CHAPTER III

METHOD OF STUDY

III.1. MODELING APPROACH

In analysing dynamics of shifting cultivation in Baduy, West Java can be done by several means. One means is by modeling the system to capture and their relationships and analysing changes through manipulating parameters of the Baduy's shifting cultivation model. For the manipulating parameters of the model can be done by using a micro computer. In this study, a computer simulation language, PRO-DYNAMO program has been used.

Generally, the problems that one addresses the perspective of system dynamics have dynamics at least two features in common (Richardson and Pugh, 1983). The first, they are dynamic: they involve quantities with change over time. They can be expressed in terms of graph of variables over time. The second feature of problems to which the system dynamic perspective applies involves the notation of the feedback.

The main steps in constructing a system dynamic model (Richardson and Pugh, 1983; Dent, 1979);

1) To specify the goal and boundaries within the system;
2) To construct causal loop diagram;
3) To translate causal loop diagram into flow chart;

4) To translate flowchart into computer model;

5) Validating and sensitivity analysis;

6) Policy analysis

III.2. THE BADUY SHIFTING CULTIVATION MODEL

The important aspect and the long term success of a shifting cultivation system in Baduy area be considered using modeling approach. The model can be constructed to focus upon the maintenance of soil fertility under the forest fallow period with current rate of growth in population. If the population increases and the land become scarce, the system eventually will cease to provide fertile soil. Sustainability will be negatively affected.

III.2.1. SCENARIOS OF SHIFTING CULTIVATION

Using model, it possible to predict and evaluate the dynamic changes in shifting cultivation, such as the impact of increasing population pressure on agricultural land. Furthermore, several scenarios and policy options can be made. For example, a) if shifting cultivation will be prohibited by government with no additional measures, what will happen to the people ?, b) if shifting cultivation will be allowed by government but with supplementary measures, such as improving soil fertility of secondary fallow land

and intensifying mixed garden systems, what will be the consequences ?, c) if non-farm jobs will be provided in the village to enhance farmers' income, such as promotion of traditional handicraft activities, and d) if family planning is instituted, controlling birth rates and thus reducing population pressure on land, what will be following in terms of the community's production, income and consumption.

All these scenarios can be analyzed by using the model. According to Stokey and Zeckhauser (1978) models are of particular importance for public policy analysts, who are frequently forced to make policy recommendations in the face of bewildering conglomerations of facts and estimates.

Finally, with regard to the development of shifting cultivation systems using for analysis, economical, ecological, psychological and political aspects can also be considered. For example, development of shifting cultivation would be achieved, if the system were able to provide adequate economic benefit to the farmer. Ecological factors should also be considered in development of shifting cultivation. For example, certain traditional agroforestry which is closely related to shifting cultivation has served important ecological functions. Mixed agroforestry gardens in Baduy exhibit beneficial ecological functions such as soil erosion control, nutrient recycling, plant gene bank conservation and pest control. Development of farming systems utilizing well-known and commonly applied traditional agroforestry systems like mixed gardens would be feasible psychologically and politically since they are already accepted by the people. It is in contrast to new an unfamiliar systems. For development to be successful, cultural realities must also be taken under consideration.

Generally, the analysis of Baduy's shifting cultivation can be a with respect to different scenarios, such as:

a) human population grows continuously;
b) forest area decrease continuously;
c) land productivity decrease continuously; and
d) there are alternative land use policies

III.2.2. HYPOTHESES

The following hypotheses have been applied in analyzing shifting cultivation in Baduy:

1) Shifting cultivation in Baduy area can not sustain sufficient food supply to its population, given the current rate of growth in population and current practices.
2) Shifting cultivation in Baduy area, on the other hand, can sustain sufficient food supply to its population, given a restricted rate of growth among traditional farming population and current practices.

3) Shifting cultivation in Baduy area can not sustain forest area given the current rate of growth in population and current practices.

