Appendix E

Potential of Irrigation Development

THE STUDY
ON
THE NATIONAL IRRIGATION MASTER PLAN
IN
THE UNITED REPUBLIC OF TANZANIA

MASTER PLAN

APPENDIX E

POTENTIAL OF IRRIGATION DEVELOPMENT

Table of Contents

List of Tables

List of Figures

Attachment

APPENDIX E

POTENTIAL OF IRRIGATION DEVELOPMENT

CHAPTER 1 WATER RESOURCES POTENTIAL

1.1 General Environment in Water

Tanzania is a rather dry country besides being close to the equator. There are small seasonal temperature variations caused by the country's proximity to the equator. Mean temperatures range from 26 °C on the coast to 17°C on the Southern Highlands. Potential evaporation in the country varies from about 1,000 mm/year in the highlands to 2,200 mm/year in the dry plains in the center of the country, as showing high potential evaporation rates in the areas with little precipitation.

More than half of the country receives annual rainfall on the average less than 800 mm. The annual rainfall varies from 500 to 1,000 mm over most of the country with highest rainfall of 1,000 to 3,000 mm in the north-west of Lake Victoria basin and in the Southern Highlands. Due to north bound migration of the Inter-Tropical Convergence Zone from December to April, most regions receive rain and this is referred to as the "wet season". The "dry season" in the months of June to October reflects the subsequent retreat of the Inter-Tropical Convergence Zone. General isohyet in entire country is shown in Figure 1.1.1.

The country is hydrologically divided into following five (5) major drainage systems:

- Indian Ocean Drainage System
- Internal Drainage System to Lake Eyasi, Natron and Bubu depression
- Internal Drainage System to Lake Rukwa
- Atlantic Ocean Drainage System, through Lake Tanganyika
- Mediterranean Sea Drainage System through Lake Victoria

Furthermore, the country is divided into following nine (9) drainage river basins, being bounded by natural river basin boundaries as shown in Figure 1.1.2.

I. Pangani River Basin
II. Ruvu/Wami River Basin
III. Rufiji River Basin
IV. Ruvuma River and the Southern Coast Basin
V. Lake Nyasa Basin

VI. Internal Drainage Basin
VII. Lake Rukwa Basin
VIII. Lake Tanganyika Basin
IX. Lake Victoria Basin

The surface river regime in the country obviously corresponds to the general rainfall pattern. Rivers and lakes start rising in November – December and generally experience a maximum in March – April with a recession period from May to October – November. Considering these hydrological circumstances, the hydrological year starts in October/November and ends in September/October in the country.

1.2 Previous Studies on the Assessment of Water Resources Potential

So far, water resource potential assessment has been done in several times through different examinations in Tanzania. Remarkable assessments previously conducted in water resources potential by the Ministry of Water are as follows:

- Water Master Plan by Region
- Rapid Water Resources Assessment
- River Basin Management Project

Water Master Plan:

Water Master Plan was compiled by region from 1970' to 1980'. This is first comprehensive achievement in water resources potential assessment, however, approach of assessment and deepness of investigation vary considerably by region. Water Master Plans in some regions has not fully covered irrigation aspect due to focusing into domestic water scheme development. Since water resource is a matter related to geophysical river basin, it is essentially contradictory to handle water resources by administrative zoning area as region. Furthermore, it has already passed about 20 years in general, it is keenly required to be updated, considering recent accurate information and data, and also adopting advanced research technology such as GIS.

Rapid Water Resources Assessment:

Responding to the need for new water resources assessment in country-wide, the Rapid Water Resources Assessment was prepared in 1995, which consisted of two volumes, Main Report and Basin Report. On the assessment, river basin demarcation divided into nine (9) major river basins was initially proposed. The assessment significantly gave an outline of water resources potential in country as an entire country basis, and indicated new direction to deal with the matter of water by a unit of river basin. As titled "Rapid" in the project name, it was rapidly arranged at the time being. Updating and deepening the previous assessment is required urgently.

River Basin Management Project (RBM):

RBM has broad development objectives as such (i) to strengthen the Government's capacity to manage water resources in the Pangani and Rufiji river basins and (ii) to improve irrigation efficiency of selected smallholder traditional irrigation schemes in the two river basins. Related to the former objectives, water resources potential for the two river basins have been studied under the RBM. The river basin management component of RBM has made significant progress in supporting institutional framework for managing some of competing demands for water, through (i) the rehabilitation of hydromet stations and laboratory facilities, (ii) the collection of water fees and fines by Basin Water Offices, (iii) the drafting of a National Water Policy, (iv) the strengthening of Basin Water Offices, and (v) the establishment of catchment level water user organizations that provide a platform for all water users to discuss and agree on water allocations.

1.3 Macroscopic Water Balance in the Country

(1) Introduction

Prior to assessment of water resources potential, it is necessary to be identified a general feature of water balance in entire Tanzania. So far, no comprehensive water balance analysis in country basis was carried out in Tanzania. Even in Rapid Water Resources Assessment which is the most reliable publication among the reports concerning water resources development, no concrete hydrological figures through systematic analysis were given. In this Study, an extensive water balance study was carried out so as to comprehensively identify quantitative water balance in the country utilizing existing available hydro-metrological data.

(2) Hydrological Water Balance by River Basin

Major factors in hydrologic cycle are rain and run-off. First of all, mean annual rainfall and mean annual run-off were estimated utilizing existing data at observation stations. The hydro-metrological data at 143 stations were used for this purpose, which were also made use of water resources potential assessment. Amount of groundwater recharge was estimated at the range of from 3.0 to 6.0

mm by river basin, on the basis of solitary observation in Dodoma and Pangani River Basin. Basin evaporation by river basin was approximated subtracting the amount of run-off and groundwater recharge from the amount of rainfall. Consequently, the basin evaporation by river basin was within the range of from 600 to 1,200 mm. It seems to be a reasonable figure as indicating about 60 % of reference evapo-transpiration (ETo) of from 1,200 to 2,000 mm, depend upon physical conditions including vegetation covers.

