MODELING ENDOGENOUS DEVELOPMENT IN RURAL SOCIETIES OF TANZANIA: THE CASE OF THE MATENGO

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ABSTRACT

Efforts to bring about sustainable rural development have not resulted in much success. Using the Matengo of Mbinga District as a case study, various forms of data were collected using a combination of techniques and approaches. These data pertained to the management and conservation of the natural resource base, technological and institutional changes. A STELLA II computer software program was used to analyze the development process of the Matengo people given their land carrying capacity, population, land use at family level, developmental process at village level, and dynamics of regional development, i.e. in the whole Matengo area. The results show that the Matengo people display elements of both stability and mobility. The ngolo farming system has been a key element to the stability of the Matengo in the highlands. The conservation element underlying the ntambo system of natural resource management has greatly been affected by the collapse of the sengu institution. Based on modeling results various development strategies appropriate to each agro-ecological zone in the District are proposed, including the promotion of intensive agriculture based on ngolo farming system and appropriate ntambo management system.

INTRODUCTION

The *ngolo* farming system has, for many years, made the Matengo people resort to permanent settlement with low mobility levels until recent years. With increasing population pressure and declining soil fertility in the old villages, mobility has imminently ensued. The phenomenon of stability is currently maintained by the existence of coffee as a cash crop and the stable *ngolo* farming system. The current mobility is being accelerated by the need to exploit the virgin Miombo woodlands in the southern rolling hills of the district, e.g. Kitanda and Lupilo villages.

In the case of Kindimba, obvious migration started in the 1960s. Family members in different households migrate on a day-to-day basis, leaving one person behind for purposes of maintaining the homestead. According to farmers there is no more possibility of staying together with children due to shortage of land. That is, without migration people in the old villages would find it difficult to survive. The mobility phenomenon is supported by such factors as pushing forces (village problems e.g. land shortage) and pulling forces (availability of land in new villages). Labour productivity in Kindimba is less and one has to work harder by spending more inputs/resources in terms of time, money and more labourers. Decline in labor and land productivity, among other factors, can escalate this mobility phenomenon in the foreseeable future. The confidence that farmers have is considered to have a relation with the farming system of the area, and particularly the traditional *ngolo (*i.e. the Matengo pit system of farming). Many farmers in the Matengo land believe that with continued use of ngolo farming system, more generations will be supported than with other farming systems. Moreover, with coffee production, people's standards of living have gone

up considerably. Coffee being a permanent occupation has made people improve their settlements

The Matengo history reveals the existence of multi-tribal communities in small areas. As population increased, people opted for a dual residence strategy while keeping their old residences under great care. The *ngolo* system of farming has made the Matengo people unique, and their typical social system based on the concepts of *ntambo* and *sengu* systems has also helped in keeping the Matengo society stable. Details on *ntambo* and *sengu* can be found in the final report of the Miombo Woodlands Agro-Ecological Research Project (1997).

A system dynamics method developed by J.W. Forrester in 1956 to analyze the dynamism of entities is now being applied to the analyses of social systems such as urban dynamics and world dynamics. The method is broadly defined as "a method to interpret the dynamism of a system with some simulation models". To date, however, it is yet to attain the stage of maturity in terms of certain theoretical concepts.

In this paper, a simple systems dynamic model to analyze the structure of the development of the Matengo society is discussed. The society is still in its initial stages of development (in the process of shifting from a subsistence economy to a market economy). Using this model, we also aim to contribute to the orientation of the development strategy in other developing areas.

Indices for Appraisal of Sustainability

In discussing a 'sustainable farming system' or 'sustainable development', we have to firstly define the term 'sustainability'. Development is originally defined as "a changing process of sustainable socio-economics with which all inhabitants can obtain liberty, equity and appropriate standards for physical well-being". Therefore, the term 'development' itself includes the meaning of 'sustainability', although the term 'sustainable development' has been commonly used since global environmental issues became evident few decades ago. Sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional changes in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in agriculture, forestry and fishery sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable, and socially acceptable.