4) Shifting cultivation in Baduy area, on other hand, can sustain forest areas given a restricted rate of growth among the traditional farming population and/or improvement in practices.

III.2.3. THE GOAL AND BOUNDARIES WITHIN THE SYSTEM

The main purpose of the study, which has mentioned earlier i.e. an evaluation sustainability of Baduy's shifting cultivation, with four main objectives of the study as also mentioned earlier in Chapter I.

Based upon the main objectives of the study, the problems and interrelationships of the components Baduy's shifting cultivation are focused. The main components of Baduy's shifting cultivation are population, agricultural land, food supply and forest area, while the boundaries of the system are the Baduy ecosystem. Based on the ecosystem boundaries, the main interrelationships of the components Baduy's shifting cultivation are in consideration more than administration boundaries. As long as a component has strong interrelationships with other main components of Baduy's shifting cultivation, although the component is located in outside of Baduy administration, it can be included in the system. For example, upland rice field (ladang) in-non Baduy area which is usually rented by outer Baduy, although is located in outside of Baduy administration, it be considered as a component of the Baduy's ecosystem, because the ladang area of non-Baduy have strong interrelationship with other components of Baduy's shifting cultivation.

III.2.4. CAUSAL LOOP DIAGRAM

Based on the goal and boundaries within the system in analyzing a model, a causal loop diagram and structure of the simulation model of the shifting cultivation in Baduy, West Java can be constructed (Figure 4).

The main sector of the model are: 1) human population, 2) food sector, 3) land use sector, and 4) soil fertility.

