0		200																			1.51	2.74	45.1	55.0	38.1	27.0	11.1
Pa - 14	I 0 - 20	7.0	5.5	50		0.69	0.05	56.5	14.6	1.7	0.3	8.3	4.6	2.1					42	16	42	C	1.54	2.9	46.9	53.1	33.9	21.4	12.5
Cm-1	II 20 - 50	7.5	6.0	50		0.23	0.02	187.1	14.3	1.9	0.2	9.2	5.2	1.4					44	14	42	C	1.49	2.07	27.9	72.1	33.3	18.5	14.8
Chekereni Paddy Field	III 50 - 90	7.0	6.0	90		0.30	0.04	60.4	17.3	2.2	0.3	9.4	5.7	1.7					46	14	40	C	1.36	2.48	45.2	54.8	27.8	18.5	9.3
Pr - 2	I 0 - 18	7.0	5.8	60	180	0.99	0.06	92.0	13.0	2.6	0.1	7.0	3.9	0.8	0.1	0.0	0.0	0.0	32	38	30	CL	1.36	2.33	41.5	58.5	32.1	15.8	16.3
Cm-1	II 18 - 30	7.1	5.7	40	190	0.72	0.05	77.1	14.8	2.4	0.1	8.4	4.7	0.7	0.0	0.0	0.0	0.0	40	22	38	CL	1.45	2.21	34.6	65.4	34.4	20.1	14.3
L. Mabogini	III 30 - 70	7.0	5.6	40	200	0.62	0.08	41.7	14.7	2.0	0.1	8.3	5.0	0.7	0.0	0.0	0.0	0.0	46	16	38	C	1.39	2.17	36.0	64.0	32.7	20.2	12.5
Upland Field	IV 70 - 100	7.0	5.5	40	310	0.43	0.06	26.5	20.5	2.1	0.1	12.6	6.1	0.5	0.0	0.1	0.0	0.0	48	18	44	C							
Pr - 3	I 0 - 15	6.5	5.3	80		0.84	0.09	110.5	20.2	3.2	0.1	7.1	6.2	0.5					50	16	34	C							
Cm-1	II 15 - 35	6.5	5.2	50		0.58	0.08	108.2	20.0	3.3	0.0	8.9	4.6	0.0					54	16	30	C							
Mtakuja	III 35 - 55	6.3	4.9	60		0.27	0.04	87.2	17.8	2.2	0.1	7.0	4.6	0.6					56	14	30	C							
Upland Field	IV 55 - 80	6.4		110																									
Pr - 4	I 0 - 15	6.8	5.8	140	380	1.40	0.17	129.5	16.6	3.2	0.1	10.0	3.4	0.6	0.1	0.0	0.1	0.1	38	14	48	SC	1.37	2.75	50.3	49.7	27.6	17.3	10.3
Cm-1	II 15 - 35	6.7	5.3	50	230	0.44	0.06	84.8	14.2	2.0	0.1	9.0	2.2	0.7	0.0	0.0	0.0	0.0	40	12	48	SC	1.35	2.19	38.8	61.3	34.8	16.2	18.6
Mtakuja	III 35 - 70	6.6	5.9	90	350	0.32	0.04	68.0	18.7	2.0	0.1	11.0	2.9	0.5	0.0	0.0	0.0	0.0	42	12	46	SC	1.38	2.47	44.1	55.9	29.3	17.4	11.9
Upland Field	IV 70-95																						1.35	2.62	48.6	51.5	26.8	14.6	12.2
Pr - 5	I 0 - 15	6.8	5.6	70		0.89	0.12	109.4	17.4	3.2	0.1	9.4	3.9	0.6					52	20	28	C							
Cm-1	II 15 - 50	6.6	5.2	60		0.34	0.05	89.8	17.6	2.6	0.0	8.9	4.2	0.0					58	16	26	C							
Mvuleni Upland Field	III 50 - 70	6.3	4.9	50		0.39	0.05	85.0	19.3	1.9	0.1	8.1	4.6	0.5					60	12	28	C							
Pr - 9	I 0 - 15	7.2	6.1	90	390	0.90	0.10	336.3	15.8	3.2	0.2	8.6	4.8	1.3	0.1	0.1	0.0	0.1	44	18	38	C							
Cm-1	II 15 - 40	7.3	6.0	70	230	0.38	0.05	169.7	12.1	2.2	0.2	7.1	4.2	1.7	0.0	0.0	0.0	0.0	50	12	38	C							
L. Mabogini Upland Field	III 40 - 80	7.3	6.0	90	210	0.29	0.02	87.1	13.2	2.1	0.1	8.9	3.5	0.8	0.0	0.0	0.0	0.0	52	14	34	C							

Table D.2.2 Chemical and Physical Properties of Soils(Representative Soil Profiles)-3/4

Site No. Soil Unit Location Land Use	Horizon (cm)	Chemical Properties																		Physical Properties								
		pH (1:2.5) H2O	pH (1:2.5) KCl	EC (1:2.5) uS	ECe uS	C %	N %	Av. P2O5 ppm	CEC meq/100g	Exchangeable Cations meq/100g soil K	Na	Ca	Mg	ESP %	Soluble Cations meq/100g soil K	Na	Ca	Mg	Texture (%) Clay	Silt	Sand	Texture	Bulk Density	Real Density	Porosity (%)	Solid Phase (%)	Field Capacity (%)	Wilting Point (%)	Av. Water Capacity (%)
Ex - 8	I 0 - 18	7.4	6.6	100		1.39	0.15	433.4	20.0	2.8	0.2	11.5	9.0	1.0					46	18	36	C	1.33	2.12	37.3	62.7	35.4	20.6	14.8
Cm-1	II 18 - 40	7.7	6.6	80		0.83	0.05	95.1	17.4	2.6	0.2	10.8	7.8	1.1					34	24	36	CL	1.36	2.67	49.0	51.0	29.2	18.4	10.8
Kaloleni	III 40 - 65	7.8	6.7	90		0.73	0.04	86.2	19.8	2.9	0.5	12.1	9.6	2.5					42	20	38	C	1.38	2.25	38.8	61.3	31.7	21.7	10.0
Upland Field	IV 65 - 100	8.0	7.0	140		0.50	0.03	84.0	14.1	1.2	0.6	11.6	5.9	4.3					48	16	36	C	1.35	2.77	51.4	48.7	30.6	21.6	9.0
Pr - 6	I 0 - 15	7.0	6.4	9,500	66,100	0.83	0.09	51.0	37.8	5.9	0.7	21.9	11.3	1.9	0.4	0.7	22.5	13.8	30	18	52	SCL							
Cm-2	II 15 - 40	7.4	7.0	6,890	23,100	0.60	0.06	126.1	23.8	4.7	0.7	15.0	6.7	2.9	0.1	0.1	5.6	46.7	34	16	50	SCL							
Mtakuja	III 40 - 60	7.0	6.0	140	600	1.02	0.09	134.8	17.0	3.7	0.2	9.9	4.7	1.2	0.1	0.1	0.0	0.1	46	14	40	C							
Grass Land	IV 60 - 80	9.0	7.7	2,360	12,320	0.68	0.07	33.1	12.8	3.8	2.0	10.6	5.0	15.6	0.2	0.5	0.2	1.3	38	16	46	SC							
Pr - 7	I 0 - 15	7.5	6.9	11,240	52,300	1.09	0.10	168.8	30.9	6.4	0.6	18.7	10.1	1.9	0.3	1.0	6.1	4.4	44	20	36	C							
Cm-2	II 15 - 40	7.7	7.0	7,330	25,900	0.66	0.04	114.9	49.1	6.7	0.7	17.4	10.0	1.4	0.1	0.2	2.1	2.7	52	18	30	C							
Oria	III 40 - 60	8.2	7.2	3,800	13,400	0.99	0.11	353.3	14.5	4.2	1.2	9.0	5.7	8.3	0.1	1.0	0.7	0.4	46	28	26	C							
Grass Land	IV 60 - 90	8.5	7.2	2,760	8,250	0.72	0.08	482.0	14.5	5.1	1.3	9.2	6.5	9.0	0.2	0.4	0.2	0.1	48	26	26	C							
Pr - 8	I 0 - 15	6.5	6.0	7,380	36,400	0.83	0.05	99.9	31.6	4.4	0.1	17.7	4.7	0.3	0.2	1.0	7.6	4.3	28	20	52	SCL	1.36	2.70	49.4	50.6	29.9	16.4	13.5
Cm-2	II 15 - 35	6.6	6.1	5,820	34,500	0.37	0.03	41.1	24.8	3.9	0.0	13.6	4.5	0.0	0.2	0.3	6.8	3.7	34	20	46	SCL	1.41	2.16	34.6	65.4	29.0	16.0	13.0
Mtakuja	III 35 - 65	7.1	6.2	3,230	14,100	0.35	0.03	154.1	16.7	3.5	0.2	9.9	3.9	1.2	0.1	0.4	5.2	2.0	36	20	44	SC	1.30	2.13	36.9	63.2	34.8	17.0	17.8
Grass Land	IV 65 - 100	8.5	7.5	2,910	10,440	0.37	0.02	601.8	13.5	3.4	1.2	11.2	4.4	8.9	0.2	0.6	6.6	0.2	34	20	46	SCL	1.23	2.21	44.5	55.6	35.6	16.0	19.6
Pr - 1	I 0 - 15	7.3	6.2	130	510	1.53	0.15	103.9	23.1	6.1	0.1	13.0	6.4	0.4	0.1	0.0	0.0	0.1	46	18	36	C							
Cm-3	II 15 - 40	6.5	6.0	640	7,720	0.69	0.04	66.1	31.1	4.7	0.4	14.0	7.1	1.3	0.1	0.2	2.2	1.6	50	16	34	C							
Chekereni	III 40 - 53	6.5	5.9	4,140	23,500	0.54	0.03	45.6	42.7	4.6	0.3	18.7	10.5	0.7	0.1	0.1	7.9	4.9	46	18	36	C							
Upland Field	IV 53 - 100	7.6	7.3	2,900	12,880	0.50	0.06	60.7	31.1	4.7	0.4	22.1	10.1	1.3	0.1	0.7	4.5	2.8	40	20	40	CL/C							
Ex - 1	I 0 - 10	6.4	4.9	90		2.40	0.27	2.8	17.1	1.2	0.2	11.6	5.8	1.2					48	12	40	C							
Cm-4	II 10 - 40	6.6	5.3	120		1.40	0.18	2.0	23.9	1.7	0.1	12.7	6.0	0.4					50	12	38	C							
Kaloleni Paddy Field	III 40 - 70	7.6	6.6	280		0.50	0.03	50.5	22.6	2.6	0.7	16.1	7.8	3.1					54	8	40	C							
Pa - 10	I 0 - 15	6.6	5.2	70		0.42	0.03	44.3	23.5	1.9	0.3	12.4	5.6	1.3					44	14	42	C	1.35	2.30	41.3	58.7	36.5	23.7	12.8
Gy-1	II 15 - 40	7.7	6.2	50		0.30	0.02	56.7	17.1	2.9	0.5	11.9	6.2	2.9					40	18	42	CL	1.42	2.19	35.2	64.8	37.4	26.6	10.8
Oria	III 40 - 70	7.9	6.3	50		0.29	0.02	64.0	15.4	3.7	0.6	10.2	5.5	3.9					36	18	46	SC	1.33	2.01	33.7	66.3	33.5	25.4	8.2
Paddy Field	IV 70 - 95	7.9		250																			1.30	2.11	38.3	61.8	34.2	24.2	10.0

Table D.2.2 Chemical and Physical Properties of Soils(Representative Soil Profiles)-4/4

Site No. / Soil Unit / Location / Land Use	Horizon (cm)	Chemical Properties: pH (1:2.5) H_2O	pH (1:2.5) KCl	EC (1:2.5) uS	ECe uS	C %	N %	Av. P2O5 ppm	CEC meq/100g	Exchangeable Cations meq/100g soil: K	Na	Ca	Mg	ESP %	Soluble Cations meq/100g soil: K	Na	Ca	Mg	Physical Properties: Texture (%) Clay	Silt	Sand	Texture	Bulk Density	Real Density	Porosity (%)	Solid Phase (%)	Field Capacity (%)	Wilting Point (%)	Av. Water Capacity (%)
Pa - 8	I 0 - 15	7.3	5.9	160		2.19	0.25	327.9	19.7	0.8	0.6	11.6	9.2	3.0					46	22	32	C							
Gy-2	II 15 - 50	6.6	5.0	130		1.81	0.13	7.0	22.1	1.2	0.8	10.4	7.3	3.6					50	26	24	C							
U. Mabogini Paddy Field	III 50 - 70	6.9	5.3	110		1.32	0.14	17.2	26.1	1.4	0.6	13.6	9.4	2.3					56	2	42	C							
Ex - 2	I 0 - 15	7.5		400																									
Gy-2	II 15 - 40	8.5	7.0	620		1.29	0.15	98.4	20.4	1.6	1.3	15.3	12.3	6.4					62	14	24	C							
Mandaka Paddy Field	III 40 - 80	9.1	7.3	660		0.84	0.06	57.9	15.3	1.5	3.0	11.0	10.2	19.6					66	12	22	C							
Ex - 4	I 0 - 20	7.5	6.2	250		2.27	0.23	7.9	24.3	1.6	0.7	14.2	11.9	2.9					58	20	22	C							
Gy-2	II 20 - 40	8.2	6.7	440		0.85	0.11	126.1	18.8	3.2	1.5	15.8	5.8	8.0					60	18	22	C							
Mandaka Paddy Field	III 40 - 80	9.0	7.4	690		0.70	0.04	15.4	18.3	4.2	2.1	12.9	11.0	11.5					60	18	22	C							
Ex - 7	I 0 - 20	8.6	6.9	590		1.21	0.10	71.3	26.4	2.4	2.4	25.6	10.0	9.1					62	18	20	C							
Gy-2	II 20 - 50	8.6	7.4	870		1.92	0.13	46.0	23.8	2.5	2.2	22.5	9.8	9.2					68	12	20	C							
Mandaka Paddy Field	III 50 - 80	8.9		1,380																									
Pa - 11	I 0 - 25	8.0	6.9	70		1.11	0.12	276.0	25.3	7.3	1.0	15.6	8.7	4.0					54	20	26	C	1.10	2.01	45.4	54.6	36.2	20.1	16.1
Fl	II 25 - 60	7.9	6.7	2,210		0.42	0.03	533.7	19.2	6.6	0.4	9.7	7.9	2.1					58	14	28	C	1.25	2.74	54.4	45.6	39.0	28.8	10.2
Rau Ya Kati Upland Field	III 60 - 80	8.0	6.9	2,830		0.38	0.03	156.4	12.7	4.5	0.9	6.0	5.1	7.1					62	14	24	C	1.35	2.64	49.0	51.1	38.2	28.4	9.8
Ex - 5	I 0 - 25	7.2	6.0	80		1.98	0.20	131.4	28.6	1.6	0.5	18.2	9.7	1.7					50	22	28	C							
Fl	II 25 - 60	7.5	6.1	70		0.65	0.08	92.1	24.6	2.0	0.6	16.7	9.2	2.4					62	18	20	C							
Mandaka Paddy Field	III 60 - 80	7.6	6.3	80		0.40	0.03	135.5	22.3	2.2	0.6	15.9	7.7	2.7					64	16	20	C							
Ex - 6	I 0 - 25	7.2	6.2	390	940	2.47	0.27	466.2	28.9	4.3	0.7	15.7	9.6	2.4	0.1	0.3	0.1	0.4	48	18	34	C							
Fl	II 25 - 60	7.9	6.7	310	450	1.19	0.10	321.7	28.4	3.7	0.9	19.4	11.4	3.2	0.0	0.3	0.0	0.0	64	14	22	C							
Mandaka Paddy Field	III 60 - 80	8.4	7.2	420	420	1.26	0.09	47.1	11.7	2.8	1.7	7.3	4.9	14.5	0.0	0.2	0.0	0.0	62	14	24	C							