We are then asked as to what kind of metric index should be used to evaluate the sustainability of an area. One index of sustainability, the carrying capacity, is generally defined as "the maximum population that can be supported by a given amount of environmental resources, particularly land area, with a certain social and cultural sense of value inherent to the region" (Fukui, 1993). In this context, a 'sustainable farming system' or ‘sustainable development' is a farming system or type of development that would not bring about a decrease in the carrying capacity in the future. In this case, however, we also consider quality of the carrying capacity and not just its quantity in calculating the degree of carrying capacity. Although the carrying capacity is calculated for the maximum population with a minimum need for food, we must recognize that a society at a subsistence economic level, the standard of living will improve as the region develops through the introduction of a market economy. This implies that the 'equality' of the carrying capacity will also change as

development proceeds. The key to enhancing the carrying capacity with improved quality of life is 'environmental conservation', although we use this keyword in a narrower sense of 'appropriate land use management'. In this view, sustainable development is regarded as the process of increasing the carrying capacity with environmental conservation.

Another question that can be raised refers to the index for measuring environmental conservation. Nowadays, for industrialized countries in the west, environmental conservation has become an important subject and reviews of rehabilitation methods for the natural environment are often made from an ecological viewpoint. This is because human beings in those countries have controlled the natural environment so intensively. However, viewpoints on environmental conservation could change both temporally and statically with the shift to a sense of value of people; and environmental conservation polices taken in the industrialized countries in the west are not necessarily those to be adopted in the developing countries of Asia and/or Africa including Tanzania.

It is an important and yet difficult task to create a policy for environmental conservation in Mbinga district, and ideas for solving this dilemma should be investigated through intensive discussions with the local people. Perhaps it is not a good idea to follow the way of the industrialized countries without giving deep thought to the many failures that have occurred in the developing countries. What is important now is to the local people to recognize the importance of environmental conservation and to establish an appropriate concept of rural development, giving consideration to the environmental conservation of the area.

Modeling Factors Investigated

With the descriptions and appraisals of the *ngolo* farming system by the participatory rural appraisal (PRA) results (Rutatora *et al*., 1995), we have developed simple system dynamics models to assess the rural development plans involving the *ngolo* farming system. Key factors in the construction of these models were (1) physical conditions (topography, climate, water resources, soil fertility, erodibility, etc, (2) social conditions [ethnicity, culture, tradition, labourers (especially female labourers), etc.], (3) economic conditions (off-farm income, capital stock, etc.), (4) population pressure (birth and death rates), (5) farm size and crops cultivated (especially cash crops), (6) people mobility, (7) infrastructure present, e.g. roads, (7) cash crop prices (e.g. coffee) and (8) carrying capacity. Amongst the key factors, the carrying capacity is the target index with which the sustainability of development is assessed. We took four viewpoints in modeling sustainable development with the *ngolo* farming system in the Matengo area. (1) Carrying capacity at the farmland level, (2) carrying capacity and land use at family level, (3) development process at the village level, (4) development dynamics in the entire Matengo area. These four models are constructed to grasp the dynamics of the rural development process from a farmland level to a regional level. Only the framework of the regional development plan is raised to present flow diagrams showing the relationship between developing factors on each level due to shortage of detailed information on the study area.

The software used to analyze the above viewpoints is called 'STELLA II', which is a powerful and sophisticated application package for system dynamics analyses on personal computers (PCs). All the diagrams and figures reported here are outputs of the 'STELLA II' software.