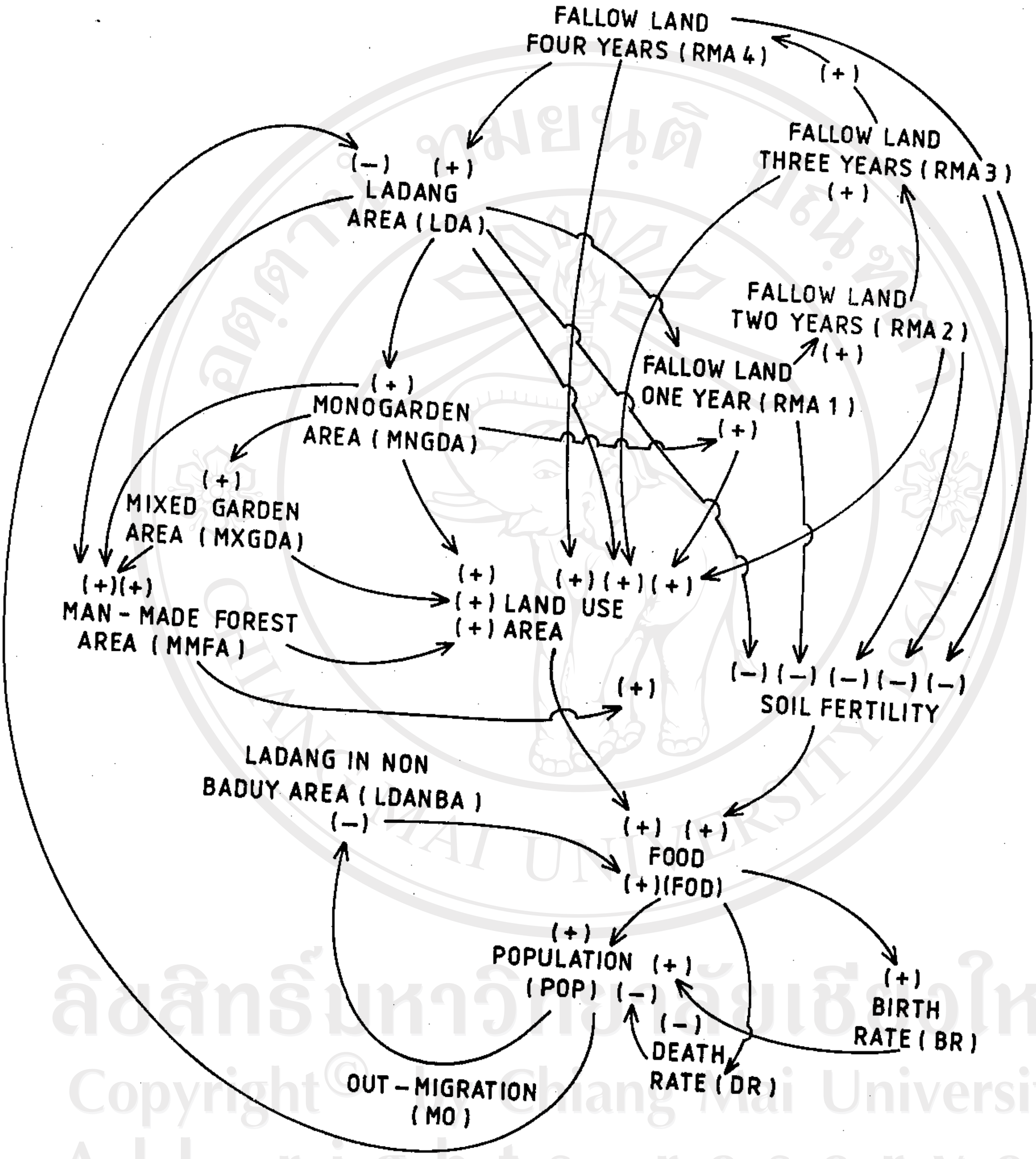

Figure 4 The principal causal loop of shifting cultivation simulation model of Baduy, West Java, Indonesia.

III.2.5. TRANSLATION OF CAUSAL LOOP DIAGRAM INTO FLOWCHART

The diagram (Figure 4) can be converted into flow chart form, which is shown in Figure 5. In this flow chart, all sectors are combined. Notation are used in Figure 5 based on Forester's system:

a) LEVEL

b) AUXILIARY

c) RATE

d) SINK OR SOURCE

e) INITIAL

f) MATERIAL FLOW

g) INFORMATION FLOW

AGP = AGRICULTURAL PRODUCTION
BR =BIRTH RATE
FCNS =FOOD CONSUMPTION
FEX =FOOD EXPORT
FIM =FOOD IMPORT
FOD =FOOD
INCFR1=INCREMENT OF SOIL FERTILITY 1 YEAR
INCFR2=INCREMENT OF SOIL FERTILITY 2 YEARS
INCFR3=INCREMENT OF SOIL FERTILITY 3 YEARS
INCFR4=INCREMENT OF SOIL FERTILITY 4 YEARS
INMML =INPUT TO MMFA DERIVED FROM LDA.FRACTION
INMNL =INPUT TO MONOGARDEN
INRML =INPUT TO RMA1
INMXM =INPUT TO MIXED-GARDEN
LDA =LADANG AREA
LDANBA=LADANG NON BADUY AREA
MI =IN-MIGRATION RATE
MMFA =MAN-MADE FOREST AREA
MNGDA =MONOGARDEN AREA
MO =OUT-MIGRATION RATE
MXGDA =MIXED-GARDEN AREA
OUMNM =OUTPUT OF MNGDA
OUMXM =OUTPUT FROM MXGDA
POP =POPULATION
RMA =REUMA AREA
RMA1 =REUMA OF FALLOW 1 YEAR
RMA2 =REUMA 2 YEARS
RMA3 =REUMA 3 YEARS
RMA4 =REUMA 4 YEARS
RMC =REUMA CUTTING
SFRT =SOIL FERTILITY
LOSS =FOOD LOSS
A1 =LADANG OUTPUT COEFFICIENT