File:DT-2

Table D.2.3 Salinity Status of Soils in the Southern Part of the Study Area-1/5

1/: Area tentatively demarcated as salt accumulated area in Phase-I Study File:DT-3

Sampling Site	Depth(cm)	pH(1:2.5)	ECe mS	CEC meq/ 100g soil	Exchangeable Cations K meq/ 100g soil	Na meq/ 100g soil	Ca meq/ 100g soil	Mg meq/ 100g soil	ESP (%)	Soluble Cations(saturated soil extract) K ppm	Na ppm	Ca ppm	Mg ppm	Soluble Anions(saturated soil extract) Cl ppm	SO4 ppm	CO3 ppm	HCO3 ppm	Salinity/Sodicity Status Salinity (ECe)	Sodicity (ESP)	Exch. Na Content
A-1	0 - 20	6.58	2.0	23.7	4.4	0.3	12.3	6.7	1.3	428	915	1,414	303	Assessment Criteria of Salinity/Sodicity Staus				non	non	low
	20 - 40	6.40	3.4	23.6	4.3	0.4	12.0	6.9	1.7	174	70	528	132		Salinity (ECe/mS)	Sodicity (ESP/%)	Exch. Na (meq)	non	non	medium
	40 - 60	6.16	5.9	15.6	2.7	0.5	8.0	4.5	3.2	204	102	643	201	very strong	-	≥ 25	≥ 2	slight	non	medium
	60 - 100	6.36	5.9	23.2	3.5	0.7	12.4	6.5	3.0	180	140	621	187	high/ stroog	≥ 15	16 - 25	0.7 - 1	slight	non	medium
A-2	0 - 20	6.90	3.3	17.7	5.0	0.1	8.8	3.8	0.6	64	210	19	3	medium/ moderate	8 - 15	11 - 16	0.3 - 0.7	slight	non	very low
	20 - 40	6.74	2.4	18.1	4.6	0.2	9.3	4.0	1.1	222	46	237	62	slight	4 - 8	6 - 11	-	non	non	low
	40 - 60	6.62	4.1	18.9	4.3	0.4	10.2	4.0	2.1	214	80	427	100	low/ non	< 4	< 6	0.1 - 0.3	slight	non	medium
	60 - 100	6.95	11.3	27.4	5.5	2.7	13.6	5.6	9.9	282	664	1,109	212	very low	-	-	< 0.1	moderate	slight	very high
	100 - 150	7.52	13.1	16.5	4.3	0.2	8.8	3.2	1.2	244	420	1,184	230					moderate	non	low
A-3	0 - 20	6.83	0.5	11.4	2.5	0.2	6.4	2.4	1.8	79	175	34	10					non	non	low
	20 - 40	6.70	0.8	16.0	3.7	0.3	8.8	3.2	1.9	58	220	20	4					non	non	medium
	40 - 60	6.55	3.7	12.9	0.2	0.6	8.4	3.6	4.7	162	192	402	92					non	non	high
	60 - 100	6.70	3.5	20.5	3.2	1.1	11.4	4.8	5.4	136	232	375	39					non	non	very low
A-4	0 - 20	7.40	0.4	15.4	3.8	0.1	8.6	2.9	0.6	78	18	17	6					non	non	very low
	20 - 40	7.11	0.8	14.5	3.5	0.1	7.8	3.1	0.7	82	36	58	18					non	non	low
	40 - 60	7.10	2.8	15.8	2.9	0.3	8.7	3.8	1.9	150	80	369	86					non	non	very low
B-1	0 - 20	6.60	0.2	17.2	4.3	0.1	8.9	3.9	0.6	78	24	9	4					non	non	very low
	20 - 40	6.55	0.2	16.5	3.5	0.1	8.9	4.0	0.6	64	15	21	11					non	non	medium
	40 - 60	6.42	2.8	18.3	3.3	0.4	9.9	4.7	2.2	116	116	292	83					strong	slight	very high
B-2	0 - 20	6.18	50.2	45.5	3.2	4.8	25.7	11.8	10.5	772	830	3,700	667					stroog	strong	very high
	20 - 40	6.30	32.4	30.5	4.3	5.5	16.9	3.8	18.0	656	765	2,267	581					strong	very strong	very high
	40 - 60	6.84	22.5	20.4	4.4	6.5	13.5	3.9	31.9	250	915	1,241	363					strong	strong	very high
	60 - 100	7.55	40.2	36.5	5.1	8.2	19.2	4.0	22.5	47	370	58	11							

Table D.2.3 Salinity Status of Soils in the Southern Part of the Study Area-2/5

1/: Area tentatively demarcated as salt accumulated area in Phase-I Study File:DT-3

Sampling Site	Depth(cm)	pH(1:2.5)	ECe mS	CEC meq/ 100g soil	Exchangeable Cations K meq/ 100g soil	Na meq/ 100g soil	Ca meq/ 100g soil	Mg meq/ 100g soil	ESP (%)	Soluble Cations(saturated soil extract) K ppm	Na ppm	Ca ppm	Mg ppm	Soluble Anions(saturated soil extract) Cl ppm	SO4 ppm	CO3 ppm	HCO3 ppm	Salinity/Sodicity Status Salinity (ECe)	Sodicity (ESP)	Exch. Na Content
B-3	0 - 20	6.14	33.1	35.2	5.1	4.2	21.2	4.7	11.9	668	525	2,670	518	9,998	960	trace	12	strong	moderate	very high
	20 - 40	6.33	24.4	31.1	3.5	3.2	12.7	11.7	10.3	320	595	1,838	418	3,969	960	trace	12	strong	slight	very high
	40 - 60	6.40	23.2	13.3	2.2	2.1	6.4	2.6	15.8	250	655	1,267	315	3,968	950	trace	12	strong	strong	very high
	60 - 100	7.03	18.6	18.4	2.9	3.7	8.6	3.2	20.1	195	755	788	229	3,969	1200	trace	12	strong	strong	very high
	100 - 150	7.77	17.7	43.9	5.8	10.1	20.7	7.3	23.0	215	915	637	218	2,552	1200	trace	24	strong	strong	very high
B-4	0 - 20	7.24	2.5	23.1	6.2	0.8	11.5	4.6	3.5	222	226	206	60					non	non	high
	20 - 40	7.33	12.7	24.3	5.4	0.3	13.7	4.9	1.2	372	740	1,197	139					moderate	non	low
	40 - 60	7.60	10.5	26.8	4.4	5.2	12.5	4.6	19.4	291	540	707	98					moderate	strong	very high
	60 - 100	8.04	11.9	29.0	4.8	9.1	10.6	4.5	31.4	270	915	288	43					moderate	very strong	very high
C-1	0 - 20	7.21	0.5	14.7	3.9	0.2	7.4	3.2	1.4	104	50	36	11					non	non	low
	20 - 40	6.95	4.7	17.5	4.0	0.3	8.9	4.3	1.7	226	108	518	92					slight	non	low
	40 - 60	6.76	17.4	24.7	3.3	0.9	13.5	6.9	3.6	160	140	1,409	298					strong	non	high
	60 - 100	7.35	17.1	42.1	6.7	2.6	24.2	8.6	6.2	160	325	1,158	390					strong	slight	very high
C-2	0 - 20	5.93	4.3	50.8	10.5	9.1	21.5	9.6	17.9	620	700	3,351	559					slight	strong	very high
	20 - 40	6.30	32.2	42.1	9.7	9.1	15.6	7.6	21.6	450	440	1,816	420					strong	strong	very high
	40 - 60	6.49	26.8	40.7	10.3	9.1	14.6	6.7	22.4	415	1,530	1,511	435					strong	strong	very high
C-3	0 - 20	6.42	34.4	43.5	11.1	4.2	19.4	8.9	9.7	752	525	2,417	621					strong	slight	very high
	20 - 40	6.60	27.8	28.4	6.2	5.4	12.0	4.8	19.0	728	658	1,776	519					strong	strong	very high
	40 - 60	6.78	20.4	28.5	5.4	5.5	11.1	6.5	19.3	333	915	1,090	336					strong	strong	very high
	60 - 100	7.02	16.7	30.1	6.2	8.3	10.0	5.6	27.6	428	1,000	871	231					strong	very strong	very high
C-4	0 - 20	7.64	1.0	29.0	6.8	7.4	10.6	4.2	25.5	154	143	48	17					non	strong	very high
	20 - 40	7.55	4.9	24.3	7.3	3.0	9.8	4.2	12.3	316	420	286	5					slight	moderate	very high
	40 - 60	7.18	14.0	29.9	6.6	5.2	12.1	5.9	17.4	436	675	965	197					moderate	strong	very high
	60 - 100	7.72	20.7	45.9	7.6	8.2	22.3	7.8	17.9	600	910	1,280	250					strong	strong	very high
	100 - 150	7.74	19.2	48.4	8.1	7.1	26.2	7.0	14.7	580	960	2,002	302					strong	moderate	very high

Assessment Criteria of Salinity/Sodicity Staus

	Salinity (ECe/mS)	Sodicity (ESP/%)	Exch. Na (meq)
very strong	-	> 25	> 2
high/ strong	> 15	16 - 25	0.7 - 1
medium/ moderate	8 - 15	11 - 16	0.3 - 0.7
slight	4 - 8	6 - 11	-
low/ non	< 4	< 6	0.1 - 0.3
very low	-	-	< 0.1

Table D.2.3 Salinity Status of Soils in the Southern Part of the Study Area-3/5

1/: Area tentatively demarcated as salt accumulated area in Phase-I Study File:DT-3

Sampling Site	Depth(cm)	pH(1:2.5)	ECe mS	CEC meq/ 100g soil	Exchangeable Cations				ESP (%)	Soluble Cations(saturated soil extract)				Soluble Anions(saturated soil extract)				Salinity/Sodicity Status		
					K meq/ 100g soil	Na meq/ 100g soil	Ca meq/ 100g soil	Mg meq/ 100g soil		K ppm	Na ppm	Ca ppm	Mg ppm	Cl ppm	SO4 ppm	CO3 ppm	HCO3 ppm	Salinity (ECe)	Sodicity (ESP)	Exch. Na Content
D-1	0 - 20	7.38	0.7	19.7	5.1	0.2	9.5	4.9	1.0	94	40	30	14					non	non	low
	20 - 40	7.28	0.4	19.1	4.8	0.2	9.5	4.6	1.0	82	36	21	9					non	non	low
	40 - 60	7.20	0.6	19.3	4.4	0.4	9.6	4.9	2.1	32	30	21	5					non	non	moderate
	60 - 100	7.45	0.3	20.4	3.8	0.4	10.7	5.6	2.0	34	50	10	5					non	non	moderate
	100 - 150	7.48	0.4	23.0	4.3	0.4	11.8	6.5	1.7	22	55	15	4					non	non	moderate
D-2	0 - 20	6.42	68.9	45.2	8.4	6.3	19.9	10.6	13.9	940	2,000	2,920	756	16,869	1,200	trace	12	strong	moderate	very high
	20 - 40	6.95	42.7	29.4	8.3	2.1	12.9	6.1	7.1	695	2,000	1,408	356	10,065	3,600	trace	12	strong	strong	very high
	40 - 60	7.73	21.3	38.5	8.4	12.5	11.2	6.3	32.5	480	1,660	509	170	3,260	3,600	trace	24	strong	very strong	very high
	60 - 100	7.88	17.3	38.3	8.3	10.3	13.5	6.3	26.9	436	1,130	569	89	2,977	2,400	trace	37	strong	very strong	very high
D-3	0 - 20	6.49	39.8	32.9	4.3	1.1	17.5	10.0	3.3	640	432	3,143	870					strong	non	high
	20 - 40	6.63	23.6	25.3	3.5	1.1	12.9	7.8	4.3	215	200	1,795	574					strong	non	high
	40 - 60	6.59	20.2	22.5	2.9	1.2	11.7	6.7	5.3	133	195	1,379	384					strong	non	high
	60 - 100	6.81	14.9	26.1	3.5	4.7	11.4	6.5	18.0	253	364	1,868	382					moderate	strong	very high
D-4	0 - 20	7.15	0.3	18.8	4.9	0.1	8.8	5.0	0.5	100	36	43	13					non	non	very low
	20 - 40	7.51	0.5	19.5	4.0	0.2	10.2	5.1	1.0	60	36	36	9					non	non	low
	40 - 60	7.26	11.6	28.1	4.3	0.8	17.2	5.8	2.8	75	60	925	191					moderate	non	high
E-1	0 - 20	6.98	6.2	27.4	5.7	0.9	13.4	7.4	3.3	300	184	576	131					slight	non	high
	20 - 40	7.00	3.9	23.2	4.6	0.7	11.7	6.2	3.0	188	140	382	76					non	non	medium
	40 - 60	6.84	6.8	23.9	3.9	2.0	11.5	6.5	8.4	75	198	397	105					slight	slight	high
	60 - 100	7.32	4.4	24.0	3.9	2.6	11.7	5.8	10.8	140	420	244	37					slight	moderate	very high
	100 - 150	8.16	1.2	32.8	6.9	2.4	17.4	6.1	7.3	120	180	35	7					non	slight	very high
E-2	0 - 20	6.31	45.8	50.2	8.6	6.3	20.6	14.8	12.5	750	960	2,136	797					strong	moderate	very high
	20 - 40	6.50	23.5	36.8	7.2	5.5	15.4	8.7	14.9	425	860	1,288	414					strong	moderate	very high
	40 - 60	6.69	16.2	34.9	5.6	6.4	15.5	7.4	18.3	428	730	884	209					strong	strong	very high
	60 - 100	7.51	12.7	36.3	6.7	8.6	13.4	7.6	23.7	195	915	333	145					moderate	strong	very high