Hydrological water balance by river basin obtained through the above analysis is shown in following table:

Hydrological Balance by River Basin

No.	Drainage River Baisins	Catchment Area (sq.km2)	Inflow	Outflow			Remarks
			Annual Mean Rainfall* (mm)	Annual Mean Runoff* (mm)	Evapo-transpiration from the Basin** (mm)	Groundwater Recharge*** (mm)	
I	*Pangani River basin*	*56,300*	*1,001.9*	*31.5*	*966*	4.0	into the Indian Ocean drainage system
II	Ruvu/Wami River Basin	72,930	765.1	51.7	710	3.0	into the Indian Ocean drainage system
III	Rufiji River Basin	177,420	988.3	185.9	799	3.0	*into the Indian Ocean* drainage system
IV	Ruvuma River and Southern Coast Basin	103,720	1,050.0	20.5	1,028	2.0	into the Indian Ocean drainage system
V	Lake Nyasa Basin	39,520	1,672.5	344.6	1,324	4.0	into the Lake Rukwa drainage system
VI	Internal Drainage Basin	153,800	619.0	36.6	577	5.0	into the Internal drainage system
VII	Lake Rukwa Basin	88,180	1,095.0	104.5	985	6.0	into the Lake Rukwa drainage system
VIII	Lake Tanganyika Basin	151,900	1,173.6	124.7	1,045	4.0	into the Atlantic Ocean drainage system
IX	Lake Victoria Basin	79,570	1,111.1	18.6	1,087	6.0	into the Mediterranean Sea drainage system
	Total	923,340	997.5	97.0	896	4.0	

* : *These were analyzed under this Study using data of 143 gauging stations.*

** : *These were estimated deducting (Runoff) and (Groundwater recharge) from (Rainfall).*

*** : *These were tentatively estimated consulting the groundwater potential map in "RAPID WATER RESOURCES ASSESSMENT, 1995".*

Source: JICA Study Team

(3) Present Water Use

In Tanzania, various water uses have intervened into the hydrological cycle as mentioned above. Key water uses in Tanzania are, namely, drinking and domestic water supply, irrigation water supply, livestock water supply, and hydro-power generation.

Previous report of Rapid Water Resources Assessment in 1995 says, amount of water use for drinking water supply was roughly at 409.4 million m^3 (in urban: 199.4 million m^3, in rural: 210.0 million m^3), and major water source for the purpose was wells at the number of 4,963 in total by which 210.3 million m^3 was probably extracted. As to irrigation water supply which is the most chief water user, it was estimated 3,900 million m^3 water assuming an irrigated area of

150,000 ha in total. For the hydro-power generation, exact figures of used water were not given because off-taken water might be released directly after while. However, those figures are likely required to be improved in accuracy, and updated.

During this field survey of the Study, present water uses were broadly re-examined utilizing recent information and data. The result of the examination in present water uses is shown in following table:

Estimated Present Water Uses

No.	Drainage River Batsins	Annual Mean Runoff (Million m³)	Groundwater Recharge (Million m³)	Present Water Use			
				Domestic water supply * Upper: (population:1000) Lower: (Million m³)	Irrigation supply ** Upper: (Area: ha) Lower: (Million m³)	Livestock supply *** Upper: (heads: 1,000) Lower: (Million m³)	Hydropower Upper: (MW) Lower: (Million c.m)
I	Pangani River basin	1,773.5	225.2	*3,507.7* 57.6	*46,347* 1,205.1	*2,675.9* 14.8	*75.0* (422.7)
II	Ruvu/Wami River Basin	3,770.5	218.8	*4,172.8* 68.5	*10,326* 268.8	*561.8* 6.1	*0.0* -
III	Rufiji River Basin	32,975.3	532.3	*4,551.1* 74.8	*35,027* 1,183.9	*1,534.5* 22.8	*280.0* -
IV	Ruvuma River and Southern Coast Basin	2,126.3	207.4	*2,208.1* 36.3	*6,263* 187.9	*595.8* 1.8	- -
V	Lake Nyasa Basin	13,618.6	158.1	*856.1* 14.1	*2,838* 78.6	*328.7* 3.1	- -
VI	Internal Drainage Basin	5,629.1	769.0	*4,455.4* 73.2	*29,239* 876.1	*4,776.8* 63.3	- -
VII	Lake Rukwa Basin	9,214.8	529.1	*1,674.3* 27.5	*12,417* 319.3	*498.0* 9.6	- -
VIII	Lake Tanganyika Basin	18,941.9	607.6	*4,692.7* 77.1	*7,416* 185.4	*3,011.3* 46.1	- -
IX	Lake Victoria Basin	1,480.0	477.4	*3,901.3* 64.1	*7,122* 111.5	*2,239.1* 39.5	- -
	Total	89,529.9	3,724.9	*30,019.5* 493.1	*156,995* 4,416.6	*16,221.9* 207.2	- -

* : *Population of each basin was estimated recombining region-wise population in 1998 on the basis of geophisical factors.*

** : *These data in irrigation supply were estimated on the basis of the present irrigated areas which were referred in several sources.*