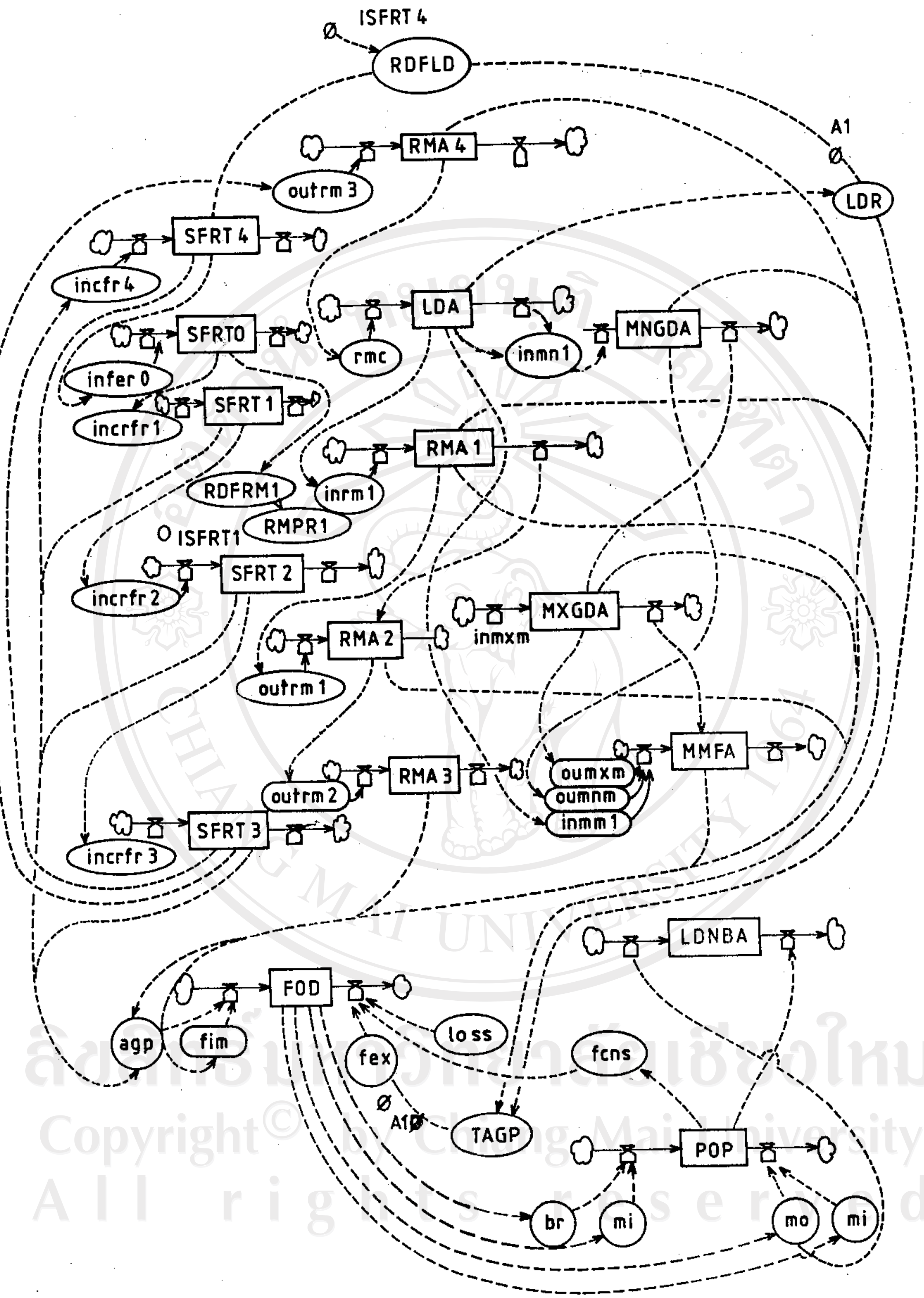

Figure 5 Flowchart of shifting cultivation model in Baduy West Java, Indonesia

III.3. MAIN SECTOR OF THE MODEL

The main sectors of the Baduy's shifting model, as mentioned earlier are human population, food sector, land use sector, and soil fertility.