Assessment Criteria of Salinity/Sodicity Staus

	Salinity (ECe/mS)	Sodicity (ESP/%)	Exch. Na (meq)
very strong	-	> 25	> 2
high/ strong	> 15	16 - 25	0.7 - 1
medium/ moderate	8 - 15	11 - 16	0.3 - 0.7
slight	4 - 8	6 - 11	-
low/ non	< 4	< 6	0.1 - 0.3
very low	-	-	< 0.1

Table D.2.3 Salinity Status of Soils in the Southern Part of the Study Area-4/5

1/: Area tentatively demarcated as salt accumulated area in Phase-I Study File:DT-3

Sampling Site	Depth(cm)	pH(1:2.5)	ECe mS	CEC meq/ 100g soil	Exchangeable Cations K meq/ 100g soil	Na meq/ 100g soil	Ca meq/ 100g soil	Mg meq/ 100g soil	ESP (%)	Soluble Cations(saturated soil extract) K ppm	Na ppm	Ca ppm	Mg ppm	Soluble Anions(saturated soil extract) Cl ppm	SO4 ppm	CO3 ppm	HCO3 ppm	Salinity/Sodicity Status Salinity (ECe)	Sodicity (ESP)	Exch. Na Content
E-3	0 - 20	7.08	23.7	42.8	7.7	5.2	18.3	11.6	12.1	510	875	1,371	444					strong	moderate	very high
	20 - 40	6.52	29.9	41.1	7.3	8.5	14.7	10.6	20.7	510	1,315	1,281	518	Assessment Criteria of Salinity/Sodicity Staus				strong	strong	very high
	40 - 60	6.85	22.7	36.6	7.1	9.1	11.4	8.9	24.9	624	1,130	1,000	300		Salinity (ECe/mS)	Sodicity (ESP/%)	Exch. Na (meq)	strong	strong	very high
	60 - 100	7.60	17.0	38.3	7.6	10.2	13.0	7.5	26.6	320	1,050	398	167	very strong	-	≥ 25	≥ 2	strong	very strong	very high
E-4	0 - 20	7.97	1.2	21.0	5.6	0.3	10.4	4.8	1.4	170	84	72	27	high/ strong	≥ 15	16 - 25	0.7 - 1	non	non	low
	20 - 40	7.20	3.5	17.8	4.1	0.4	8.6	4.7	2.2	216	157	436	85	medium/ moderate	8 - 15	11 - 16	0.3 - 0.7	non	non	medium
	40 - 60	7.02	8.3	21.8	3.2	0.6	12.5	5.6	2.8	85	90	687	186	slight	4 - 8	6 - 11	-	slight	non	medium
F-1	0 - 20	6.76	0.8	22.8	5.0	0.2	10.8	6.8	0.9	100	46	46	22	low/ non	< 4	< 6	0.1 - 0.3	non	non	low
	20 - 40	6.62	0.3	22.3	4.1	0.4	10.8	7.0	1.8	38	43	14	6	very low	-	-	< 0.1	non	non	medium
	40 - 60	6.45	0.4	21.0	3.4	0.6	10.1	7.0	2.9	34	78	16	10					non	non	medium
	60 - 100	6.41	2.2	21.5	3.2	1.1	10.2	7.1	5.1	68	280	137	63					non	non	high
F-2	0 - 20	6.94	0.4	23.7	5.9	0.2	10.6	7.0	0.8	78	63	12	7					non	non	low
	20 - 40	6.76	0.7	23.5	5.4	0.3	10.5	7.3	1.3	90	60	35	18					non	non	low
	40 - 60	6.31	2.3	20.8	3.8	0.8	9.3	6.9	3.8	94	210	165	40					non	non	high
	60 - 100	6.30	4.2	27.5	4.4	3.2	12.1	7.7	11.6	140	248	240	63					slight	moderate	very high
	100 - 150	7.49	5.8	32.2	4.3	5.5	15.0	7.4	17.1	170	600	327	57					slight	strong	very high
F-3	0 - 20	7.80	0.6	23.5	7.1	0.3	10.4	5.7	1.3	166	50	37	12	1,559	7,200	trace	159	non	non	low
	20 - 40	7.38	3.9	22.5	6.1	0.5	9.7	6.2	2.2	266	202	405	68	1,701	3,200	trace	24	non	non	medium
	40 - 60	6.77	9.3	30.2	4.6	7.5	11.4	6.8	24.8	316	320	787	179	2,410	3,600	trace	24	moderate	strong	very high
	60 - 100	6.92	12.7	30.9	4.3	3.1	14.9	8.5	10.0	300	532	551	267	567	1,200	trace	61	moderate	slight	very high
F-4	0 - 20	0.94	24.9	40.7	4.3	8.3	17.2	10.9	20.4	332	900	2,592	391					strong	strong	very high
	20 - 40	5.68	23.8	33.9	3.6	4.6	15.4	10.3	13.6	108	940	1,451	351					strong	moderate	very high
	40 - 60	6.08	17.4	32.4	3.5	8.6	13.5	6.8	26.5	108	915	775	244					strong	very strong	very high

Table D.2.3 Salinity Status of Soils in the Southern Part of the Study Area-5/5

1/: Area tentatively demarcated as salt accumulated area in Phase-I Study File:DT-3

Sampling Site	Depth(cm)	pH(1:2.5)	ECe mS	CEC meq/ 100g soil	Exchangeable Cations				ESP (%)	Soluble Cations(saturated soil extract)				Soluble Anions(saturated soil extract)				Salinity/Sodicity Status		
					K meq/ 100g soil	Na meq/ 100g soil	Ca meq/ 100g soil	Mg meq/ 100g soil		K ppm	Na ppm	Ca ppm	Mg ppm	Cl ppm	SO4 ppm	CO3 ppm	HCO3 ppm	Salinity (ECe)	Sodicity (ESP)	Exch. Na Content
G-1	0 - 20	7.23	8.3	20.3	3.3	0.7	10.5	5.8	3.4	120	135	497	144					slight	non	medium
	20 - 40	6.96	5.0	20.2	3.3	0.7	10.9	5.3	3.5	65	105	284	107	Assessment Criteria of Salinity/Sodicity Staus				slight	non	medium
	40 - 60	6.90	6.4	19.0	2.8	1.2	10.2	4.8	6.3	45	135	404	105		Salinity (ECe/mS)	Sodicity (ESP/%)	Exch. Na (meq)	slight	slight	high
	60 - 100	7.36	6.8	20.2	2.7	2.0	10.8	4.7	9.9	33	335	274	70	very strong	-	≥ 25	≥ 2	slight	slight	high
G-2	0 - 20	6.20	64.0	50.3	7.3	1.2	29.1	12.7	2.4	555	1,420	3,424	874	high/ strong	≥ 15	16 - 25	0.7 - 1	strong	non	high
	20 - 40	6.53	37.7	43.0	8.4	5.5	19.2	9.9	12.8	375	1,010	2,247	607	medium/ moderate	8 - 15	11 - 16	0.3 - 0.7	strong	moderate	very high
	40 - 60	7.07	24.0	35.4	6.5	7.4	14.7	6.8	20.9	280	960	1,146	291	slight	4 - 8	6 - 11	-	strong	strong	very high
	60 - 100	7.33	15.8	38.5	6.2	9.0	15.7	7.6	23.4	150	700	500	160	low/ non	< 4	< 6	0.1 - 0.3	strong	strong	very high
G-3	0 - 20	6.05	55.9	52.2	7.1	7.4	25.7	12.0	14.2	545	1,220	3,610	889	very low	-	-	< 0.1	strong	moderate	very high
	20 - 40	6.46	34.6	31.7	7.0	1.0	15.2	8.5	3.2	375	1,530	1,695	510					strong	non	high
	40 - 60	6.95	21.4	32.9	5.6	9.8	10.8	6.7	29.8	300	1,130	929	435					strong	very strong	very high
	60 - 100	7.73	61.1	36.3	5.6	9.3	14.4	7.0	25.6	150	1,050	397	145					strong	strong	very high
H-1	0 - 20	7.19	4.7	23.7	6.2	0.6	11.9	4.9	2.5	108	90	238	62					slight	non	medium
	20 - 40	6.82	6.0	22.6	6.8	0.8	9.8	5.2	3.5	85	90	320	86					slight	non	high
	40 - 60	6.32	16.8	23.2	3.5	1.6	12.9	5.3	6.9	130	255	1,127	302					strong	slight	high
	60 - 100	6.98	18.7	29.8	1.0	3.7	16.5	8.6	12.4	108	370	1,397	272					strong	moderate	very high
H-2	0 - 20	7.49	2.8	20.5	4.6	0.4	11.1	4.4	2.0	75	38	156	32					non	non	medium
	20 - 40	7.29	4.7	18.0	3.6	0.4	10.2	3.8	2.2	85	45	332	60					slight	non	medium
	40 - 60	6.78	9.4	21.0	3.5	0.9	11.8	4.8	4.3	278	260	1,132	205					moderate	non	high
	60 - 100	6.93	23.4	32.2	5.5	6.9	13.2	6.7	21.4	213	530	707	200					strong	strong	very high
I-1	0 - 20	5.98	17.1	29.1	3.5	1.7	13.1	10.8	5.8	332	568	679	205					strong	non	high
	20 - 40	6.32	43.5	40.4	4.1	2.6	20.9	12.8	6.4	205	530	1,885	664					strong	strong	very high
	40 - 60	6.78	31.6	34.3	4.3	5.7	15.9	8.4	16.6	268	530	1,135	440					strong	strong	very high
	60 - 100	7.19	24.5	34.9	5.1	1.7	17.3	10.8	4.9	428	615	2,685	366					strong	non	high

1/: Area tentatively demarcated as salt accumulated area in Phase-I Study

Table D.2.4 Repesentative Soil Profiles(1/4)

Eutric Cambisols, Phreatic Phase (Cm-1)

Location	Lower Mabogini (Pa-3)
Land Form	Flat/Paddy field
Parent Material	Alluvial deposits(volcanic origin)
Land Use	Paddy field; fallow longer than 1 year
Groundwater Depth	> 150 cm

Depth(cm)	Profile Description and Characteristics
0 - 18	Dark reddish brown(5YR3/2), clay with silt content less than 20%, reddish brown mottles on structure surface, weakly developed blocky structure, slightly sticky when wet & moderately hard when dry, few to common fine pores, pH(1:2.5) 6.4, ECe 0.09mS, bulk density 1.48, available water capacity(AWC) 11.1% , clear wavy boundary
18 - 50	Dark reddish brown(5YR3/3), heavy clay with silt content less than 20%, very weakly developed blocky structure, sticky when wet & very hard when dry, few medium pores(2mm), pH(1:2.5) 7.4, ECe 0.09 mS, bulk density 1.48, AWC 14.6%, gradual diffused boundary
50 - 90	Dark reddish brown(5YR3/3), heavy clay with silt content less than 10%, weakly developed subangular structure, sticky when wet & very hard when dry, very few round gravel content(< 3% & 2-3mm), pH(1:2.5) 7.2, ECe 0.13mS, bulk density 1.38, AWC 10.0%, gradual diffused boundary
90 - 105	Dark reddish brown(5YR3/3), clay, structureless, sticky when wet & very hard when dry, very few round gravel content(< 3% & 2-5mm) , gradual diffused boundary
> 105	Dark reddish brown(5YR3/3), clay, structureless, sticky when wet & very hard when dry, round gravel content 15%(2-5mm)

Analytical Data of Soil

	CEC(meq)	Av.P_2O_5(ppm)	Ex. K(meq)	ESP(%)
0 - 18	14.9	33.2	1.1	1.3
18 - 50	14.0	554.7	1.9	2.9
50 - 90	15.9	221.6	2.1	3.1

Eutric Cambisols, Phreatic Phase (Cm-1)

Location	Chekereni (Pa-14)
Land Form	Flat/Paddy field
Parent Material	Alluvial deposits(volcanic origin)
Land Use	Paddy field under fallow
Groundwater Depth	85 cm

Depth(cm)	Profile Description and Characteristics
0 - 20	Dark reddish brown(5YR3/3), clay with silt content less than 20%, well developed blocky structure, slightly sticky when wet & moderately hard when dry, few to common fine pores, pH(1:2.5) 7.0, EC 0.05mS, bulk density 1.54, available water capacity(AWC) 12.5%, clear wavy boundary
20 - 50	Dark reddish brown(5YR3/4), clay with silt content less than 20%, weakly developed subangular structure, sticky when wet & hard when dry, hardness very high, pH(1:2.5) 7.5, EC 0.05mS, bulk density 1.49, AWC 14.8%, gradual diffused boundary
50 - 90	Dark reddish brown(5YR3/4), clay with silt content less than 20%, weakly developed subangular structure, sticky when wet & hard when dry, very few round gravel content(< 3% & 2-5mm), pH(1:2.5) 7.0, EC 0.09mS, bulk density 1.36, AWC 9.3%

Analytical Data of Soil

	CEC(meq)	Av.P_2O_5(ppm)	Ex. K(meq)	ESP(%)
0 - 20	14.6	56.5	1.7	2.1
20 - 50	14.3	187.1	1.9	1.4
50 - 90	17.3	60.4	2.2	1.7

Table D.2.4 Repesentative Soil Profiles(2/4)