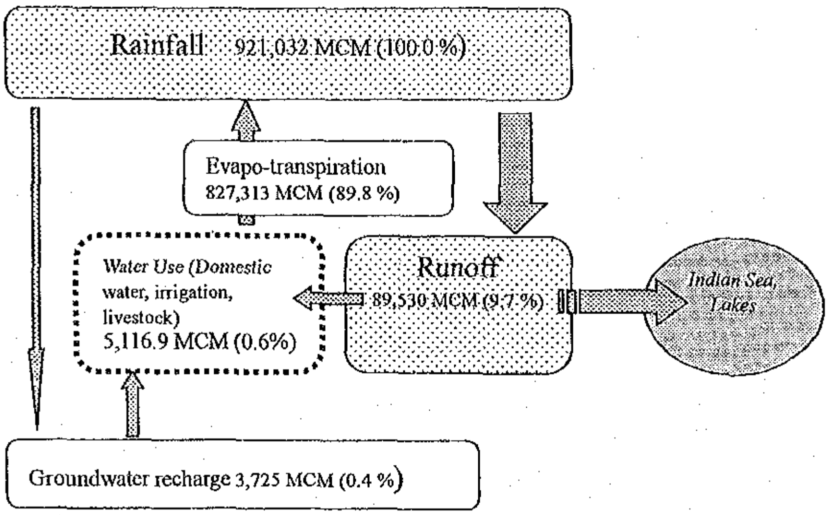
***: *Heads of livestock (cattle, goats and sheep) in each basin were estimated recombining the data in the District Integrated Agricultural Survey 1998/99 on the basis of geophysical factors. 30 lit/day and 5 lit/day of water requirement are applied for a cattle and a goat, respectively.*

Source: JICA Study Team

(4) Water Balance with Present Water Use

On the basis of the result of water balance analysis, the amount of water source for present water use seems to be much abundant in quantity. Water balance with present water use in Tanzania is schematically shown in following figure:

General Water Balance in Entire Tanzania



Source: JICA Study Team

According to the above figure, amount of water for the present water use shares less than 1 % of rainfall which is a total input for the broad hydrological cycle. On the other hand, seasonal fluctuation of availability of water is a crucial factor in Tanzania, even if it is sufficient in quantity of water. As being made clear in following paragraph of this report, intermittent or ephemeral rivers are prominent in the country. Those rivers fluctuate in flow regime rapidly, and off-taking at constant discharge is hardly allowable through a year.

Situation of inequality between river flow regime and water use is schematically shown in Figure 1.3.1. The figure shows together with the general shape of flow regime of river basin and water use assuming off-taking at constant discharge, by river basin. According to the figure, a difficulty could be recognized to off-take water during dry season in several river basins even now, even though river flow is abundant in total quantity. For the areas where fluctuation of river flow regime suffers stable irrigation water supply, dam reservoir will be proposed to regulate its rise and fall of river flow in future.

1.4 Method of Assessment of Water Resources Potential

For the availability of surface water, two characteristics in quantitative availability and in flow regime are considered in this Study. Quantitative availability is to be made clear preparing a distribution map of specific run-off in entire country. Specific run-off was analyzed utilizing existing hydro-meteorological data of 143 observation stations in total. Salient feature of observation station is shown in Table 1.4.1, location of the stations is shown in Figure 1.4.1.

Characteristics of flow regime can be unveiled by means of flow duration curve, and additionally an indicator of Base Flow Index (BFI) is also available. Flow duration curve is one which gives a relationship between discharge of any given magnitude and the percentage of time that discharge is exceeded. In this study, one-day flow duration curve was applied. One-day flow duration curve can be derived by assigning daily flows for the whole period of record to class intervals and counting the number of occurrences within each interval. The total number of occurrences above the lower limit of each class interval is then expressed as a percentage of the total number of days in the record. Flow duration curve is presented as Q_d (P). Herein, d is an averaged unit of discharge handling in the analysis, as 1 or 5 when daily average discharge or average discharge during 5 days are applied, respectively. P is a percentage of the total number of days in the record occurring above the signified discharge, as 100 when signifying minimum discharge.

Furthermore, BFI is generally a measure of indexing hydrology of a catchment or the effect of geology on low flows. It can be thought of as a measure of the proportion of river's runoff that derives from sub-surface water, computing as the ratio between base flow and total flow. A catchment with BFI approaching 1.0 has high base flow component whereas a catchment with BFI approaching 0.0 has almost surface flow contribution.

Besides the surface water, groundwater may also be a water source for irrigation water supply, especially for intensive irrigated agriculture. During this survey term, groundwater potential was also examined by means of reviewing previous outcomes in hydro-geological investigations.

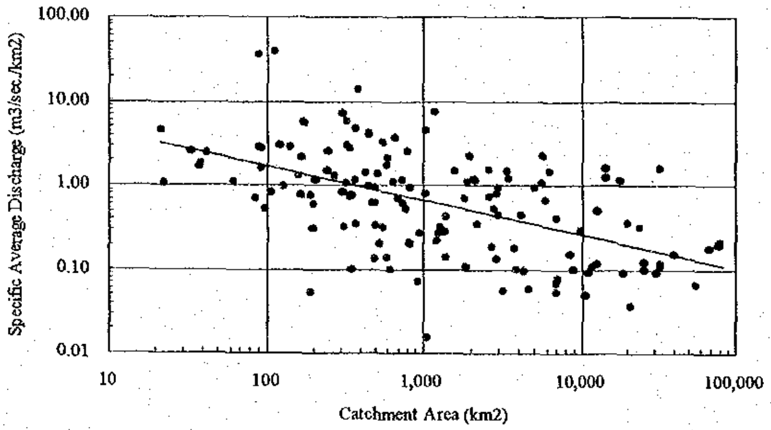
1.5 Assessment Results

(1) Specific Run-off

Specific run-off of every concerned hydro-meteorological stations was calculated at annual mean level. Distribution of the obtained figures of specific run-off in whole Tanzania is shown on a map of the country in Figure 1.5.1. According to the figure, a trend lowered in central areas and southern part could be identified. That tendency is not contradicted with the general sharp of rainfall distribution.