Those components have interrelationship to formalize a system. Changes in a certain component of the system will affect to other components. Each component and interrelationship among component of Baduy's shifting cultivation will be described below.

III.3.1. HUMAN POPULATION SECTOR

The main component of the Baduy's shifting cultivation is population. The Baduy population is an integral part of the system. In this model population of Baduy can be determined by changes both input and output of population level.

Inputs for population level can be determined by birth rate and in-migration rate, while outputs for population can be determined by death rate and out-migration rate (Figure 4 and 5). Because of the tradition of the Baduy, there was no in-migration of other group of non-Baduy people. Migration was mainly out migration and coming back of Baduy people to their area. It is caused either because agricultural land was not sufficient or their secondary forest (reuma) area was not ready for cultivation. They stayed in non-Baduy area for cultivation by renting land from non-Baduy people. All inner Baduy inhabitants about 10 per cent of the total population, had never practiced shifting cultivation in non-Baduy area. Both out-migration and in-migration in the simulation is taken to be 5 per cent of population. The birth and death rate fraction is calculated from secondary data in 1984/1985 which is based on the crude death rate and the crude birth rate (Barclay, 1958) . The birth and death rate is 37 per cent and 1.6 per cent of annual population, respectively.

Furthermore, components of birth, death, in-migration and out-migration rate are determined by food level. The food level can determine positive impacts on birth and in-migration rate and negative impacts on death and out-migration rate.

In this model is assumed a level of food supply has some responses to population in birth, death, in-migration, and out-migration rate. If food surplus, defined as the excess of food availability over food consumption as a percentage of food consumption, increases 1 per cent, birth and in-migaration rate will increases 0.1 per cent. While, if food deficit, defined as negative food surplus, increases 1 per cent death and out-migration will increase 1 per cent. These coefficients still need to be verified in the future.

In this model also be tried to simulate no relationship between food supply and population growth. More detailed mathematical equations are presented in Appendix 1.

III.3.2. FOOD SECTOR

Dynamics of food in Baduy is considered to be determined by the input and output of food level. Food input is assumed determined by agricultural production and food import. While food output is assumed determined by food consumption, food export and food loss. In this model, it is assumed that food export and food loss is a fixed proportion of total agricultural production.

Food exports contribute to cash income while cash income is used to finance food imports. Cash income can also be determined by off-farm income which is a function of the balance between total agricultural production and basic needs requirements of the household.

Sources of food in Baduy are mainly from agricultural production, with minor amounts bought from the market. Agricultural land use types can be divided into five types, namely upland rice field (ladang), secondary forest (reuma), annual-perennial mixed garden (kebun campuran), monoculture garden (kebun) and man-made forest (hutan kampung) (Figure 4 and 5).

The agricultural land provides rice as staple food and other products, such as fruits, vegetables, spices, medicinal plants, building materials and fire wood. However, rice can be produced only from upland rice fields (ladang) and is never sold. Other non-rice production is used for both home consumption and cash income.

Food import is mainly obtained from food buying in markets or small shops in non Baduy area. Besides they get also from agricultural production of non Baduy, particularly if they rent of land in non Baduy area. The degree to which land in non Baduy area is rented depends on the number of people who migrated out to non Baduy area.

Total basic need requirement and food consumption is determined by the number of population.

Outputs from food level will be determined by food consumption, food export and losses. Food losses are assumed at 5 per cent of production due to post harvest and storage losses. Food consumption is determined by population.