Eutric Cambisols, Phreatic Phase (Cm-1)

Location	Chekereni (Pr-9)
Land Form	Flat to gently undulating
Parent Material	Alluvial deposits(volcanic origin)
Land Use	Upland Field(maize)
Groundwater Depth	> 150 cm

Depth(cm)	Profile Description and Characteristics
0 - 15	Dull reddish brown(5YR4/3), clay with silt content less than 20%, weakly developed blocky & subangular structure, slightly sticky when wet & moderately hard when dry, few medium pores, pH(1:2.5) 7.2, ECe 0.39mS, clear wavy boundary
15 - 40	Dull reddish brown(5YR4/4), heavy clay with silt content less than 20%, weakly developed blocky structure, sticky when wet & hard when dry, few to common fine pores, very few round gravel content(< 3% & 5mm), pH(1:2.5) 7.3, ECe 0.23mS, diffused boundary
40 - 80	Dark reddish brown(5YR3/4), heavy clay with silt content less than 20%, structureless, sticky when wet & hard when dry, few fine pores, few round gravel content(3% & 2-5mm), pH(1:2.5) 7.3, ECe 0.21mS, gradual diffused boundary
80 - 120	Dark reddish brown(5YR3/4), sandy clay, structureless, sticky when wet & hard when dry, common to abundant round gravel content(15 % & 2-10mm)

Analytical Data of The Soil

	CEC(meq)	Av.P2O5(ppm)	Ex. K(meq)	ESP(%)
0 - 15	15.8	336.3	3.2	1.3
15 - 40	12.1	169.7	2.2	1.7
40 - 80	13.2	87.1	2.1	0.8

Eutric Cambisols, Saline/Sodic Phase (Cm-2)

Location	Mtakuja (Pr-8)
Land Form	Flat
Parent Material	Alluvial deposits(volcanic origin)
Land Use	Uncultivated land poorly used for grazing
Groundwater Depth	> 150 cm

Depth(cm)	Profile Description and Characteristics
0 - 15	Dark reddish brown(5YR3/3), sandy clay loam, weakly developed subangular structure, slightly sticky when we & moderately hard when dry, few fine pores, pH(1:2.5) 6.5, ECe 36.4mS, bulk density 1.36, available water capacity (AWC) 13.5%, diffused boundary
15 - 35	Dark reddish brown(5YR3/3), sandy clay loam with silt content of 20%, structureless, sticky when wet & hard when dry, few fine pores, very few round gravel content(< 3% & 2mm), pH(1:2.5) 6.6, ECe 34.5mS, bulk density 1.41, AWC 13.0%, slight reaction to HCl in a part of the layer(accumulation of $CaCO_3$), gradual diffused boundary
35 - 65	Dark reddish brown(5YR3/4), sandy clay with silt content of 20%, structureless, sticky when wet & hard when dry, very few round gravel content(< 3% & 2-5mm), pH(1:2.5) 7.1, ECe 14.1mS, bulk density 1.30, AWC 17.8%, gradual diffused boundary
65 - 105	Dark reddish brown(5YR3/4), sandy clay loam, slightly sodic layer, structureless, sticky when wet & hard when dry, few round gravel content(3% & 2-5mm) , pH(1:2.5) 8.5, ECe 10.4mS, bulk density 1.23, AWC 19.6%, gradual diffused boundary
>105	Dark reddish brown(5YR3/4), sandy clay, structureless, sticky when wet & hard when dry, abundant round gravel content(15 % & 2-10mm)

Analytical Data of The Soil

	CEC(meq)	Av.P2O5(ppm)	Ex. K(meq)	ESP(%)
0 - 15	31.6	99.9	4.4	0.3
15 - 35	24.8	41.1	3.9	0.0
35 - 65	16.7	154.1	3.5	1.2
65 - 105	13.5	601.8	3.4	8.9

Table D.2.4 Repesentative Soil Profiles(3/4)

Vertic Cambisols, Poorly Drained Phase (Cm-4)

Location	Kaloleni (Ex-1)
Land Form	Flat/Paddy field
Parent Material	Colluvial deposits(volcanic origin)
Land Use	Paddy field just after harvest; small size plot
Groundwater Depth	30 cm

Depth(cm)	Profile Description and Characteristics
0 - 10	Yellowish gray(2.5Y4/1), few brown mottles, clay with silt fraction less than 20%, massive, Vertisols like surface cracks in dry surface, sticky when wet & hard when dry, pH(1:2.5) 6.4, EC 0.09mS, gradual diffused boundary
10 - 40	Dark olive gray(2.5GY4/1), heavy clay with silt fraction less than 20%, massive, very sticky when wet & hard when dry, pH(1:2.5) 6.6, EC 0.12mS, gradual diffused boundary
40 - 70	Dark olive gray (5GY4/1), heavy clay with silt fraction less than 10%, massive, sticky to very sticky when wet & hard when dry, pH(1:2.5) 7.6, EC 0.28mS, diffused boundary
> 70	Grayish yellow brown(10YR4/2) + yellowish gray(2.5Y4/1), sandy clay, massive, sticky when wet & hard when dry, mixing of surface soils through cracks in dry season observed

Analytical Data of The Soil

	CEC(meq)	Av.P2O5(ppm)	Ex. K(meq)	ESP(%)
0 - 10	17.1	2.8	1.2	1.2
10 - 40	23.9	2.0	1.7	0.4
40 - 70	22.6	50.5	2.6	3.1

Mollic Gleysol (Gy-1)

Location	Oria (Pa-10)
Land Form	Flat/Paddy field
Parent Material	Alluvial deposits(volcanic origin)
Land Use	Paddy field; fallow longer than 1 year & covered with thick grass vegetation
Groundwater Depth	> 120 cm

Depth(cm)	Profile Description and Characteristics
0 - 15	Grayish brown(5YR4/2), clay with silt content of less than 20%, weakly developed blocky & subangular structure, slightly sticky when wet & moderately hard when dry, pH(1:2.5) 6.6, EC 0.07mS, bulk density 1.35, available water capacity(AWC) 12.8%, clear wavy boundary
15 - 40	Dark reddish brown(5YR3/3), clay to clay loam with silt content of less than 20%, weakly developed subangular structure, sticky to very sticky when wet & hard to very hard when dry, hardness very high, few fine pores, pH(1:2.5) 7.7, EC 0.05mS, bulk density 1.42, AWC 10.8%, gradual diffused boundary
40 - 70	Dark reddish brown(5YR3/3), sandy clay, weakly developed subangular structure, sticky to very sticky when wet & hard to very hard when dry, friable when moist, pH(1:2.5) 7.9, EC 0.05mS, bulk density 1.33, AWC 8.2%, gradual diffused boundary
70 - 95	Dark reddish brown(5YR3/4), sandy clay, structureless, sticky when wet & hard when dry, few round gravel content(3% & 2-5mm) , pH(1:2.5) 7.9, EC 0.25mS, bulk density 1.30, AWC 10.0%, gradual diffused boundary
>110	Common to abundant round gravel content(15 % & 2-10mm)

Analytical Data of The Soil

	CEC(meq)	Av.P2O5(ppm)	Ex. K(meq)	ESP(%)
0 - 15	23.5	44.3	1.9	1.3
15 - 40	17.1	56.7	2.9	2.9
40 - 70	15.4	64.0	3.7	3.9

Table D.2.4 Repesentative Soil Profiles(4/4)

Typic Eutric Gleysols, Poorly Drained Phase (Gy-2)

Location	Mandaka (Ex-4)
Land Form	Flat/Paddy field
Parent Material	Alluvial deposits(volcanic origin)
Land Use	Paddy field just after harvest; newly developed from upland field in 1996
Groundwater Depth	+ 1 - 3 cm; inundated area due to seasonal flood, soil drainability moderate

Depth(cm)	Profile Description and Characteristics
0 - 20	Brownish black(5YR3/1), abundant mottles of dark reddish brawn, heavy clay with silt content of less than 10%, structureless, slightly sticky when wet & hard when dry, pH(1:2.5) 7.5, EC 0.25mS, silt deposits in the surface due to flooding, clear wavy boundary
20 - 40	Dark reddish brown(5YR3/3), few grayish brawn mottles, heavy clay with silt content of 20%, structureless, very sticky when wet & very hard when dry, pH(1:2.5) 8.2, EC 0.44mS, gradual diffused boundary
40 - 80	Dark reddish brown(5YR3/3), few grayish brawn mottles, heavy clay with silt content of less than 20%, slightly sodic layer, structureless, very sticky when wet & very hard when dry, pH(1:2.5) 9.0, EC 0.69mS, gradual diffused boundary
80 - 100	Dark reddish brown(5YR3/3), few grayish brawn mottles, heavy clay, structureless, very sticky when wet & very hard when dry

Analytical Data of The Soil

	CEC(meq)	Av.P2O5(ppm)	Ex. K(meq)	ESP(%)
0 - 20	24.3	7.9	1.6	2.9
20 - 40	18.8	126.1	3.2	8.0
40 - 70	18.3	15.4	4.2	11.5

Typic Eutric Fluvisols (Fl)

Location	Rau Ya Kati (Pa-11)
Land Form	Flat/Paddy field
Parent Material	Alluvial deposits(volcanic origin)
Land Use	Paddy field; fallow with thick grass vegetation
Groundwater Depth	> 150 cm

Depth(cm)	Profile Description and Characteristics
0 - 25	Dark reddish brown(5YR3/4), heavy clay with silt content of 20%, weakly developed blocky structure, slightly sticky when wet & hard when dry, few fine pores, pH(1:2.5) 8.0, EC 0.07mS, bulk density 1.10, available water capacity(AWC) 16.1%, gradual diffused boundary
25 - 60	Dark reddish brown(5YR3/3), heavy clay with silt content of less than 20%, moderately developed subangular structure, sticky when wet & very hard when dry, hardness very high, pH(1:2.5) 7.9, EC 2.21mS, bulk density 1.25, AWC 10.2%, gradual diffused boundary
60 - 80	Dark reddish brown(5YR3/3), heavy clay with silt content of less than 20%, moderately developed subangular structure, sticky when wet & very hard when dry, hardness very high, pH(1:2.5) 8.0, EC 2.83mS, bulk density 1.35, AWC 9.8%, gradual diffused boundary
> 80	Dark reddish brown(5YR3/3), heavy clay, structureless, sticky when wet & very hard when dry, very few round gravel content(<3% & 5-10mm)

Analytical Data of The Soil

	CEC(meq)	Av.P2O5(ppm)	Ex. K(meq)	ESP(%)
0 - 25	25.3	276.0	7.3	4.0
25 - 60	19.2	533.7	6.6	2.1
60 - 80	12.7	156.4	4.5	7.1

Table D.2.5 Land Suitability Classification Criteria

I. Suitability for Irrigated Paddy Field

Land Qualities & Characteristics	(Symbol)	Degree of Suitability or Limitations 1/ S1	S2	S3	N
1. Soil Conditions					
- Soil Texture(surface soil: 0 - 40cm)	t	C - CL	HC, SCL, L - SL	LS	S
- CEC(meq/100g soil; surface soil: 0 - 40cm)	e	> 30	15 - 30	< 15	-
- Salinity(ECe mS/cm; surface soil: 0 - 20cm)	s	< 4	4 - 8	8 - 20	> 20
- Sodicity(ESP %; surface soil: 0 - 40cm)	z	< 11	11 - 25	25 - 35	> 35
- Effective Soil Depth(cm)	l	>80	50 - 80	20 - 50	<20
- Trafficability(soil drainage)	c	good - moderate	imperfect	poor	very poor
2. Drainage Conditions					
- Drainability	w	moderate	imperfect / well	poor	rapid
- Seasonal Flooding/Inundation	f	no flooding hazard	no flooding hazard	seasonal inundation	permanently inundated
3. Slope/Macro Relief	r	< 1 %	1 - 3 %	3 - 8 %	> 8 %

1/: S1 --- suitable/no or slight limitations; S2 --- moderately suitable/slight to moderate limitations;
S3 --- marginally suitable/moderate to severe limitations; N --- not suitable/very to extremely severe limitations

II. Suitability for Irrigated Upland Crops

Land Qualities & Characteristics	(Symbol)	Degree of Suitability or Limitations 1/ S1	S2	S3	N
1. Soil Conditions					
- Soil Texture(surface soil: 0 - 40cm)	t	L - CL	C, SL	LS, HC	S
- CEC(meq/100g soil; surface soil: 0 - 40cm)	e	> 30	15 - 30	< 15	-
- pH(H2O, 1:2.5; surface soil: 0 - 20cm)	a	5.5 - 7.5	7.6 - 8.0	8.0 - 8.5	< 4.0, >8.5
- Salinity(ECe mS/cm; surface soil: 0 - 40cm)	s	< 2.5	2.5 - 6	6 - 15	> 15
- Sodicity(ESP %; surface soil: 0 - 40cm)	z	< 6	6 - 11	11 - 25	> 25
- Salinity/Sodicity hazard (Groundwater Depth cm in rainy season)	h	> 200	100 - 200	< 100	-
- Effective Soil Depth(cm)	l	>100	50 - 100	25 - 50	<25
- Available Water Capacity(surface soil; %)	m	> 10	5 - 10	< 5	-
- Trafficability(soil drainage)		good - moderate	imperfect	poor	very poor
2. Drainage Conditions					
- Drainability	w	well	moderate	imperfect - poor	very poor
- Seasonal Flooding/Inundation	f	no flooding hazard	no flooding hazard	seasonal inundation	permanently inundated
3. Slope/Macro Relief	r	< 2 %	2 - 5 %	5 - 8 %	> 8 %

1/: S1 --- suitable/no or slight limitations; S2 --- moderately suitable/slight to moderate limitations; File: DT-5
S3 --- marginally suitable/moderate to severe limitations; N --- not suitable/very to extremely severe limitations