By the way, utilized figures of specific run-off were not actually calculated ones, but those were adjusted figures in consideration with magnitude of catchment area. Generally speaking, a fact is known that specific run-off become smaller as catchment area become larger. There is a great difference in catchment area among concerned stations, as from the largest of 80,040 km^2 (station:1KA3) to the smallest of 22km^2 (station:1HA9A). In fact, a significant minus correlation relation between the calculated figures of specific run-off and magnitude of catchment area was identified as shown in the following figure:

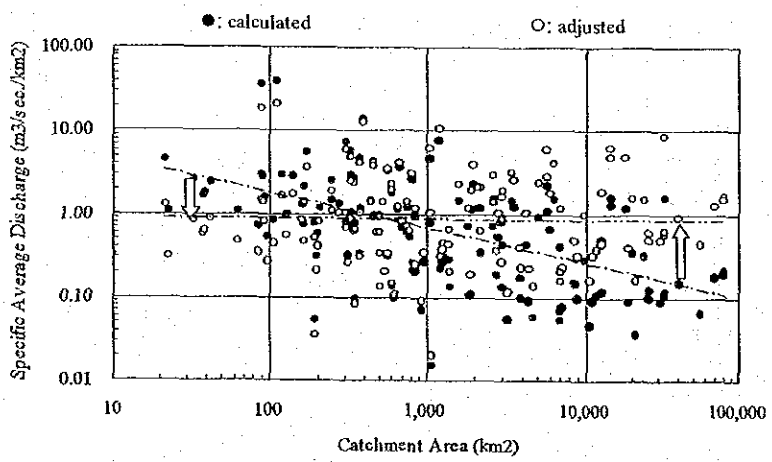
Correlation Relation between Specific Discharge and Catchment Area



Source: JICA Study Team

The above figure appears a necessity to be adjusted the calculated figures of specific run-off when a considerable difference in catchment area of concerned sites exists. In the Study, adjusted method was applied as shown in the following figure: It was adjusted the calculated figures to the values of the same as assuming having unified standard catchment area. In this case, 500 km^2 of catchment area was assumed as the standard catchment area because it was a sufficient catchment area for small scale irrigation schemes.

Adjustment of Calculated Specific Discharge Considering difference in Catchment Area



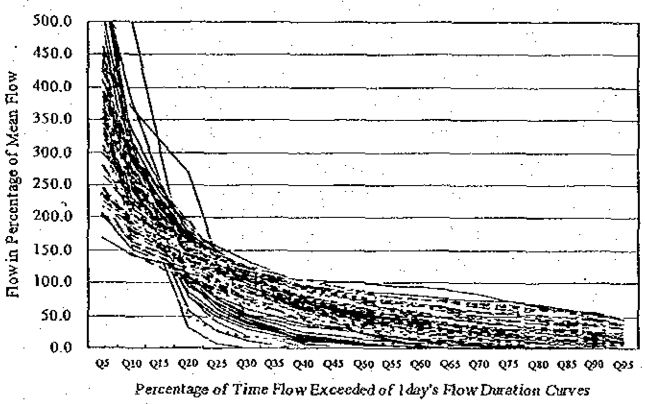
Source: JICA Study Team

Outline of surface water potential in the country could be identified in consideration with the above result on specific run-off distribution. Moreover, besides the potential as a natural condition, artificial restraint in water resources management is also not negligible. Water right is an important artificial control. Although identification of existing obstructions of water and granting water right for the obstruction are still under progress, new water obstruction seems to be hardly allowable especially in Pangani and Rufiji River Basins due to congestion of existing water obstructions. Individual consultation for new water obstruction in viewpoint of water right might be done for new irrigation scheme development especially concerning to the both river basin.

(2) Flow Regime

As mentioned above, flow duration curves were utilized in the analysis of flow regime. Flow duration curves of the concerned stations were formed as follows (see Table 1.5.1):

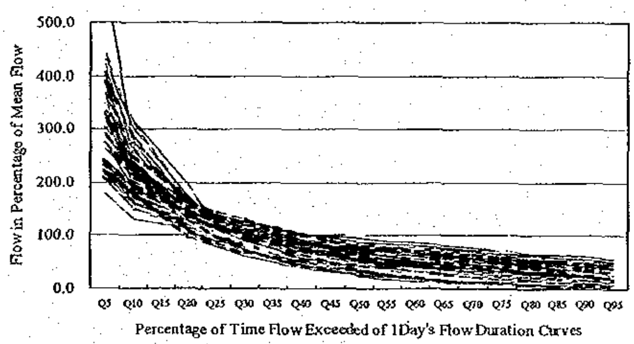
Calculated Flow Duration Curves in Entire Tanzania



Source: JICA Study Team

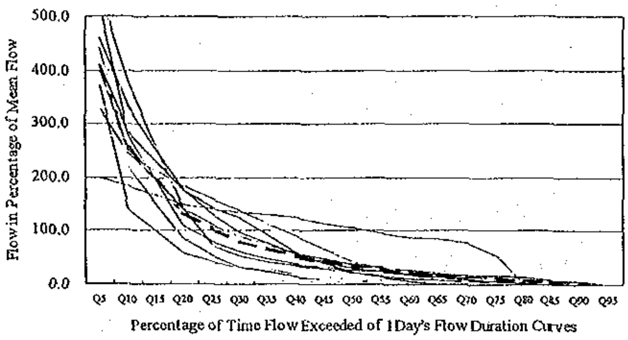
The calculated flow duration curves can be classified into three types by a percentage of time flow exceeded zero, as following:

Group A of Flow Duration Curves ($Q_1(95)>0$)