System Dynamics Models for Appraising the Carrying Capacity

Farmland Level

Various physical, social, and economic factors of farms were taken to evaluate the production, carrying capacity, and sustainability at the farmland level. Those factors included soil properties, slope, drainage, rainfall, temperature, water resources, irrigation facilities, etc. for the physical factors. The financial power (capital and wealth) of the farmers is a key economic factor that shows their capability to buy inputs such as fertilizer or improved seeds (hybrid type) to increase agricultural production. Labour availability, based on culture and traditions of the area (women labourers are indispensable to the *hgolo*' farming system), is a principal social factor. A flow diagram is presented in Fig. 1 to express the relation between these factors

Household Level

Farmers in the Matengo area normally possess farmlands far away from their homes (1 to 2 km in the lowlands and 4 to 6, in some cases up to 30 km in the highlands) in addition to farmlands near the homestead. In the Matengo society, the eldest son traditionally inherits his father's farm. However, he and his brothers are forced to open new areas of land away from home and sometimes to emigrate if land is scarce in their village. This process is expressed in Fig. 2. When land is abundant and the carrying capacity of the household exceeds the household population, capital stock could be increased in the household to allow more use of agricultural inputs and the farmer could maintain a certain level of carrying capacity. This brings a sustainable food security at the subsistence level and an introduction of cash crops such as coffee or tobacco. Thereafter, the farmer further increases his carrying capacity. Problems occur when the increase in population exceeds the increase in carrying capacity and land holding would be controlled through emigration to other areas.

Village Development Model

Table 1 shows the average household population and farmland area for six Matengo villages (50 samples for each village) (Laswai, *et al.*, 1995). Although the family size in each village is almost the same, there is quite a difference in the land holding areas among the villages. There is a tendency for farmers in the highlands to hold less farmland and to have less food security than in the lowlands. The land use patterns in the villages depend on the land tenure, the carrying capacity, and the population of individual farmers. The number of immigrants/emigrants to and/or from a village is determined by the carrying capacity of the village. The development process in this manner can be modeled as in Fig. 3.

Regional Development Model

The Matengo area has historically developed mainly in the highlands. As population pressure increased, the Matengo extended their territory by reclaiming new areas in the lowlands (mainly to the east and south). In both the highlands and lowlands, land is managed in relation to the carrying capacity (even if it is not intentional). When we consider that the highlands have already reached a saturated level, it would be rather difficult to increase the carrying capacity and decrease the population pressure. Taking into consideration all these different real conditions, the dynamics of regional development can be expressed as in Fig. 4.

Table 1. Average household population, farmland and food deficiency in six villages in the Matengo area (Laswai *et. al*., 1995)

	Highlands			Lowlands		
Amani Village	Mahenge	Ngima	Tukuzi	Kagugu	Lupilo	Makoro
Ave. household size	6.52	6.66	7.18	6.08	5.76	6.90
Ave. farm size (acre)	8.30	12.94	7.22	10.27	7.16	16.69
• (Near home)	8.30	12.94	7.22	10.27	7.16	16.69
• (Away from home)	3.78	7.94	4.28	6.38	2.27	9.08
Ave. distance to farms (km)	4.71	6.24	5.80	1.93	0.82	2.86
Percent household in food Shortage (%)	36.00	60.00	54.00	34.70	6.00	18.00

An Example of the Simulation Results

The flow diagrams shown in Fig. (1-4) for the farmland level, the household level, the village level, and the regional level, respectively, are still in progress mainly due to the lack of information and the difficulty involved in presenting the model parameters. However, it is useful for the acquisition of more data and model modification to examine the model response using some hypothetical (but reasonable) parameters.

Figure 5 shows the results of a test run with hypothetical input data for a 5,000 ha village with an initial population of 200 for 100 years. The dynamics of population increase as well as farmland (ridge, *ngolo*, and coffee fields) expansion/depletion showed that the models could represent the rural development process well and provided a promising tool for appraising the development strategies for the village level through sensitivity analyses of key input parameters. However, further field investigations are needed in order to improve the model parameters and to modify its structure.