Table D.2.6 Land Suitability Classification

Soil Classification/ Soil Unit		Areal Extent		Suitability Ratings for Irrigated Rcie										Suitability Ratings for Irrigated Upland Crops										
				Degrre of Suitability or Limitations										Degrre of Suitability or Limitations										
Soil Unit	Mapping Symbol	(ha)	(%)	t	e	s	z	l	c	w	f	r	Suitability Classes	t	e	a	s	z	h	l	m	w	f	r	Suitability Classes
Dystric Cambisols, Phreatic Phase	Cm - 1	6,044	72	S1	S2	S1	S1	S1	S1	S1	S1	S1	S2e	S1	S2	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2e
Eutric Cambisols, Saline/Sodic Phase	Cm - 2	980	12	S1	S1	N	S1	S1	S1	S1	S1	S1	Ns	S1	S1	S1	N	S3	S2	S1	S1	S1	S1	S1	Ns
Eutric Cambisols, Slight to Moderate Saline Phase	Cm - 3	280	3	S1	S1	S2	S2	S1	S1	S1	S1	S1	S2esz	S1	S1	S1	S3	S2	S2	S1	S1	S1	S1	S1	S3s
Vertic Cambisols, Poorly Drained Phase	Cm - 4	160	2	S1	S2	S1	S1	S1	S1	S2	S1	S1	S2ew	S1	S2	S1	S1	S1	S1	S1	S1	S3	S1	S1	S3w
Mollic Gleysols	Gy - 1	430	5	S1	S2	S1	S1	S1	S1	S1	S1	S1	S2e	S1	S2	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2e
Typic Eutric Gleysols, Poorly Drained Phase	Gy - 2	360	4	S1	S2	S1	S1	S1	S1	S2	S1	S1	S2ew	S1	S2	S1	S1	S1	S1	S1	S1	S3	S1	S1	S3w
Typic Eutric Fluvisols	Fl	190	2	S1	S2	S1	S1	S1	S1	S1	S1	S1	S2e	S1	S2	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2e
Study Area Total		8,444	100																					

1/: S2 Moderately suitable, S3 Marginally suitable, N Currently not suitable

File:DT-6

Table D.3.1 Water Quality of Shallow Wells in and around the Study Area

Location No.	Sampling Location	In Rainy Season (Sampled in May 1997)				In Dry Season (sampled in December 1997)			
		Groundwater Level (m)	pH	EC(uS)	Na (ppm)	Groundwater Level (m)	pH	EC(uS)	Na (ppm)
W-1	Chekereni	2.7	8.2	4,210	840	2.0	8.0	8,440	1,400
W-3	Groundwater at soil test pit site: Pa-14	0.9	6.9	331	28	-	-	-	-
W-4	Chekereni/southern end	0.9	7.5	12,270	1,500	3.7	7.7	10,770	1,900
W-5	Chekereni/along main road	2.1	7.7	1,325	140	1.0	7.8	1,450	170
W-6	Chekereni/village	2.7	7.9	2,500	430	3.0	7.8	3,050	520
W-7	Chekereni/along main road	2.9	8.3	7,090	1,300	3.0	8.1	7,830	1,400
W-8	Oria	2.0	7.0	736	52	-	-	-	-
W-9	Groundwater at soil auger site: Pr-7	0.5-0.8	7.2	22,700	4,200	-	-	-	-
W-10	Oria/NAFCO boundary	0.8	7.3	35,000	4,700	-	-	-	-
W-11	Oria/NAFCO settlement	1.8	7.9	3,870	520	-	-	-	-
W-12	Oria/project upland field	2.9	8.0	1,610	270	-	-	-	-
W-13	Rau Ya Kati	1.9	7.6	1,270	64	-	-	-	-
W-14	Groundwater at soil test pit site: Pa-13	1.3	6.8	246	30	-	-	-	-
W-15	Rau Ya Kati	2.9	7.7	1,366	170	-	-	-	-
W-16	Rau Ya Kati/sisal estate	1.2	6.7	391	39	-	-	-	-
W-17	Mserekia	1.1	8.9	4,450	840	1.4	8.6	5,130	1,100
W-18	Mtakuja	3.7	8.4	1,100	220	-	-	-	-
W-19	Mtakuja	3.5	8.5	1,350	300	3.7	7.9	2,220	410
W-20	Mtakuja	4.6	8.4	5,510	1,100	4.9	8.3	4,940	1,200
W-21	Mtakuja	1.6	7.5	9,900	1,100	2.2	8.1	2,000	220
W-22	Mtakuja/TPC boundary	1.6	8.2	3,560	560	1.2	8.1	11,570	3,000
W-23	Mserekia	1.0	8.6	5,030	960	-	-	-	-
W-24	Mvuleni	3.0	8.4	4,780	920	4.4	8.3	7,550	1,700
W-25	Mabogini	4.7	7.7	749	120	4.2	8.2	2,900	590
W-26	Mabogini/northern end	7.0	7.0	1,109	120	-	-	-	-
W-27	Kahe(outside Study Area)	4.2	8.9	1,990	450	-	-	-	-
W-28	Kahe(outside Study Area)	3.0	7.0	832	69	-	-	-	-
W-29	Mtakuja/central part	-	-	-	-	3.1	7.8	2,920	630
W-30	Mtakuja/southern part	-	-	-	-	1.5	8.3	11,000	2,200
W-31	Chekereni/southern end	-	-	-	-	2.8	7.9	1,720	310
W-32	Mtakuja/central part	-	-	-	-	2.9	7.5	3,810	700
W-33	Mtakuja/central part	-	-	-	-	3.4	7.9	13,110	1,800
W-34	Oria/southern end of Study Area	-	-	-	-	3.4	7.8	9,560	1,700
W-35	Oria/southern end of Study Area	-	-	-	-	2.5	7.6	3,740	550
W-36	Oria/southern end of Study Area	-	-	-	-	2.8	7.8	4,030	770
W-37	Oria/along NAFCO canal	-	-	-	-	1.2	8.0	9,390	1,800
W-38	Oria/southern end of Study Area	-	-	-	-	2.9	6.9	17,290	3,000
W-39	Makuja/along NAFCO canal	-	-	-	-	2.5	7.4	2,560	310

File DT-7

Table D.3.2 Chemical Properties of Soils in Paddy Fields and Upland Fields in Existing Lower Moshi Project Area

File:DT-8

Site No./Soil Unit Location Land Use	Horizon (cm)	pH(1:2.5) H_2O	EC(1:2.5) (E.S)	ECe (E.S)	CEC meq/100g	Exchangeable Cations meq/100g soil				ESP %	Soluble Cations in Saturated Soil Extract meq/100g soil				Soluble Cations in Saturated Soil Extract ppm					Texture
						K	Na	Ca	Mg		K	Na	Ca	Mg	K	Na	Ca	Mg	SAR	
Pa - 1	I 0 - 15	6.0	50	160	16.0	1.5	0.2	5.8	3.3	1.3	0.0	0.0	0.0	0.0	17	20	5	11	1.2	C
Cm-1	II 15 - 30	7.0	60	180	15.1	2.3	0.4	7.4	5.3	2.6	0.0	0.1	0.0	0.0	17	23	2	3	2.5	C
L. Mabogini Paddy Field	III 30 - 50	6.3	50	90	15.7	2.1	0.5	5.6	4.2	3.2	0.0	0.1	0.0	0.0	12	23	1	1	4.0	C
Pa - 1s Cm-1	A 0 - 15	7.1	70	260	16.0	2.5	0.2	8.9	4.7	1.3	0.0	0.0	0.0	0.0	32	20	5	10	1.2	
Upland Field Adjacent to Pa-1	B 15 - 30	7.1	60	240	15.3	1.6	0.2	10.0	4.1	1.3	0.3	0.4	0.0	0.0	260	180	5	10	10.7	
Pa - 3	I 0 - 18	6.4	40	90	14.9	1.1	0.2	6.3	4.3	1.3	0.0	0.0	0.0	0.0	12	20	4	9	1.3	C
Cm-1	II 18 - 50	7.4	60	90	14.0	1.9	0.4	8.7	5.1	2.9	0.0	0.0	0.0	0.0	10	21	1	1	3.6	C
L. Mabogini Paddy Field	III 50 - 90	7.2	60	130	15.9	2.1	0.5	10.3	4.4	3.1	0.0	0.0	0.0	0.0	12	21	1	2	2.6	C
Pa - 4	I 0 - 15	6.6	90	130	19.2	3.7	0.1	8.5	4.6	0.5	0.1	0.0	0.0	0.0	49	6	2	7	0.4	C
Cm-1	II 15 - 45	6.4	70	110	18.8	2.6	0.2	8.8	4.0	1.1	0.0	0.0	0.0	0.0	24	11	1	2	1.4	C
L. Mabogini	III 45 - 65	6.0	70	150	20.6	2.2	0.3	7.4	4.1	1.5	0.0	0.1	0.0	0.0	18	28	3	4	2.4	C
Upland Field	IV 65 - 110	5.9	90	100	23.2	2.3	0.4	7.2	4.7	1.7	0.0	0.1	0.0	0.0	16	28	3	3	2.9	C
Pa - 5 Cm-1	I 0 - 20	6.5	50	160	19.6	1.4	0.5	9.4	5.1	2.6	0.0	0.0	0.0	0.1	10	21	3	12	1.2	C
Chekereni Paddy Field	II 20 - 40	7.2	60	160	15.8	1.7	0.4	9.4	5.7	2.5	0.0	0.0	0.0	0.0	13	21	2	5	1.8	C
Pa - 5s Cm-1	A 0 - 15	8.7	2,540	15,700	13.0	3.4	2.0	11.4	3.7	15.4	0.3	1.0	0.8	0.5	205	452	304	110	5.6	
Upland Field Adjacent to Pa-5	B 15 - 30	6.4	2,910	13,800	37.8	3.3	0.4	15.5	11.1	1.1	0.3	2.6	4.1	2.7	215	1,200	1646	638	6.3	
Pa - 6 Cm-1	I 0 - 20	6.8	60	220	16.1	1.4	0.3	8.3	5.1	1.9	0.0	0.1	0.0	0.1	25	30	9	13	1.5	SCL
Chekereni Paddy Field	II 20 - 35	7.4	80	310	16.1	1.9	0.4	11.0	5.3	2.5	0.0	0.1	0.0	0.1	19	34	9	13	1.7	SC
Pa - 6s Cm-1	A 0 - 15	7.4	350	1,490	17.5	4.5	0.4	10.4	4.9	2.3	0.2	2.2	0.3	0.5	120	1,000	130	114	15.4	
Upland Field Adjacent to Pa-6	B 15 - 30	7.2	1,070	4,370	16.0	3.5	0.1	9.6	4.1	0.6	0.3	2.3	0.9	0.7	195	1,080	371	170	11.6	
Pa - 7	I 0 - 20	7.4	110	330	17.8	3.9	0.2	11.3	4.7	1.1	0.1	0.0	0.0	0.0	77	18	11	12	0.9	CL
Cm-1	II 20 - 40	7.1	200	900	16.9	3.2	0.2	10.1	4.3	1.2	0.1	0.1	0.2	0.1	81	32	75	28	0.8	C
Chekereni Upland Field	III 40 - 60	7.2	80	280	16.2	3.0	0.2	9.0	5.0	1.2	0.1	0.0	0.0	0.0	43	11	9	9	0.6	C
Pa - 12	I 0 - 20	7.9	190	640	24.8	6.6	0.2	16.6	7.8	0.8	0.2	0.0	0.0	0.1	152	12	17	19	0.5	CL
Cm-1	II 20 - 35	7.6	390	1,680	27.3	5.6	0.3	14.4	5.9	1.1	0.3	0.1	0.3	0.2	195	42	121	50	0.8	C
Oria Upland Field	III 35 - 70	7.2	710	3,600	25.8	4.5	0.4	16.7	5.5	1.6	0.2	0.2	1.0	0.6	193	90	403	141	1.0	C
Pa - 13	I 0 - 15	6.3	70		21.6	1.1	0.3	10.8	4.2	1.4										C
Cm-1	II 15 - 30	7.2	70		20.7	1.3	0.3	13.7	6.6	1.4										C
Rau Ya Kati Paddy Field	III 30 - 60	7.5	50		16.5	1.4	0.4	10.0	7.8	2.4										C

Table D.3.3 Findings of Fields Survey in Paddy Fields in the Downstream of Project Area

Scheme	Location	Major Findings
Lumukuna	Left bank of Pangani river	- Developed in 1984 and presently double cropping of paddy practiced - Yield of paddy in a field surveyed: 4 t/ha (IR 54; after winnowing; extension officer) - Reportedly salt injury at initial growth stage observed in depressed parts of a field - Flooding frequency about once per 10 years - Water quality at nearby Pangani river: pH 8.4 & 8.8; EC 940 uS - Normal growth of paddy observed
Kirya	Right bank of Pangani river	- Developed in around 1984 and presently double cropping of paddy(IR54) practiced - Yield of paddy in a field surveyed: 4 t/ha (extension officer) - Reportedly no salt injury - Water quality at nearby irrigation canal: pH 8.9; EC 920 uS - Groundwater depth: 100cm; pH 7.2 - Soil properties: - Normal growth of paddy observed
Kiruani	Right bank of Kikuletwa river	- Paddy fields located at downstream of Kikuletwa and water resource taken directly from Kikuletwa - Developed in around 1984 and double cropping of paddy practiced - Yield of paddy in a field surveyed: 4 t/ha (farmers) - Reportedly no salt injury - Seasonal flooding in May/June - Quality of flooded water in paddy fields: pH 7.8; EC 580 uS - No paddy grown at the time of survey in June