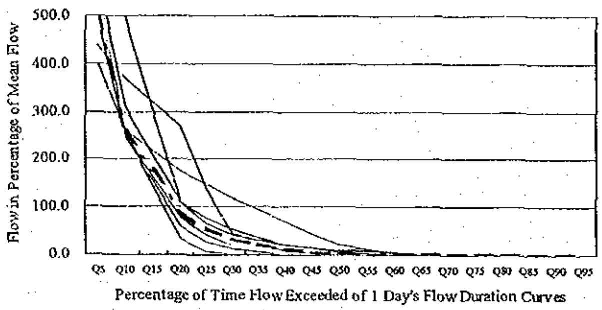
Source: JICA Study Team

Group B of Flow Duration Curves ($Q_1(65)>0$, $Q_1(95)<0$)



Source: JICA Study Team

Group C of Flow Duration Curves ($Q_1(65)=0$)



Source: JICA Study Team

Each group of flow duration curve has different characteristics in flow regime, and method of water use is also different from each other. Rivers classified into the Group A are perennial rivers for which stable and constant water abstraction is achievable. Rivers into Group C are ephemeral rivers for which water use is short-lived within a year. Rivers into Group B are intermittent which has an intermediate characteristic between the both. Ratio of numbers of the river classified in each group are obtained at 68.5 %, 17.5 % and 14.0 % of Group A, B and C, respectively.

(3) Regional Distribution Concerning to Flow Regime

Regional distribution of flow regime was examined utilizing obtained flow duration curves in every concerned station. Paying attention to the value of Q1(75) in the flow duration curves, the regional distribution was formed as shown in Figure 1.5.2. Herein, the figure of 75 % means that it can be seen water flow at the duration of at least three fourth in a year.

According to the figure of regional distribution in the country concerning to flow regime, range of $Q_1(75)=0$ extends in marginal areas in Central Tanzania and southern parts. It is corresponding to a fact that water harvesting is prominent in those areas.

(4) Base Flow Index

Besides above explained analysis, an examination in BFI was also carried out. The regional distribution of BFI was drawn into a map of the country. The result is shown in Figure 1.5.3. Taking the characteristics of BFI into consideration, the distribution seems to be similar to the distribution of $Q_1(P)$. Actually, it was observed that the distribution of BFI varied complicatedly by locality rather than the flow regime's distribution.

(5) Groundwater Potential

Groundwater potential cannot be simply assessed by specified single factor. It is much related with hydro-geological characteristics, which is used to vary in zoned microscopic area. Tendency of groundwater potential could be outlined overlooking the general hydro-geological structure in the country. The general outline of groundwater potential for the entire country was summarized as showing in Figure 1.5.4, utilizing previous result of investigation such as Rapid Water Resources Assessment Vol. I.

CHAPTER 2 LAND RESOURCES POTENTIAL

2.1 Land Unit Classification

A thorough study on soils and physiography in Tanzania have been carried out by E. De Pauw under the Project of Crop Monitoring and Early Warning Systems by investigating and evaluating the different data sources of soil works in the country in order to compile the provisional purpose-oriented ecological and soil maps. Soil varies over distances that can not be mapped at the scales of either 1:1,000,000 or 1:2,000,000 which are appropriate scales for national soil map. The only substantial gain of information by mapping at scale 1:1,000,000 concerns physiography rather than soils. A map of the physiography has, therefore, been prepared with land unit as the mapping unit in which the occurring soils have been situated with certain proportions. Land unit is the area fairly homogenous in terms of physiography and parent materials and are characterized by a particular soil distribution as specified by soil association.

128 land units were distinguished according to the position in the terrain and the proportions of the occurring soils. Each land unit was briefly described based on various viewpoints including slope and salinity. According to this description, land units were classified into three major classes, namely highly suitable, moderately suitable and marginal. Major criteria for the classification were based on slope, physical condition of the land, susceptibility to soil erosion and flood conditions. Plains characterized by flat to gently undulating terrain (slope range 0-2) are suitable for irrigation development. Among them, highly suitable areas are riverine flood plains, alluvial flats (lacustrine plains, flood plains and alluvial complexes) and subsidence basins characterized by flat alluvial plains, particularly those which are less affected by flood and salinity. Marginal land units are those characterized by strongly dissected rolling to steep hills (slope range 10-45%), flood plains affected by salinity and hardpan, rocky hills with gently to steep footslopes (2-16%), mountainous terrain with steep slopes, dissected hilly plateau and rock hilly terrain (rocky hills, escarpments, and slopes). The result of this classification is shown in Table 2.1.1.

Based on the above-mentioned classification, the land suitability map (Figure 2.1.1) was processed from digitized land unit map. This land suitability map was then utilized to produce the final land resources potential map to be explained in the following clause.

2.2 Soil Type Classification

The SADCC soil map was prepared for entire SADCC region including Tanzania based on the above-mentioned soil map prepared by E. De Pauw. The soil maps from different countries were digitized and one system was developed to unify the different national maps. The legend developed is based on the FAO/UNESCO Soil Map of the World. This soil map provides general information on major soil types and their distribution in the country.

30 major soil types were distinguished based on the dominant and associated soils distributed in the above-mentioned land units with different proportions. Characteristic of each major soil type is described in Soil Map of the World, FAO/UNESCO. According to this description, the major soil types were classified into three major classes, namely highly suitable, moderately suitable and marginal. Major criteria used were natural soil fertility levels, soil profile characteristics (such as hardpan), salinity levels, and drainage characteristics (well drained or poorly drained). It is apparent that most of the alluvial and volcanic soils have natural fertility and thus they are highly suitable for irrigation. Alluvial/colluvial soils are also highly suitable for irrigation. Such soils are found on flat to undulating plains, the high natural fertility and favorable topography permit irrigated agriculture. The soils with high percentage of organic matter are confined to basins and depressions, and if well drained they can permit the cultivation of crops. Volcanic soils are also suitable because they have excellent internal drainage and high aggregate stability, thus less susceptible to erosion. Marginal soils are those characterized by petro-calcic horizon. Such soils if irrigated can enhance salinization due to the impermeable petro-calcic horizon. Also, all the saline soils are marginal for irrigation, particularly in seasonally or permanently waterlogged areas because leaching will not be possible due to waterlogging. Strongly weathered acid soils with a low base saturation are marginal for irrigation because they are often associated with aluminum toxicity and the soils are susceptible to soil erosion. These limitations pose severe limitation to cropping. Such soils are most common in old land surfaces with a hilly or undulating topography. The result of this classification is shown in Table 2.2.1.