Strategy for the Sustainable Development of the Matengo Area

In previous sections, the structure of the development process for the Matengo areas was modeled and analyzed. The following is discussion of the development strategy of the area in the near future. The main issue of the area where the development is still at its initial stage is to stabilize the rural society with sustainable agriculture on the subsistence level. Although the development process at the next stage depends on national policies for physical and socio-economic development, the enhancement of living standards for the inhabitants and its sustainability should also be added to the development goals for the area. The Matengo area is classified into three zones (highland zone, lowland zone, and undeveloped fringe zone) as shown in Fig. 6. Because each zone has a different type of development process, a development strategy should be considered for each zone, respectively.

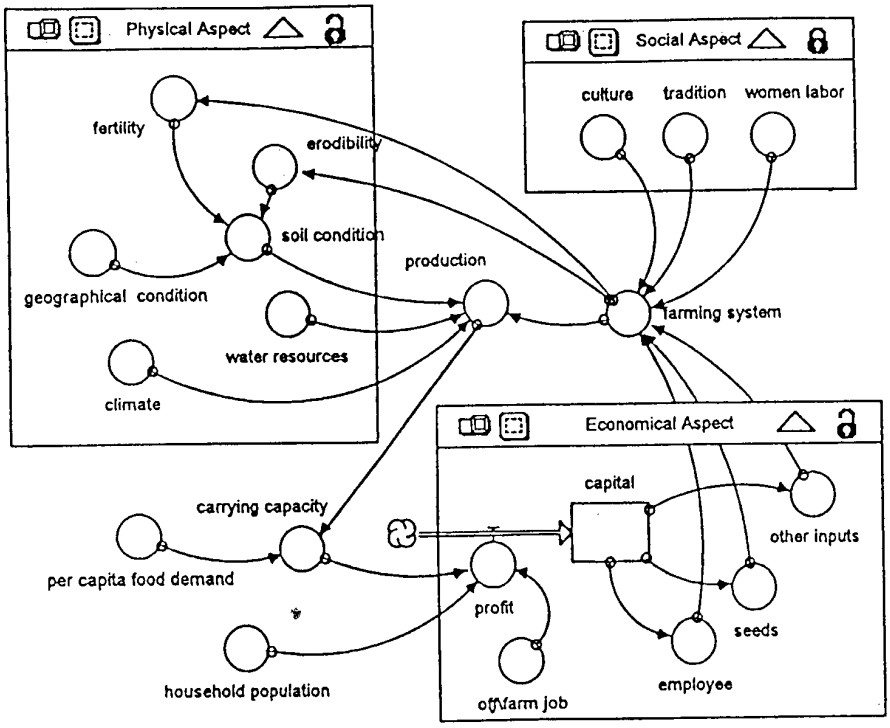

Figure 1. Carrying capacity model at the farmland level

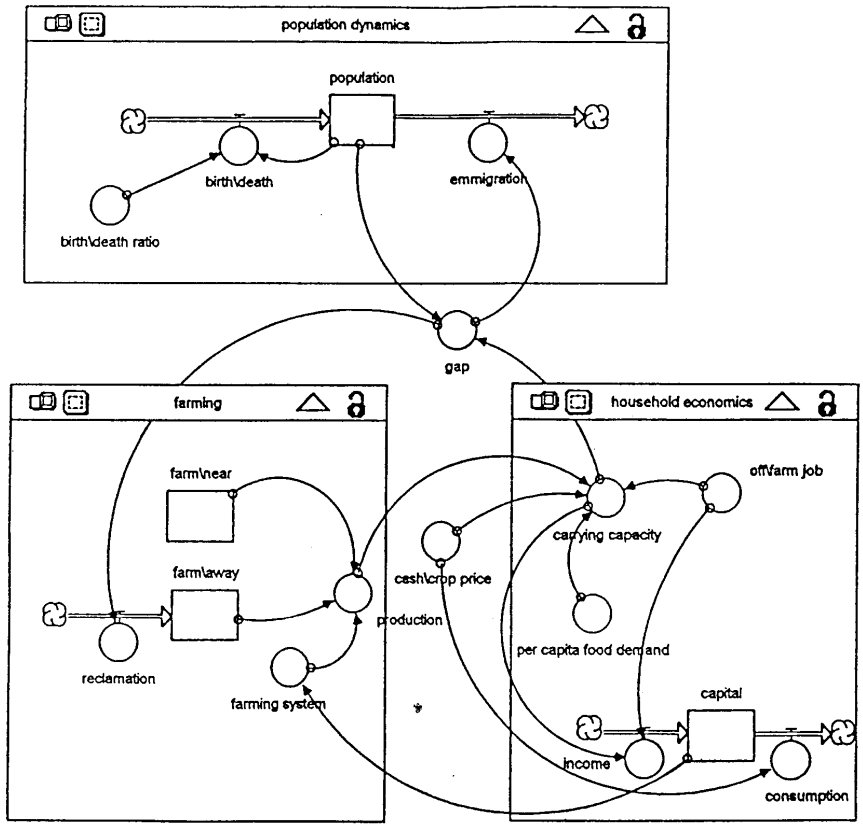

Figure 2. Carrying capacity model at the household level

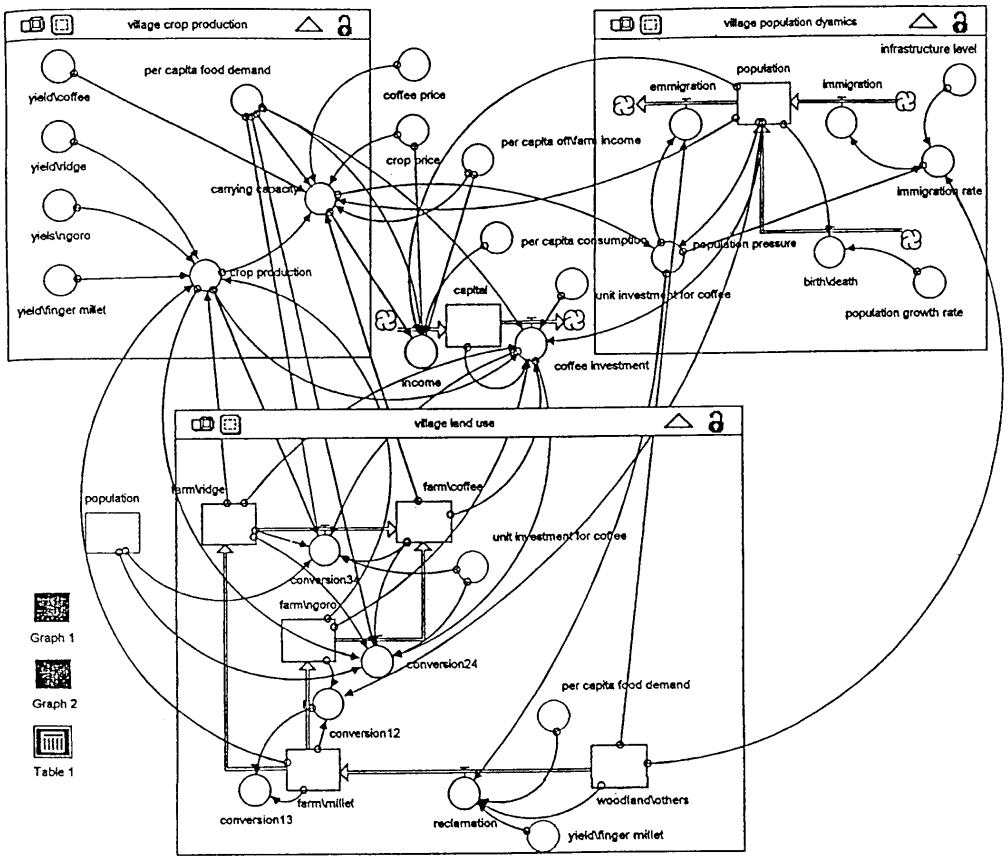

Figure 3. Model for the development process of a village

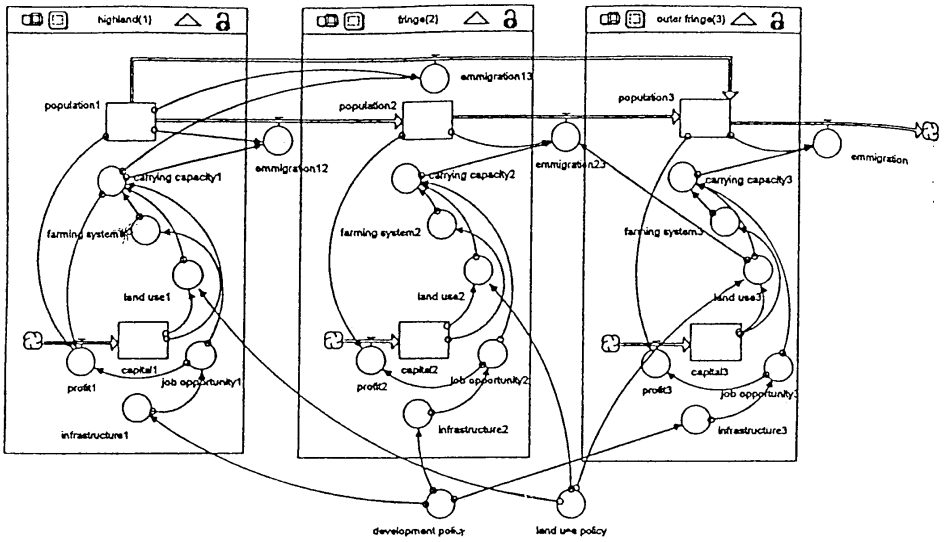

Figure 4. Regional Development model

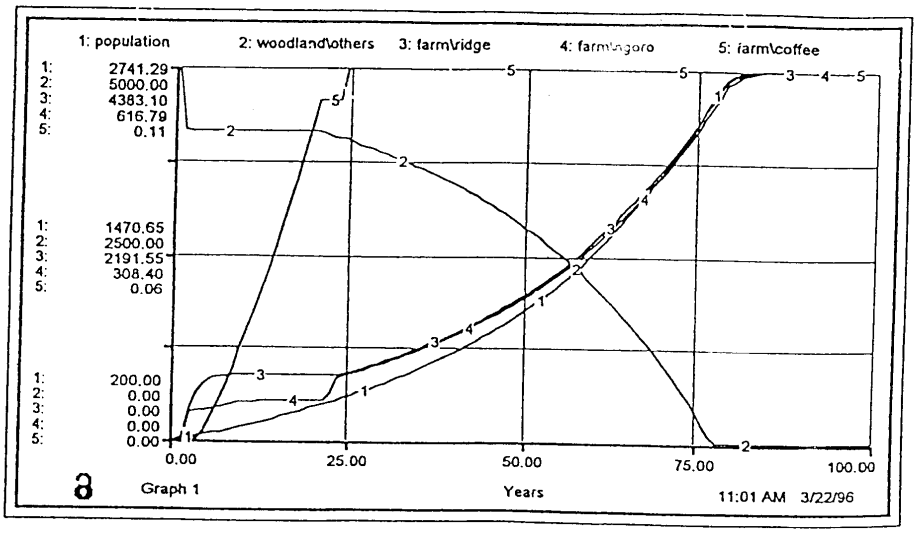

Figure 5. An example of simulated results for the village development model

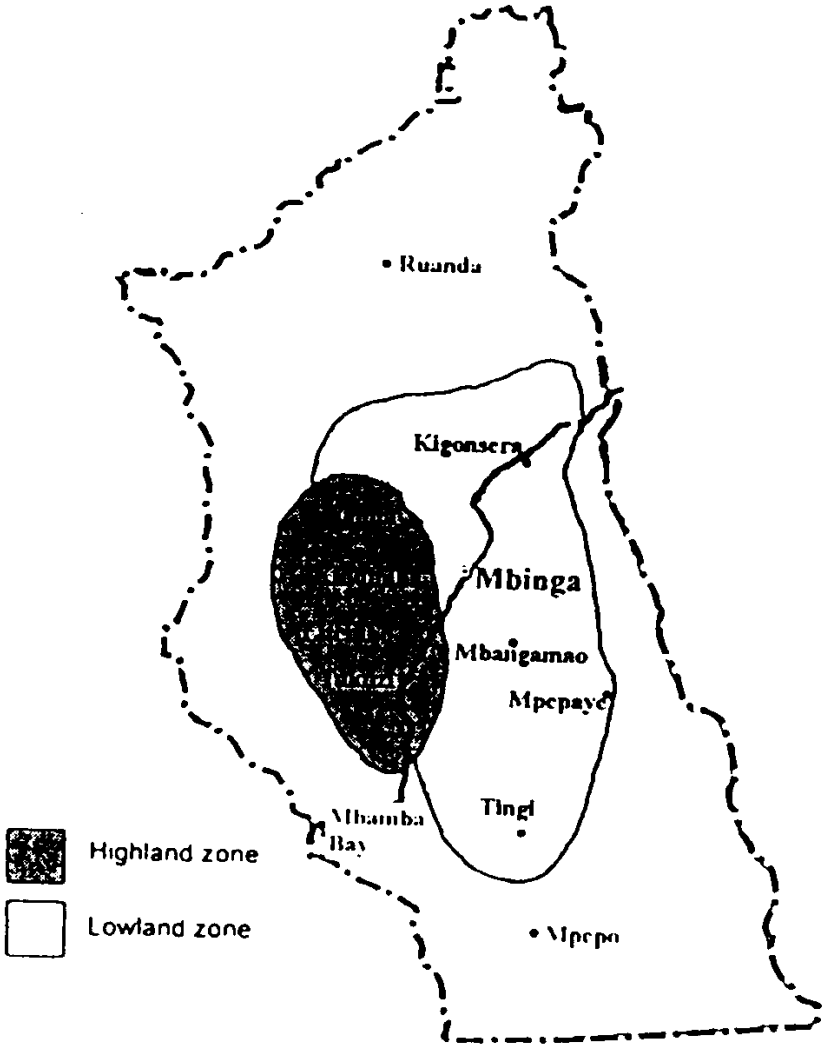

Figure 6. Two development zones in the Mbinga area

Development Goals for the Highland Zone

In the Matengo area, land was historically managed within the ' unit that consists of a ridge area delineated on both sides by streams and utilized by one family. Due to the increased population pressure, land inheritance, and division by family members, however, this land use system within the *'ntambo'* unit is now collapsing in the highlands. Under these conditions, emphasis in the highlands zone should be placed on the enhancement of the carrying capacity by extending the intensive agriculture to support the increased village population. To attain this goal, the expansion of coffee production is firstly considered. In

fact, coffee production in the highlands has increased drastically. This is partly due to the damage to the coffee production in Brazil by climatic hazard over the past few years. In 1995, the price of coffee beans doubled and the Matengo people got a higher income than they had expected. This situation is not going to be everlasting, and thus the sustainability of coffee production is quite doubtful. For its sustainability, there needs to be a domestic coffee market in Tanzania, which would remain stable regardless of the fluctuation of the world market. And improvements to the infrastructure, such as road networks and farm management system to increase the farmers' income, should be incorporated into the development policy. Unfortunately, all of these improvements cannot be attained by farmers themselves, but by the Tanzanian government and, perhaps with foreign assistance.