File: DT-9

Figures

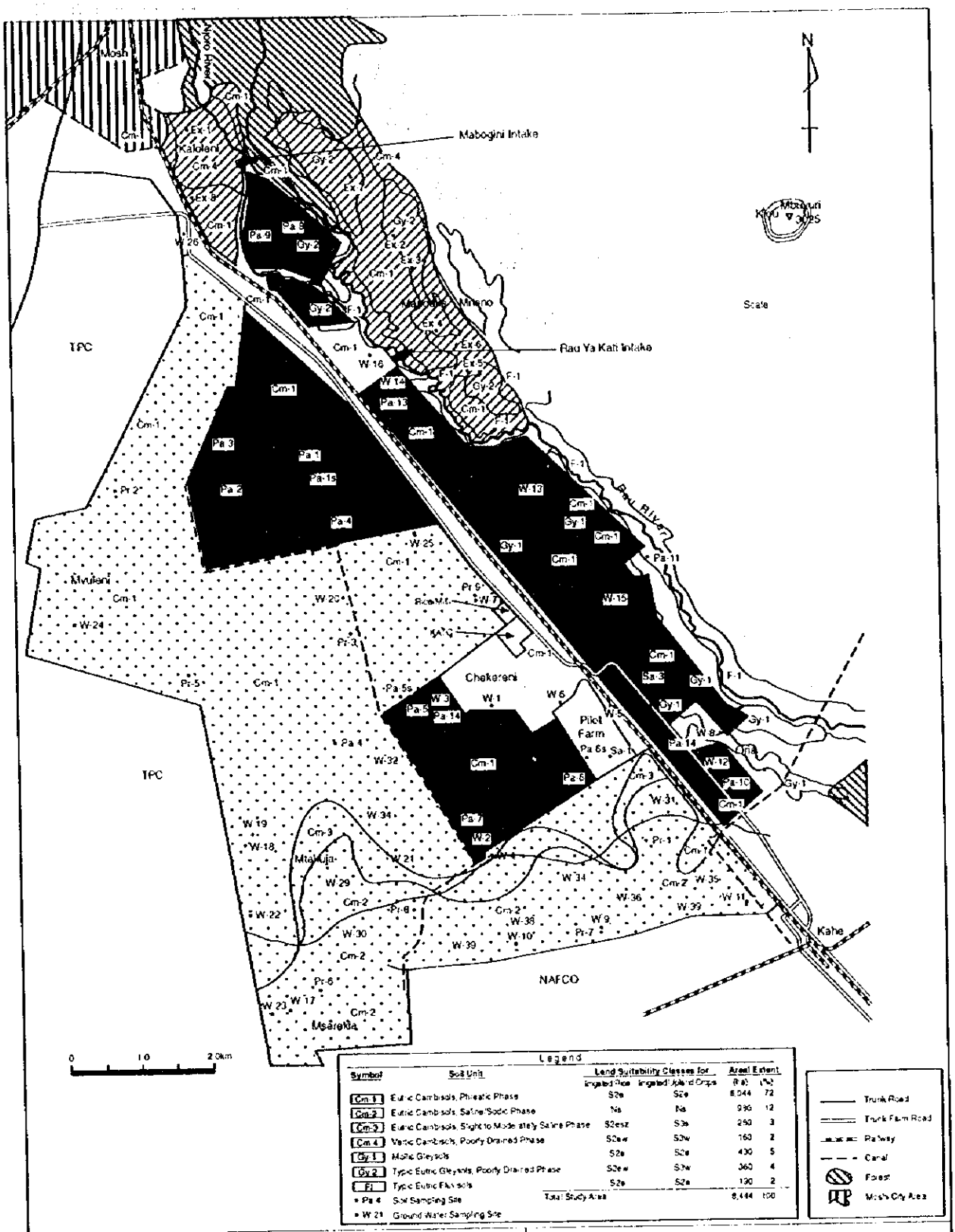

Figure D.2.1
Soil Map in the Study Area

The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania

Japan International Cooperation Agency

ANNEX-E

AGRICULTURE

ANNEX - E

AGRICULTURE

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ANNEX - E

AGRICULTURE

1 INTRODUCTION

This Annex details the present agriculture in the Study Area and the agriculture development plan in the Project Area formulated based on the present Study and is composed of three chapters. Chapter 1 is this introduction and explains briefly the contents of this Annex.

Chapter 2 deals with the present agriculture conditions in the Study Area. The Section 2.1 gives brief description on the agriculture in the Study Area and Section 2.2 indicates the present land use in the Study Area by categorising into 6 land use types.

Section 2.3 describes the present crop production in the Area which is the main topic of this chapter and presents cropping pattern, cropped area, cropping intensity, crop yields and production and other agronomic aspects.

Section 2.4 and 2.5 mention post harvest facilities and animal husbandry in and around the Study Area, respectively.

Section 2.6 discusses the problems and constraints for agriculture development in the Study Area identified through the study.

Chapter 3 presents the proposed agriculture development plan in the Project Area which is delineated as the results of the agricultural land use planning and the irrigation study. The chapter discuss the basic development concepts for agriculture development in Section 3.1 and the proposed land use plan in Section 3.2. In the land use plan, the development of paddy fields in the entire irrigation command area or the entire Project Area is proposed.

The proposed cropping pattern and the anticipated crop yields and crop production plan is given in Sections 3.3 and 3.4, respectively. In the sections, the paddy cultivation at 100 % cropping intensity in the rainy season and 50 % in the dry season is planed on the basis of the results of the agriculture and irrigation study and the estimated crop production under the Project is estimated. In the proposed cropping pattern, the introduction of alfalfa as a soil amelioration crop and as a forage crop is planned.

The proposed farming practices are discussed in Section 3.5 in which special attentions are given to variety, nursery preparation, land preparation and fertilisation. In addition, the results of the study on machinery requirements and labour balance are shown in the section. Similarly, the results of the study on the post-harvest facilities and animal husbandry under with-project conditions are respectively presented in Sections 3.6 and 3.7.

2 PRESENT AGRICULTURE IN THE STUDY AREA

2.1 General

Agriculture in the Study Area is characterised by small-scale individually owned farms, extensive maize cultivation under rainfed conditions in the rainy season and irrigated paddy cultivation both in the Existing Lower Moshi Project Area and in the Expanded Area. The prominent feature in crop production in the Area is high productivity of paddy. The average unit yield is over 6t/ha in the former and 3.5 to 4.5 t/ha in the latter compared with the national average of less than 2 t/ha. However, the productivity of upland crops is low due to unstable rainfall and the adaptation of traditional less intensive farming practices. Animal husbandry is also common agriculture activities in the Study Area. However, the productivity is low because of the traditional animal raising system prevailing in the Area and the poor grazing capacity in the dry season.

Major settlements and farmlands are located in the upper and the middle parts of the Study Area. The main crops grown are maize and paddy, with some very limited portions of other crops such as beans, sunflower, sorghum, groundnut, and green grams. Most of the lands are cultivated by land holders with or without employing casual labours. However, cultivation of lands under tenants or contract terms is also common. The tenant fees of upland fields are paid in cash or in kind. In the case of paddy fields, the terms are strictly in cash paid at the time of leasing. The size of land holdings of paddy fields in the Existing Lower Moshi Project Area averages 2 plots (0.6 ha) per farmer, and about 50 % of the paddy fields are owned by the residents of the related villages. That of upland fields varies considerably depending on individuals and locations.

In the southern part of the Study Area along the border of NAFCO, there exist salt affected lands where accumulated salts in soils might have prevented the introduction of crop production and Maasai pastoralists with their relatively large number of cattle, goats and sheep use the lands to graze their stocks.

Bordering the Study Area, there are two large scale government estate farms, TPC and NAFCO. TPC is a sugar estate of some 6,000 ha with surface irrigation facilities taking water from the Kikafu and Kikuletwa rivers and groundwater. NAFCO originally aimed at the production of cereal crops, however, the production of alfalfa and paddy is predominant activities at present. The areal extent of the former is 113 ha and that of the latter is 208 ha. Paddy is cultivated by smallholders under land lease arrangement. NAFCO has an official water right of 10 m3 from the Miwaleni Spring. The ownership and management of these state farms will be transferred to a private sector in the near future under the present government privatisation policy. In addition, there is a small scale individual estate farm of 114 ha, Mabogini Sugar Estate, neighbouring the Existing Lower Moshi Project Area. Presently, some 26 ha of the farm is used for paddy fields by small holders under lease contract and no sugar cane is grown.

2.2 Present Land Use

The land use features of the Study Area are characterised by the existence of the Lower Moshi Agriculture Development Project and by the status that the vast nearly flat lands are almost entirely used for crop production purposes except for areas used for village or housing yards and some salt-affected areas left as grassland or grazing lands in the south. However, the land use intensity in the Study Area is generally restricted because of water supply constraints even in the Existing Lower Moshi Project Area. The present land use of the Study Area can be classified into 6 land use categories: 1) irrigated paddy fields in the Existing Lower Moshi Project Area, 2) irrigated paddy fields in the Expanded Area, 3) irrigable upland fields in the Existing Lower Moshi Project Area, 4) rainfed upland fields in the Expanded and New Extension Areas, 5) grassland and grazing land, and 6) village and housing yards as shown in Table E.2.1 and Figure E.2.1 The specific features and the aerial extent of each category of land use are as follows:

(1) Irrigated Paddy Fields/Existing Lower Moshi Project Area (gross 1,492 ha; 18 % of the Study Area)

The irrigated paddy fields developed under the Lower Moshi Agriculture Development Project came to be utilised partly in 1985 and fully in 1987. However, because of water supply constraints annual cropped areas of paddy have been decreasing substantially in recent years. Presently, no double cropping of paddy is practised and the annual cropped area of paddy in 1995 and 1996 was only 529 and 816 ha, respectively. Presently, the paddy fields are utilised for rotation cropping in three cropping seasons of February/March to June/July, June/July to October/November, and October/November to February/March. In the area, cultivation of upland crops was allowed since 1995 and maize cultivation depending on rain of the rainy season (April - May) is practised from March to August. Annual cropping intensity of paddy in the past 5 years from 1992 to 1996 averaged 70 %. Paddy fields were neatly developed under the Lower Moshi Agriculture Development Project and the standard size of a paddy field is 30 x 100 m or 0.3 ha/plot.

(2) Irrigated Paddy Fields/Expanded Area (gross 510 ha; 6 % of the Study Area)

The existence of irrigated paddy fields under the traditional irrigation system in the Expanded Area, Mandaka Mnono and Kaloleni, was reported in the feasibility report on the Lower Moshi Agriculture Development Project and gradual expansion of paddy fields through the extension of canal systems and the development of new water sources has been reported by KADP. Presently, small plots of paddy field (mostly less than 0.05 ha) developed by farmers themselves are substantially extending along the Rau and Njoro river. The gross area of paddy fields in the area is 330 ha in Mandaka Mnono and 180 ha in Kaloleni. After the implementation of the Agriculture Development Project, cultivation of IR 54 (variety exclusively grown in the Existing Lower Moshi Project Area) took the place of single cropping of a local variety with a long growth duration in the area and double cropping of paddy is practised in areas where irrigation water supply in the dry season is available. However, the Expanded Area is generally poorly drained because of restricted drainage conditions and/or absence of drainage facilities and manual land preparation is common accordingly. The paddy fields in the Expanded Area, especially in Mandaka, are susceptible to seasonal flooding from April to May.

(3) Irrigable Upland Fields (gross 1,162 ha; 14 % of the Study Area)

This land use category accounts for the rainfed upland fields within the command area of the Existing Lower Moshi Project Area, and presently no irrigation farming is practised. No land development was implemented under the project, however, land forms of the area are generally flat with slight local micro-undulation. Crop cultivation in the area is restricted to the rainy season. Maize is the primary crop and almost exclusively cultivated in the entire area. The second crop is beans commonly inter-cropped between maize, however the cropped area is negligible compared with that of maize. Other minor crops include sunflower, sorghum, groundnut, and green grams. Cropped area is estimated at about 90 % of the gross area although the area varies to a certain extent annually depending on rainfall distribution. Because of annual variation of rainfall distribution, crop production is unstable and productivity is low.

(4) Rainfed Upland Fields (gross 4,160 ha; 49 % of the Study Area)

This land use category includes rainfed upland fields in the Expanded Area and New Extension Area. The aerial extent of the former is limited to about 350 ha and part of the area is within the command area of the existing (traditional) irrigation system. The lands in the New Extension Area are mostly used for crop production except for some grassland and village and housing yards and the aerial extent of farmlands is 3,810 ha (gross) or 77 % of the whole New Extension Area. Land forms and land use pattern of this category of lands are similar to those of the upland fields in the Existing Lower Moshi Project Area and are almost exclusively used for maize cultivation in the rainy season. The annual cropping intensity of this category of land in the New Extension Area is estimated at 95 % of the net area. In the Expanded Area, cultivation of more diversified crops is practised and cultivation of banana is common although the aerial extent is limited.

(5) Grassland and Grazing Land (gross 970 ha; 11 % of the Study Area)

This category of land use represents the areas with poorly to moderately populated grass vegetation with shrub and poorly utilised as grazing land for cattle, goats and sheep or left abandoned. Almost all the lands of this category lie in salt-affected areas along the NAFCO irrigation canal at the southern part of the Study Area. In the area, there exist individually owned cattle ranches of about 85 ha for dairy purpose and a part of the reserved grazing land(120 ha) of Mtakuja village. Restricted crop cultivation due to salt accumulation might have resulted in the distribution of poorly utilised grassland in the area. The distribution of grassland in other areas is limited and scattered.

(6) Village Yards and Housing Yards (gross 150 ha; 2 % of the Study Area)

This land use category includes the settlement areas of Mtakuja, Mvuleni and Mserkia along the western border of the Study Area. Settlements of other villages are located outside the Study Area.

2.3 Crop Production

2.3.1 Cropping Pattern

The cropping pattern presently adopted in the Study Area is determined basically by water availability, i.e. upland crop cultivation by rainfall distribution in a year and paddy cultivation by availability of irrigation water supply. The prevailing cropping calendar in the area is as shown in Figure.E.2 and described below:

(1) Paddy Cultivation in Existing Lower Moshi Project Area

In the area, a high yielding variety, IR 54 with growth duration of 135 - 145 days, is exclusively planted. The originally recommended cropping pattern in the area was determined by KADP on the basis of the findings during KADC activities. The original pattern was formulated so as to avoid crop losses due to low temperature during the booting stage and consisted of 2 cropping seasons as follows;

Rainy season	February/March to June/July
Dry season	August/September to December/January

However, in order to overcome restriction in cropped area due to water shortage and to expand cropping area to the possible extent within the availability of water sources, the modified cropping calendar of 3 cropping seasons per year has been adopted since 1988. The present cropping pattern in the Existing Lower Moshi Project Area is established based on the modified cropping calendar as follows:

Rainy season	February/March to June/July
Early dry season	June/July to October/November
Late dry season	October/November to February/March

(2) Paddy Cultivation in Expanded Area

Before the development of the Existing Lower Moshi Project Area, cultivation of local varieties of paddy with a long growth duration was prevailing farming practices in the Expanded Area. However, soon after the successful production of IR 54 in the Existing Lower Moshi Project Area, the introduction of IR 54 in the Expanded Area was rapidly expanded and presently almost all paddy fields in the area are planted with IR 54. The basic and prevailing paddy cropping calendar is more or less similar to the originally recommended cropping calendar for the Existing Lower Moshi Project Area as follows:

Rainy season	January/February to May/June
Dry season	July/August to November/December

However, because of seasonal inundation and water supply constraints, the cropping calendar of the area is rather diversified. In the southern part of Mandaka susceptible to seasonal inundation in April and May, paddy cultivation starts in May after receding of inundated water and a single cropping of paddy is prevailing. Further, when the seasonal inundation lasts to June, the start of cropping season delays to some extent

(3) Upland Crop Cultivation

Cropping calendars of upland crops in the Study Area are adjusted to the rainfall distribution in the rainy season, in which land preparation is done in February in advance to the start of rain and seeds are sown under dry land conditions prior to the beginning of the season. There are some annual variations in the commencement of the rainy season, however, the usual cropping calendar for maize and other upland crops is from March to July/August.