Based on the above-mentioned classification, the soil suitability map (Figure 2.2.1) was processed from digitized SADCC soil map. This soil suitability map was then utilized to produce the final land resources potential map to be explained in the following clause.

2.3 Land Cover Classification

The Ministry of Natural Resources and Tourism (MNRT) implemented a National Reconnaissance Level Land Use and Natural Resources Mapping Project as a part of Forest Resources Management Project during 1994 and 1997. The objectives of the project are (i) to provide country-wide baseline forest resources information regarding forest areas and forest types, (ii) to provide baseline information about other land uses particularly agriculture, (iii) to facilitate an assessment of natural resource and land use change over time and (iv) to develop the framework for regular national resource monitoring. This project consists of the following 4 components;

- The Forest Management component,
- The Land Cover and Land Use Mapping component,
- The Tanzania Natural Resources Information Center component, and
- The Land Policy Reform component.

Since 48 Landsat TM scenes (paths: 165-172, rows: 61-68) obtained during 1994 and 1996 was utilized as original data for the Land Cover and Land Use Mapping, the most up-to-date series of vegetation and land use maps have been produced under this project. The image processing activities have been carried out to produce accurately geo-referenced satellite image maps that correspond precisely to the existing 1:250,000 scale topographic map series. As a result, 64 image maps to cover the whole country with the legend shown in Table 2.3.1 were produced and the protected areas such as Forest Reserves, National Parks, Game Reserves and Conservation Areas were also located in this map. The distribution of such protected areas is shown in Figure 2.3.1.

Both digital and hard copy data were only available for 64 separate image maps and it was inconvenient for the study on national level. After the discussion with the Institute of Resource Assessment, University of Dar es Salaam, it was decided to combine all 64 sheets by using modified legend of only major land cover types. The distribution of land cover for each district along with the distribution of protected area is shown in Table 2.3.2.

Modified Legend for National Level Land Cover Map

Land Cover / Use
Natural Forest Mangrove Plantation
Woodland
Bushland
Grassland
Cultivated Land
Bare Soil Salt Crusts Rock Outcrops
Water Swamp/Marsh (Permanent)
Urban Area/Airfields

Source: Prepared by the Study Team

Similar to land units and major soil types, the land cover suitability map (Figure 2.3.2) was processed from digitized national level land cover map based on the classification criteria as shown below.

Classification Criteria for Land Cover Suitability Map

Legend of Suitability Map	Legend of Land Cover Map
Highly Suitable	- Cultivated Land
Moderately Suitable	- Bushland - Grassland
Forest, Marginal Land and Protected Area	- Protected areas including Forest Reserves, Game Reserves, National Parks and Conservation Areas - Natural Forest - Mangrove - Plantation - Woodland - Bare Soil - Salt Crusts - Rock Outcrops - Water - Swamp/Marsh (Permanent) - Urban Area/Airfields

Source: Based on National Reconnaissance Level Land Use and Natural Resources Mapping Project, 1997

Since cultivated land has higher priority for irrigation development, cultivated land was classified as highly suitable area. The areas belong to bushland and grassland were classified as moderately suitable area. Various forest types including natural forest, mangrove, plantation and woodland should be conserved. Other categories such as bare soil, salt crusts, rock outcrops, water surface and urban areas are marginal for irrigation development. All such areas were therefore eliminated from the classification of land cover suitability.

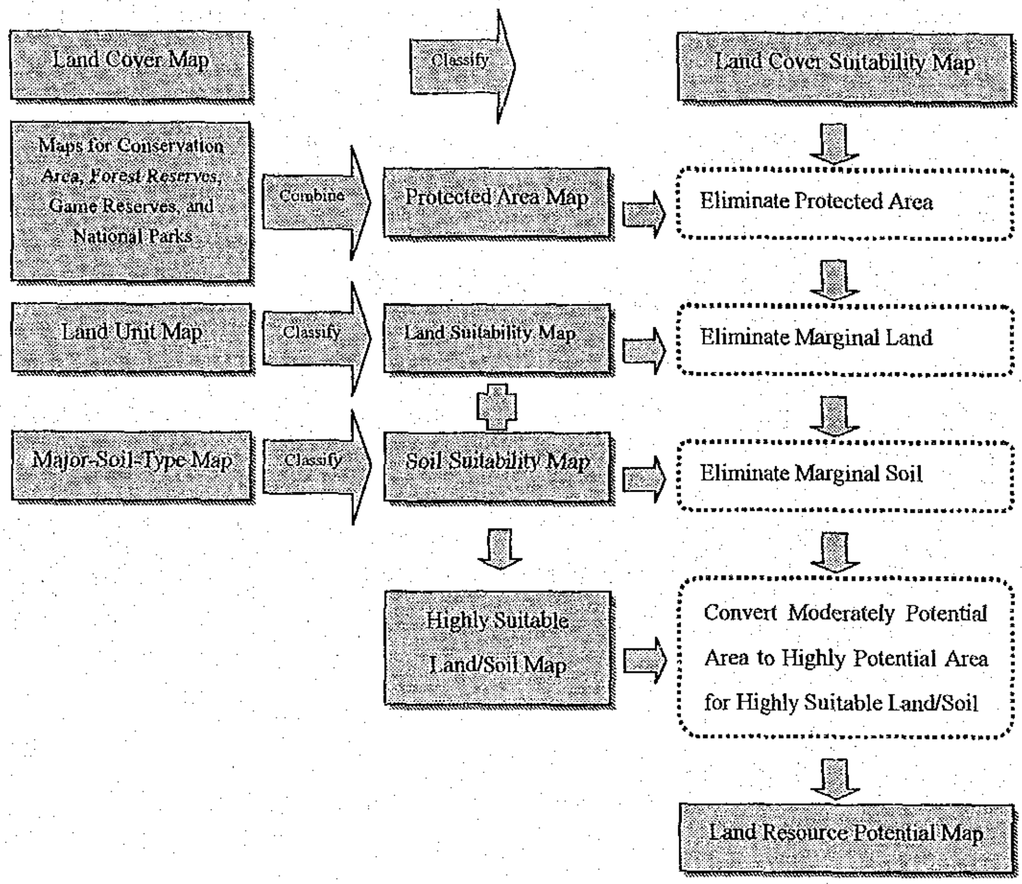
This land cover suitability map was then utilized to produce the final land resources potential map to be explained in the following clause.