The introduction of cash crops other than coffee and the promotion of livestock production are other possible strategies for development in this zone. Although livestock production is not widely practiced by farmers in the Mbinga district today, it is one of the key factors in the development strategy not only for the sake of increasing income but also for the improvement of the nutrient intake of the people. In addition to the above ideas, the improvement of educational facilities and the promotion of other sectors are also important. In the Matengo highlands where the development stage is shifting from the subsistence level to the next level, the development of the 'regional agriculture' might be the key to the development strategy. However, whatever process may lead to the development of the highland zone, the conservation of land resources and the environment is a premise in the development of the area. Also, in order to preserve the Matengo's identity, the farming system must not be abandoned at least along the steep slopes. Therefore, the goal for developing the highland zone are summarized as the 'promotion of intensive agriculture based on the farming system'.

Development Goals for the Lowland Zone

The lowland zone is a newly developed area in comparison to the highland zone and land use is managed on the basis of *'ntambo'*, especially in the villages most recently developed close to the undeveloped fringe. In the newly reclaimed villages, farmers can open lands as widely as possible for inheritance by their successors and/or relatives by just following the traditional system seen in the highland zone. The construction of new infrastructure, such as roads and educational facilities are indispensable for further developments in the lowland zone in which other land use issues may arise. Therefore, similar problems of high population pressure and land shortage will be encountered. It is very important to consider these problems in advance, in order to avoid the deterioration of the Miombo forests and disordered land use, and to direct the development concept for maintaining the ordered land use system, including the conservation of the Miombo valley from the viewpoint of water resource management. Hence, the goal of the development in the lowland zone is summarized as the "development with ordered land use based on appropriate

Development Goals for the Undeveloped Fringe zone

As the population movement from the highland zone to the lowland zone proceeds, due to an increase in population and the shortage of land, further population movement from the highland and lowland zones to the undeveloped fringe may occur in the near future. The Miombo woods mainly occupy the land presently in the undeveloped fringe and the careful development of this zone must be considered. For example, the undeveloped fringe zone spreads into the bed of the Ruvuma River with an altitude of less than 900 m.a.s.l., and the

natural conditions such as weather and soil may differ from those in the highland and lowland zones. Since coffee cannot be grown in this undeveloped fringe zone because of the relatively high temperatures, farmers should select suitable crops to grow in this zone. For this purpose, therefore, a land suitability map must be prepared through intensive field surveys and investigations.

At the moment, the miombo woodlands cannot be seen on a wide scale in the highland and/or lowland zones due to extensive development. From the viewpoints of environmental conservation and ecology, however, it is important to determine the land use concepts for the undeveloped fringe zone in advance, before new reclamation and developments take place. A land use policy with an appropriate land use control regulation on the district level should be established, and the local government must present development concepts for this zone considering various natural, social, and economic conditions. In this context, the final development goal for the undeveloped fringe can be stated as the "development with the careful consideration of environmental conservation based on land use concepts".

CONCLUSIONS AND RECOMMENDATIONS

The Matengo people have displayed elements of both stability and mobility. The *ngolo* farming system has been the key element to the stability of the Matengo in the highlands. However, with time and due to population pressure in the highlands people have been forced to migrate into the lowlands in the east and south of the district in search of agricultural land. The conservation element underlying the *ntambo* system of land management has greatly been affected with the collapse of the local leadership structure (*sengu*).

Development strategies appropriate to each of the three zones (highland, lowland and undeveloped fringe) in the district have been proposed. The promotion of intensive agriculture based on *ngolo* farming system is proposed for the development of the highland zone. Development of the lowland zone should be approached through 'ordered land use based on appropriate *ntambo* management'. Finally, the development goal for the undeveloped fringe zone is 'environmental conservation based on land use concepts'. To achieve the above further investigations involving the cooperation of the local people and government is essential.

ACKNOWLEDGMENTS

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