2.3.2 Cropped Area and Cropping Intensity

Time series data on cropped areas in the paddy fields in the Existing Lower Moshi Project Area recorded by KADP are presented in Tables E.2.2 and E.2.3. As shown in the tables, the highest annual cropping intensity of paddy in the past was 137 % in 1990. Since then, annual cropped areas decreased substantially to date. The cropped area and cropping intensity of paddy for the past 5 years from 1992 to 1996 averaged 772 ha and 70 % respectively. Aiming at efficient utilisation of land, cultivation of upland crops was allowed since 1995 in the Existing Project Area and maize cultivation is presently practised in the rainy season in about 30 to 50 % of the Area.

In contrast, no official statistic data on cropped areas are available on the Expanded Area, the New Extension Area and the irrigable upland fields in the Existing Lower Moshi Project Area. Accordingly, the present status of crop production in the Study Area was examined based on findings of land use survey, information on cropped areas provided by agriculture extension officers and village offices. The present cropped areas obtained are presented in Table E.2.4 and summarised below.

	Rainy Season	Dry Season	Annual
Irrigated Paddy	600 ha	930 ha	1,530 ha
Existing Lower Moshi Project Area	140 ha	640 ha	780 ha
Expanded Area	460 ha	290 ha	750 ha
Maize	5,056 ha	0 ha	5,056 ha
Total Study Area	5,656 ha	930 ha	6,586 ha

On the basis of the said estimated cropped area, the present overall annual cropping intensity in the Study Area is calculated at 104 % as shown in Table E.2.4 and summarised below.

	Rainy Season	Dry Season	Anoual
Existing Lower Moshi Project Area	13 %	58 %	71 %
Expanded Area	100 %	63 %	163 %
New Extension Area	95 %	-	95 %
Overall Study Area	89 %	15 %	104 %

2.3.3 Crop Yields and Production

In the Existing Lower Moshi Project Area, paddy cultivation basically following the recommended farming practices of KADP is being carried out successfully and considerably higher yields have been realised since the introduction of the practices. Time series paddy yields in the Existing Lower Moshi Project Area obtained through the extensive crop cut survey are recorded by KADP(Table E.2.2 & E.2.3). According to the records, the average paddy yield from 1987 to 1991 was 6.3 t/ha, and that from 1992 to 1996 was: 5.9 t/ha in the rainy season, 6.5 t/ha in the early dry season, 7.0 t/ha in the late dry season, averaging 6.6 t/ha annually.

In contrast to paddy cultivation, upland crop cultivation, almost exclusively maize, in the Study Area is done under rainfed conditions and is less intensive except for limited exceptional cases. Therefore, crop yields are largely dependent on rainfall distribution in the cropping season (April - June) and are unstable. Based on information provided by agriculture extension officers and farmers, the present yield levels of maize in the Existing Lower Moshi Project Area and Expanded Area are estimated at 2.0 t/ha on average and those in the New Extension Area are at 1.2 t/ha. The areawise present crop yields in the Study Area are summarised below.

	Rainy Season	Dry Season	Average
Irrigated Paddy			
Existing Lower Moshi Project Area	5.9 t/ha	6.5 & 7.0** t/ha	6.6 t/ha
Expanded Area	3.5 t/ha	4.5 t/ha	3.9 t/ha
Maize			
Existing & Expanded Area	2.0 t/ha	-	-
New Extension Area	1.2 t/ha	-	-

Note: ** Early dry season 6.5 t/ha & late dry season 7.0 t/ha

From the estimated cropped areas and crop yields, the present seasonal crop production in the Study Area is estimated at 2,400 and 5,600 tons of paddy respectively for the rainy and dry season and 7,500 tons of maize in the rainy season. The annual production of paddy is around 8,000 tons as shown in Table E.2.4 and summarised below.

	Rainy Season	Dry Season	Annual
Irrigated Paddy	2,400 t/annual	5,600 t/annual	8,000 t/annual
Maize	7,500 t/annual		7,500 t/annual

2.3.4 Pests and Diseases

(1) Insect Pests

A number of insect pests of paddy in the Study Area were identified by KADP. Among them, the most destructive ones are striped stem borer, paddy hispa, stalk eyed shoot fly and armyworms. Fortunately, however, no serious insect attacks on paddy have ever experienced in the Study Area, favoured by rather dry climatic conditions and low cropping intensity due to water shortage. However, the increase of cropping intensity and continuous use of a single variety will induce serious outbreak of certain insect pests in the future.

(2) Disease

The existence of several fungal diseases and one bacterial disease of paddy were identified by the JICA experts in 1990 and 1992. Fortunately, however, no serious diseases of paddy have ever infested in the Study Area, favoured by rather dry climatic conditions and low cropping intensity due to water shortage. The common diseases found in the Area are sheath blight and sheath rot. However, the increase of cropping intensity and continuous use of a single variety will build the danger of outbreak of certain diseases in the future.

(3) Rodents

Rats eat paddy plants at any stage but do the greatest damage after panicle initiation. However, in the Existing Lower Moshi Project Area where scheduled planting times are well observed and field sanitation is kept at satisfactory level, no serious damages caused by rats have been reported.

(4) Birds

If bird scaring after flowering is neglected, birds will cause serious damage to paddy production in the Study Area. Among birds which attack paddy after flowering, the most destructive bird is Quelea-Quelea. The bird is a kind of migrant birds coming from Central Region and the population is usually highest in January and February when the late dry season crop matures. Accordingly, the late dry season crop is more susceptible for bird attack compared with crops in other seasons.

2.3.5 Farming Practices and Use of Farm Inputs

Adaptation of recommended farming practices is the official condition for paddy cultivation in the Existing Lower Moshi Project Area (District Regulation of Agriculture in Lower Moshi Agriculture Development Project) and the prevailing farming practices in the area are basically similar to the recommendations. The prominent feature of paddy farming in the Existing Lower Moshi Project Area is the employment of a communal nursery system in each tertiary block which, together with scheduled mechanical land preparation under KADP tractor hiring services, enables the observance of the cropping schedule by individual farmers. In the Expanded Area, however, some variations from the recommendations are noticed in the prevailing practices even though farmers are following farming practices in the Existing Lower Moshi Project Area. In both areas, cultivation of a single variety of paddy, IR 54, is almost exclusively practised, which may indicates the vulnerability of paddy farming in the areas to the outbreak of certain pests and diseases on a substantial scale. Farming practices for upland crops, maize, are considerably away from the recommended practices of the District Agriculture Office, probably due to instability of production depending on rainfall distribution in a year and farmers' poor financial status to adopt costly farming practices. Machinery use is basically limited to land preparation works and transportation in the Study Area and other farming practices are solely carried out manually.

The prevailing farming practices in the Study Area are presented in comparison with the recommended ones in Tables E.2.5 and E.2.6. Some specific features of the prevailing farming practices for paddy and maize cultivation and use of farm inputs in the Area are explained in the following sections.

(1) Variety

A high yielding medium growth duration variety of IR-54 selected by KADC/KADP is almost exclusively used for paddy cultivation presently in the Study Area as mentioned earlier. Varietal characteristics of the variety are given in Table E.2.7. In addition to the vulnerability of cultivation of a single variety to the infestation of pest and disease, the continuous use of self-multiplied seeds might have resulted in the deterioration of purity or quality of the variety because of the lack of quality seed multiplication and seed replacement system in the Area.

In maize cultivation, cultivation of self-multiplied seeds is prevailing and use of quality seeds is limited, especially in the New Extension Area because mainly of unstable productivity under rainfed conditions and higher prices of quality seeds. Varieties commonly cultivated are Tuxpeno(composite) and CG4141(hybrid). Varietal characteristics of the varieties are given in Table E.2.7.

(2) Nursery and Sowing

In the Existing Lower Moshi Project Area, the communal nursery system by a tertiary block is employed in which all the farmers prepare seed beds and nurse seedlings in cooperation at the same time at a selected plot of the tertiary block. Seeding rate is about 45 k/ha. While, nursery is prepared individually and seeding rate is around 55 kg/ha in the Expanded Area.

In case of maize, seeds are usually drilled in line at spacing of 75x60cm, 80x50cm and 90x30cm and seeding rate is optimal at about 25 kg/ha.

(3) Land Preparation

Land preparation works in the Study Area are usually done mechanically except for paddy fields in the Expanded Area where poor drainage conditions restrict use of machinery for the works. In the Existing Lower Moshi Project Area, 2 rotary cultivation by a 4 wheel tractor(40-50HP) under flooded conditions for puddling(direct puddling method without ploughing) are employed for land preparation. The efficiency of the tractor operation is 0.9 to 1.2 ha/unit/day. In upland fields, the use of seasonal tractor hiring services of a private sector is common for land preparation and 1 direction of disc ploughing by a large scale tractor is usually done. Land preparation in paddy fields in the Expanded Area is almost exclusively done manually. One specific feature in land preparation works in paddy fields is in bond shaping works. Farmers usually tend to cut bounds in land clearing operation and reshape them to very narrow width, which may cause seepage losses of irrigation water.

(4) Fertilisation

Fertilisation is common practices in paddy cultivation. Average doses in the Existing Lower Moshi Project Area are Urea 320 kg/ha and Ammonium Sulphate 110 kg/ha(in total N 170 kg/ha) and a bit higher than recommended N rate by KADP. In the Expanded Area, the same are Urea 270 kg/ha(N125 kg/ha). Such fertilisers are usually applied in three top dressings and a basal dressing is not common. Other fertilisers(P and K) are seldom used in the Study Area. In contrast, fertilisation is limited in maize cultivation.

(5) Others

Insecticide spray or broadcasting is commonly practised both for paddy and maize. Three spray of Basudin(Diazinon) in paddy and one broadcasting or dressing of Endosulfan in maize are common practices. In addition, two weedings per season are usually done for both paddy and maize. Harvesting and threshing of paddy and harvesting and shelling of maize are manually done. Bird scaring in paddy cultivation is another important laborious practices inevitable in the Study Area.

2.3.6 Farm Machinery

(1) Tractors

The land preparation works in the Study Area are usually done mechanically by employing 4 wheel tractors. However, the number of operational tractors possessed by the villages in the Area is only 19 units in total as shown in Table E.2.8 and land preparation works in the Area except for the paddy fields in the Existing Lower Moshi Project Area, therefore, are mostly being carried out with the help of tractors hired from private sectors. It is reported that a number of large tractors are operated for land preparation for maize in upland fields prior to the onset of the rainy season from February to March. Land preparation for upland crops is disc ploughing and usually done by 60 to 80 HP tractors. Tractor hiring service charge for disc ploughing was around Tsh. 25,000/ha in 1997. While, all the farmers in the Existing Lower Moshi Project Area can receive KADP's land preparation services for paddy cultivation by paying a plot charge (one plot: 0.3ha), which covers land preparation charge, water charge, and canal maintenance charge. The plot charge in 1997 is Tsh. 26,000 for members of CHAWAMPU and Tsh. 30,000 for non-members.

(2) Other Machines

Other than land preparation works and transportation of products or farm inputs, all farming practices from planting to harvest are usually done manually and no farm machinery except for sprayers and 8 units of corn sheller in Mabogini is possessed in the Study Area as shown in Table E.2.8. In the Existing Lower Moshi Project Area, the number of sprayer is one unit per 3 to 5 farmers.

2.3.7 Labour Requirements

Present labour requirements per ha for paddy and maize cultivation are estimated on the basis of the results of Farm Interview Survey, data on paddy cultivation collected by KADP and interview with village extension officers as shown in Table E.2.9. The unit labour requirements for paddy are estimated at 155 mandays/ha and 165 to 170 mandays/ha, respectively in the Existing Lower Moshi Project Area and the Expanded Area. The unit requirements are higher in the latter where land preparation is done manually. In case of maize, the unit requirements in the Existing Lower Moshi Project Area and Expanded Area are estimated at 65 man-days/ha and those in the New Extension Area are 59 man-days/ha. The largest labour inputs in paddy cultivation in the Existing Lower Moshi Project Area is for bird scaring(23% of total), followed by weeding(twice; 19%), harvesting/transportation(19%) and transplanting(17%). The same in the Expanded Area is for land preparation(24% of total), followed by bird scaring(21%) and transplanting(18%). The same in maize cultivation is for weeding, followed by harvesting and planting.

The monthly labour requirements for crop production in the Study Area as a whole are estimated based on the unit labour requirements for paddy and maize as shown in Table E.2.10. As shown in the table, the annual total labour requirements for crop production are estimated at 555,000 mandays and the peak monthly labour requirements is some 83,000 mandays in April, the 1st weeding season for maize. Assuming the available labour forces in the Study Area at 10, 700 as shown in the table, the labour forces in the Area are estimated to be sufficient as a whole. However, a number of casual labourers coming from the within and the outside of the Study Area are reported to be engaging in farming activities such as transplanting, weeding and harvesting operations. In and around the Study Area and in Tanzania as a whole, permanent and seasonal unemployment is common phenomenon and casual or seasonal labourers are usually hired for farm operations, especially in planting/sowing, weeding and harvesting seasons. Comparatively large scale farmers in Mabogini, Mandaka and Kaloleni reported labour shortage experienced sometimes in such specific seasons. The major sources of casual and seasonal labour supply for the Study Area are Lushoto, Tanga and surrounding areas. Farmers in the New Extension Area and irrigable upland fields of the Existing Lower Moshi Project Area are also major labour sources for paddy cultivation in the Area.