2.4 Identification of Land Resources Potential

Land resources potential map was prepared based on the all the above-mentioned maps such as land suitability, soil suitability, land cover suitability and protected area according to the data processing system as shown below.

The land cover suitability map was used as a base potential map for the current analysis. Since the protected areas including Forest Reserves, National Parks, Game Reserves and Conservation Areas are not allowed to develop, all the protected areas were eliminated from the potential area. Marginal land such as mountainous ranges, steeply sloping land and saline areas were then eliminated from the potential area. Marginal soils such as saline soils were further eliminated from the potential area. Finally, the moderately potential areas were converted to highly potential areas in case the land unit and soil type were both classified into highly suitable. The land resource potential map thus created is shown in Figure 2.4.1.

Preparation Process of Land Resource Potential Map



Source: Prepared by the Study Team

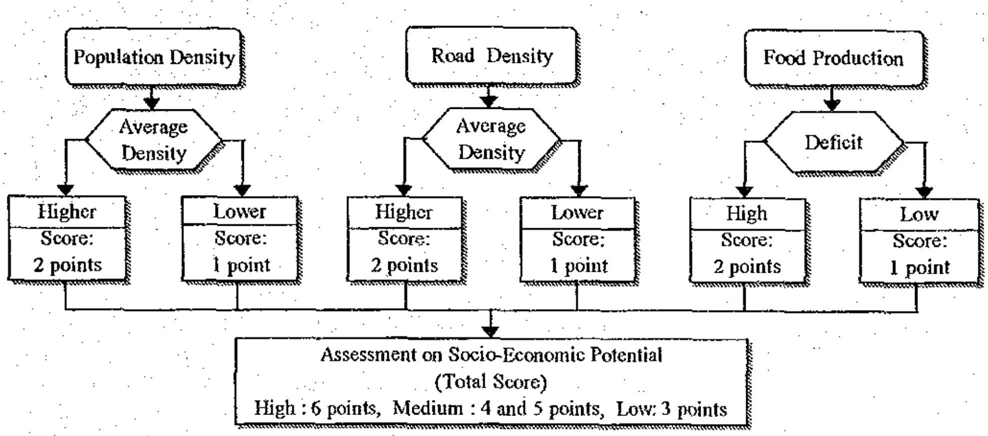
CHAPTER 3 SOCIO-ECONOMIC POTENTIAL

3.1 Assessment Methodology for Socio-economic Potential

Factors to be considered for assessment of socio-economic potential are (a) size of market, (b) distance to market and its accessibility, and (c) availability of agricultural labor. In this assessment, population density, road density and food deficit are employed as indicators expressing the said factors.

As for population and road densities, all districts are classified into two areas, namely higher and lower density districts as compared with the average density in population and road of Mainland. On the other hand, food deficit is evaluated from the results of questionnaire survey and inspection by Food Security Department, MAFS. The deficit scores 2 points and surplus one point. Finally, the socio-economic potential is expressed by total scores; high potential for 6 points, medium potential for 4 to 5 points, and low potential for 3 points as shown in the following figure:

Assessment Flow of Socio-Economic Potential



Source: Prepared by the Study Team

3.2 Population Density

Population density is estimated using the district area[1] and the estimated population for 2002[2]. In this Study, the districts newly established are used, and the population for them is calculated on the pro rata basis of area if its data is not available. Table 3.2.1 presents the district area, population and road density. The

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[1] *Socio-Economic Profiles for respective regions jointly prepared by the Planning Commission and Regional Commissioner's Office in 1998*

[2] *Tanzania Population Projections (2000 – 2025) prepared by the President's Office*

average population density except Dar es Salaam Region is estimated at 36 pesons/km^2, and then socio-economic potential by population density is assessed hereby.

- Higher Potential (more than or equal to 36 persons/km^2) : 69 districts
- Lower Potential (less than 36 persons/km^2) : 30 districts

3.3 Road Density

The Socio-Economic Profiles also present the length of roads in the respective districts, such as trunk, regional, district and other small roads. The socio-economic potential by road density is assessed using the estimated average road length of 93 m/ km^2.

- Higher Potential (more than or equal to 93 m/km^2) : 70 districts
- Lower Potential (less than 93 m/km^2) : 29 districts

The results are shown in Table 3.2.1.

3.4 Food Deficit

The Food Security Department of MAFS executed the questionnaire survey on food situation for the statistically selected 35 households for respective districts in 2001. The survey results are expressed in percentage of number of households replied as "Deficit" to the said 35 households, and then more than or equal to 50% is defined as the food deficit area, which is compiled in A Statistical Analysis of the 2000/01. In case of no reply, the food situation is judged by inspection by staff of the Food Security Department of MAFS.

- Higher Potential (more than or equal to 50%) : 31 districts
- Lower Potential (less than 50%) : 68 districts

The breakdown of deficit for respective regions is given in Table 3.2.1.