2.4 Post Harvest Facilities

2.4.1 Rice Milling Facilities

After the development of the Existing Lower Moshi Irrigation Project, rice production in and around the Study Area have substantially increased and a number of small to medium scale rice milling facilities by private sector have been established, mainly for household consumption purpose in villages in the Area and partly for market consumption in Moshi urban area. In addition, a large scale rice mill was constructed under Japanese Grand Aid Program in 1989 in Chekereni.

(1) Small Scale Rice Mills in The Study Area

In total of 14 small scale rice mills are operated primarily for household consumption and partly for marketing purpose in the Study Area as shown in Table E.2.8. All of those mills except one operated by village government are individually owned. Among 6 villages having paddy fields in the Area, Mabogini, Chekereni and Oria has such rice mills and rice milling for household consumption in the remaining 3 villages, Rau Ya Kati, Mandaka and Kaloleni, is done at mills in neighbouring villages. The milling capacity of such small scale mills is in the range of 100 to 200 kg of paddy per hour and total milling capacity is roughly estimated at around 14 t/day. However, the actual milling volume per day is estimated at around 500 kg/mill because of small batches of paddy brought in for milling. There is a little difference in milling cost depending on mills but the cost is around Tsh. 17/kg in general. The milling charge of small mills is high in comparison with KPHC (Tsh. 15/kg), but farmers use them to mill small quantity for daily consumption because KPHC accepts paddy only in large quantity. A small scale drying yard used for final drying prior to milling is constructed generally attached to a rice mill. There are 13 such drying yards in total in the Study Area.

(2) Kilimanjaro Paddy Hulling Company (KPHC)

The rice mill plant of KPHC was established under Japanese Grand Aid program in 1989 as the central rice milling facilities for the Existing Lower Moshi Project Area and surroundings. In 1990, it was transferred from KADP to KNCU on a sale cum loan contract for Tsh.380 million at a 3 % interest and a grace period of 5 years and the plant is presently operated by KPHC which is the subsidiary of KNCU.

The rice mill facilities consist of a rice mill plant(2 lines), a godown and a drying yard. The plant has the milling capacity of 30 tons of dried paddy per day(8 hours operation) and 750 tons per month(25 days operation). The storage is for short term storing of paddy and rice and has the capacity of 1,800 tons. The size of drying yard is about 3,200 m2.

KPHC presently only offer milling services to farmers and traders in and around the Study Area and is not involved in marketing operation of rice. The monthly processing volumes of paddy of the rice mill in 1996 are shown in Table E.2.11. As shown in the table, the rice mill received 4,928 tons of paddy and processed 4,515 tons in the year. The volume is about 55 % of its present annual processing capacity of 8,250 tons. The rice mill has become popular in and around the Study Area, because rice milled in the facility is of high quality without containing foreign matters such as small stones, sand, straws or unfilled grains. Presently, nearly 50% of the annual processed paddy comes from the outside of the Existing Lower Moshi Project Area as shown in Table E.2.12.

KPHC is now facing the serious problem of operating below its capacity due to the inadequate supply of paddy as mentioned above. As shown in Table E.2.11, the mill was operated at about or less than 50 % of its monthly capacity for 9 months in 1996. There was no single month in which it operated at full capacity in the past since its establishment. Because of the operation of the mill far below of its capacity, the financial status of KPHC is poor as shown in Table E.2.13. For the improvement of the financial status of the firm, the increase of paddy supply to the capacity of the mill is considered essential. Accordingly, it is expected that, together with the necessary improvement of management skills of the rice mill, huge increase of paddy production under the present Project will surely present a good opportunity for the improvement of the financial status of the mill. However, the efforts of the management of the mill to improve services and efficiency and to attract interests of paddy farmers and farmers groups are considered essential for the realisation of such chances.

Other problems encountered by the management of the mill is the regular devaluation of the Tanzanian Shilling which bring about substantial escalation of spare parts prices. Further, disposal of husks has also become a serious problem. Previously they had been burnt out but presently they have been left being piled out in the compound of the mill because of air pollution problem. The manager of KPHC informed that a site for disposal of husks(burning) has been secured in an isolated area and the problem is to get vehicles to dispose of them.

(3) Small to Medium Scale Rice Mills in Moshi Urban Area

In addition to the above small scale and large scale rice mills in the Study Area, substantial number of small to medium scale rice mills are operated in the Moshi urban area. The number of such rice mills registered at Municipal Office is 44 and almost all of them are owned individually. The total milling capacities of those mills in the urban area are roughly estimated over 100 t/day.

2.4.2 Other Facilities

(1) Storage Facilities

In the Study Area, farmers usually sell most of paddy at fields after harvesting to traders from outside or inside the Area and the rest for family consumption are kept at home after sun drying. Some farmers who sell rice to traders take paddy to a rice mill in a village and sell rice after milling. KPHC has a facility for short term storage for both paddy and rice and attached to small scale rice mills in the Area there exist several small storage facilities. In case of maize, farmers shell it and dry it in the sun on mats or floors after harvesting. Most farmers store them at home and mill them when needed for family consumption or sell it when the price rises. Accordingly, storing of quantity of farm products for marketing operation is not practised in the Study Area.

There are several small scale godowns owned individually or by village government in the Study Area as shown in Table E-8, but they are seldom used for storing of farm products except for the small scale godowns attached to rice mills. In Mabogini, there are 4 godowns individually owned and attached to rice mills used for short term storage of paddy and rice. In Chekereni there is 1 village godown which is mainly for storing food aid and are rarely used. The godown was built to store cotton which was the main cash crop in the Study Area before. After the introduction of paddy cultivation the usefulness of the godown decreased because paddy and maize are sold immediately after harvesting or stored in household. Another godown owned by village is in Mtakuja which is also for storing food aid and is rarely used.

In addition to the small scale godowns owned individually or by village, there are 4 godwons of medium to large scale operated by cooperatives in the Study Area; 2 owned by CHAWAMPU in Mabogini and Chekereni, 1 by KNCU in Mabogini and 1 by KPHC within the rice mill. One godown of CHAWAMPU is used as office premises and for storage of properties of Mabogini village. KNCU godown is used to store chemicals/fertilisers for coffee production. The one in KPHC is for short term storage of paddy and rice as mentioned earlier.

In contrast to the limitation of storage facilities in the Study Area, there are substantial number and capacity of storage facilities in the Moshi urban area. The number of large scale storage facilities for cereals registered at District Agriculture Office is counted 29 and total storage capacity is roughly estimated at 73,000 m³(Table E.2.8). In addition to those facilities, there are a number of storage facilities for farm products and inputs in the area.

(2) Corn Flour Mills

Totally 19 small scale corn flour mills are operated in 6 villages in the Study Area(Table E.2.8). Among the mills, 18 are individually owned and 1 is by Chekereni village. Milling capacities of such mills are usually 100 to 200 kg of grain per hour. Milling charge per kg of grain is around Tsh. 15 - 17.

2.5 Animal Husbandry

Animal husbandry is a common activity in the Study Area as it is regarded as a resource of wealth and an insurance against crop failure or any other problems. In addition, as the results of Farm Interview Survey under the present Study indicate, livestock production is an important source of supplementary income specially for small landholders. Accordingly, the number of animals possessed in villages in the Area is substantially large as shown in the following table.

Unit: head

Village	Cattle	Goat	Sheep	No. in Animal Unit 1/
Mabogini	1,239	2,471	426	1,496
Rau Ya Kati	670	1,428	724	926
Chekereni	814	2,460	632	1,220
Oria	1,880	2,802	916	2,135
Mandaka Mnono	682	1,104	439	814
Kaloleni	6	298	49	73
Mtakuja	3,024	4,000	1,800	3,398
Mvuleni	350	500	200	399
Total	8,665	15,063	5,186	10,461

1/: Converted into animal unit by 0.2 x No. of goat & sheep & 0.74 x No. of cattle assuming cow/bull : heifer/steer: calf = 3 : 1 : 1

Source: Results of hearing survey by the Study Team

As shown in the table, the population of goat is the largest in the Study Area followed by cattle. However, when compared by the number of animal units, cattle is by far the largest. Among villages, the animal population in Mtakuja where Maasai pastoralists domicile is the largest followed by Oria and Mabogini which have larger village areas. The number in Kaloleni is extremely limited due to its location in the Moshi urban area. According to the District Livestock Development Office, the past change in animal population is reported to be negligible. Pigs and poultry are minor animals and a few farmers rear donkeys as draft power. In the Existing Lower Moshi Project Area, animal husbandry is principally concentrated in small farm households because large size land holders generally reside in the slope of the Mt. Kilimanjaro and raise their animals in the domiciling area. In Mtakuja village, the majority of livestock keepers are Maasai people. There reside 20 Maasai families and posses 80 to 200 cattle per family. Their cultural and social heritage is bound to the livestock and a large number of livestock is the symbol of wealth and social status. Almost all the cattle kept are indigenous breed, Tanzanian Short Horn Zebu. However, the raising of exotic breeds for dairy purpose is also practised in a limited extent. The exotic breeds introduced in the Area include Ayrshire, Friesian and Jersey. In the southern end of the Study Area along NAFCO, three ranches for cattle, in total of 85ha, are established for dairy production purpose.

Animal husbandry in the Study Area is generally practised in traditional ways and animal feeding is solely depend on crude feed. In the rainy season from March to August when almost the entire farm lands in the Area are used for crop cultivation, feeding of cattle in homestead under zero grazing system is commonly practised and grazing is limited to non-farm land and fallow land. Under the zero grazing system, grasses and crop residues are fed to animals and use of concentrated feeds is limited to dairy cattle. In the dry season from September to February when most of the farm lands are kept under fallow, grazing is practised in farm lands or non-farm lands and feeding of crop residues is not so common. While, Maasai pastoralists in Mtakuja village take their cattle to grass lands in the neighbouring districts or utilise the reserved grazing land(240ha) in the village in the rainy season and graze them in farm lands and in the reserved lands in the dry season. Sheep and goat are raised under open grazing system throughout a year. The grazing capacity of farm land in the dry season is estimated at 4 to 6 ha to an animal unit.

Livestock production depends on achieving a better balance between the livestock population and feed supply. Feeding capacity of lands in the Study Area is higher in the rainy season compared with that of the dry season. During the rainy season, the animals are comparatively well fed owing to abundant grasses in non-farm land and fallow land, but they lost weight during the dry season because of shortage of feed resources. Accordingly, the feed supply in the dry season is considered to be the limiting factor in animal husbandry in the Area. The effective utilisation of crop residues will be one potential measure for the improvement of livestock production, especially in the dry season. The expansion of cultivated areas of paddy in both the rainy and dry seasons and the introduction of alfalfa under the present Project will present chances for improvement of feeding system of animals in the Area.

Major cattle diseases in and around the Area are tick born diseases such as East Coast Fever, Anaplasmosis, Babesiosis and Heart Water. Artificial insemination for the improvement of genetic resources of cattle has not been introduced yet in the Area.

The limitation of veterinary services, genetic resources of animals and extension services present other constraints for animal husbandry in the Area. The provision of veterinary services, improvement of animal breeds and livestock extension activities is under the jurisdiction of District Livestock Development Office. Presently, there is one Veterinary Center in Chekereni and one Ward Livestock Extension Officer in the Study Area. However, such services rendered by the Office are limited compared with the animal population and demand for such services. Regardless with the animal population, facilities for animal husbandry are limited in and around the Study Area. There are one cattle dip and two animal trough in Mtakuja village but all are not in use presently. The slaughter house(Abattoir) is located in the urban area of Moshi and operated under the jurisdiction of Moshi Municipal Government. The facility is for slaughtering demand of Moshi and Hai districts and the numbers of animals handled in 1996/97 are: cattle 7,235 heads, goat 3,155 heads and sheep 1,250 heads.

2.6 Problems and Constraints for Agricultural Development

2.6.1 Agronomic and Agro-economic Problems and Constraints

The land resources in the Study Area are presently utilised to a substantial degree within the limitations of climatic conditions and the restriction of irrigation water supply. For the realisation of the high agriculture development potential in the Area which has been proved in the Existing Lower Moshi Project Area, however, there exist other constraints of different natures than climatic ones and limitation in irrigation water supply. Degrees and types of constraints are area specific as discussed in the previous chapters. The constraints commonly found in the Area and area specific ones in the individual target area of development, i.e. Existing Lower Moshi Project Area, Expanded Area and New Extension Area, are as follows:

(1) Common Constraints in The Study Area

- Restricted cropping season due to climatic conditions; unreliable and limited rainfall, prolonged dry spell and possibility of occurrence of cool temperature injury to paddy;
- Low and unstable rainfed upland crops production under less intensive farming practices: use of self multiplied seeds and limited use of fertiliser, etc.;
- Absence of a quality paddy seed supply system and continuous use of a single variety of self-multiplied seed;
- Need for soil and water management to avoid salinity/sodicity problems;
- Poor financial status of farmers limiting access to necessary farm inputs;
- Limitation of grazing lands due to crop cultivation in the dry season; and
- Cooperative activities not yet rooted firmly and economic activities such as farm inputs supply and marketing of farm products are generally limited.

(2) Specific Constraints in Existing Lower Moshi Project Area

- Limitation of irrigation water supply

(3) Specific Constraints in Expanded Area

- Poor drainage conditions and partly susceptible to seasonal inundation; and
- Restriction for mechanisation of land preparation due to lack of farm roads, small plot size and poor drainage conditions.

(4) Specific Constraints in New Expansion Area

- Presence of salt affected areas,
- Existence of shallow groundwater of very poor quality and danger of further accumulation of salts (southern part); and
- Extremely poor financial status of farmers depending on rainfed farming.

2.6.2 Physical and Institutional Problems and Constraints

The physical and institutional problems and constraints for agriculture development identified through the study on the irrigation and institutional sectors are as follows;

(1) Physical Constraints

- Insufficient irrigation water supply due to shortage of water sources;
- Substantial rooms for improvement of operation and management of existing irrigation system;
- Financial constraints of the project management organisation resulting in insufficient staffing and restricted activities; and
- No irrigation facilities in the New Extension Area and limited experiences of farmers in operation and management of irrigation system.

(2) Institutional Constraints

- Low participation rate of CHAWAMPU;
- Existence of many offenders of irrigation schedule;
- Imperfect CHAWAMPU's by-law;
- Inadequate activities of O&M organisation; and
- Lack of solidarity as a rural community.