3.5 Identification of Socio-economic Potential

Based on the results of the study on population density, road density and cereal deficit, the socio-economic potential is assessed as shown in Table 3.2.1.

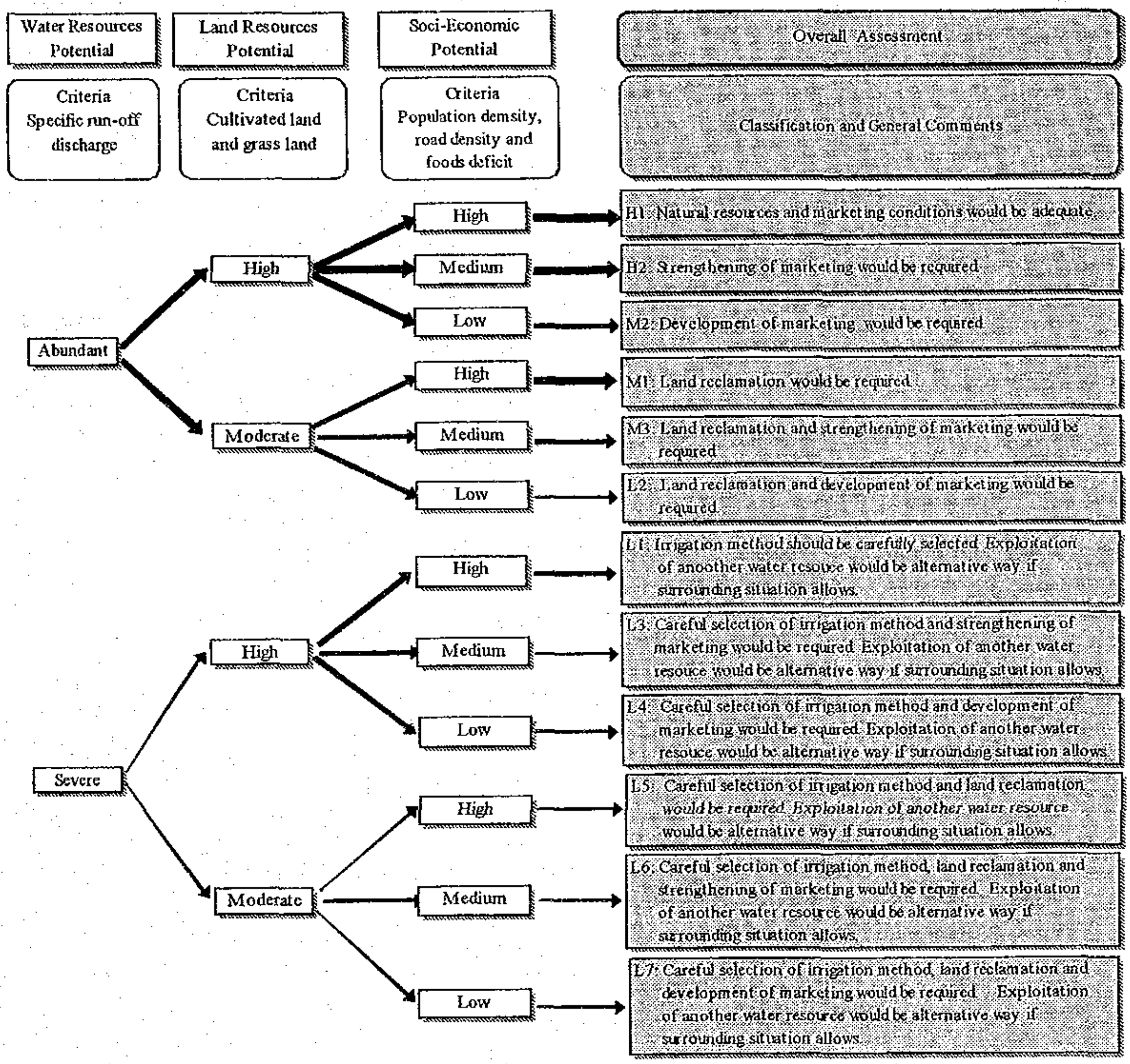
Out of 99 districts, 25 districts are categorized as a high potential area from socio-economic viewpoints, 58 districts as a medium potential area and 16 districts as a low potential area.

Since the paved road gives positive effects to the socio-economic potential, the potential for the area within 50 km of the paved road were lastly upgraded. The final socio-economic potential thus determined is shown in Figure 3.5.1.

CHAPTER 4 IDENTIFICATION OF IRRIGATION DEVELOPMENT POTENTIAL AREA

Irrigation development potential area is demarcated based on the results of study on water resources, land resources and socio-economic potentials mentioned above. The demarcation is made by overlaying these three assessment maps, and then high, moderate and severe areas are roughly identified. The locations of high, moderate and severe areas in potential are shown in Figures 4.1.1. Furthermore, these three areas are divided into the twelve groups as shown in the following figure:

Identification of Irrigation Potential Area



Note: Protected land in land resources is always regarded as "Omissible Area" even for abundant water resources and high socio-economi potential.
Exploitation of another water resourse means use of water of Lake Victoria, etc.

Source: Prepared by the Study Team

Table 4.1.1 presents irrigation potentials on the district basis. The study results show the total area of 94.8 million ha, consisting of 2.1 million ha for "High Potential Area" (H1 – H2), 4.8 million ha for "Medium Potential Area" (M1 – M3), 22.3 million ha of "Low Potential Area" (L1 – L7), 31.1 million ha for "Forest/Marginal Area ", 7.3 million ha for "Water Body", and 27.1 million ha for "Protected Area". Tables 4.1.2 & 4.1.3 present the more detailed information on the above. And the irrigation development potential areas on the district basis are given in Attachment.