A) AGRICULTURAL PRODUCTION

Based upon secondary data in 1985/1986, each household of Baduy society obtained income from agricultural amounting to about Rp 78,564 per household per year. The price of unhusked rice was Rp 200 per liter, with 1.25 kg of unhusked rice equal to 1 liter of unhusked rice and 1 US $ equal to

Rp 625. The average landholding of upland rice field (ladang), monoculture garden (kebun), mixed garden (kebun campuran), man-made forest (hutan kampung) and secondary forest (reuma) for each household recorded was 0.7 ha, 0.6 ha, 0.7 ha, 0.03 ha and 0.8 ha, respectively. However, based on calculating of survey data of the total area, average upland rice, monoculture garden, mixed garden, man-made forest and secondary forest for each household was 0.7 ha, 0.7 ha, 0.04 ha, 0.08 ha, and 1.25 ha, respectively.

Production of each land use type is presented in Table 10 (Chapter IV). It can be seen from Table 10 that the secondary forest (reuma) has an important role not only in forest succession to provide biomass for upland rice fields (ladang) and soil conservation, but also for providing economic benefits. Many products are usually harvested from reuma, such as fruits, vegetables, building materials and fire wood. The upland rice field (ladang), although from the stand point of production function is less important than secondary forest (reuma) production, however, ladang is very important for Baduy society, because ladang provides rice for home consumption, while other types of agroecosystem provided non-rice products. Average rice production only of ladang recorded was 488 kg of unhusked rice per household equal to 697 kg of unhusked rice per hectare per year. However, based on census of total population the ladang production per hectare is equivalent to 1,900 kg rice. This number is higher than average production of case study in outer Baduy. Because in total census data is included ladang production of inner Baduy, which is high due to still have enough fallow time in inner Baduy area. Moreover, cultivating rice in upland fields (ladang) at Baduy society is very important, because it has strong interrelationships with their religion or culture (Iskandar, 1985). Rice has been allowed to be planted only in the uplands, but it is forbidden to plant in irrigated fields (sawah).

The Baduy people, particularly those of outer Baduy, besides practicing shifting cultivation in their area, also practice shifting cultivation in non Baduy area. They usually rent land from non Baduy people to do shifting cultivation. For rented land, they use 3 systems:

First, they rent land in non-Baduy using cash money at Rp 20,000-Rp 60,000 per hectare per year.

Second, they rent land in non-Baduy by share cropping, in which agricultural products after harvest are divided into 10:1 or 10:2 shares. For example, if they get 100 kg rice, the rice will be divided into 90 kg and 80 kg for the tenant and 10 kg and 20 kg for the land owners, respectively.

Third, the tenant will not pay, in cash or production, however, during renting and before leaving they are obligated to weed the land owners' plantations of economic crops, such as cloves and oranges.

B) FOOD CONSUMPTION

Baduy people consume many kinds of foodstuffs. Based on data from 1984/1985, about 39 varieties, 22 varieties and 25 varieties of foodstuff are usually consumed by people at breakfast, lunch and dinner, respectively. Sources of foodstuffs were mainly from agricultural production and only little was purchased. Foodstuffs which were eaten most frequently were rice, salt, salted fish, fish paste with hot relishes (sambal), cooked banana and vegetables. Salted fish was the most common source of animal protein, while rice was main source of carbohydrates.

III.3.3. LAND USE SECTOR

The five types of land use, upland rice (ladang), monoculture garden (kebun), mixed garden (kebun campuran), man-made forest (reuma) and secondary forest (reuma) are closely related. Therefore, changes in one type of land use will affect the other land use types (Figure 4 and 5). At present, the most significant changes in land use sector are mainly among reuma, ladang, mono culture garden and mixed garden.

Mature secondary forest or reuma of fallow time 4 years (RMA4) is cutted every year for practicing of shifting cultivation, which is usually need about 0.16 ha/family. However, constraining cutting only available mature secondary forest. Accordingly, mature secondary forest cutting is limited after mature secondary forest area becomes scarce.

Ladang field after annual crops are harvested, the fields are abandoned, which will develop into immature secondary forest (RMA1) by natural succession. However, some fraction of the abandonment ladang fields can also be developed into monogarden, if the land is planted by annual crops, such as sweet potatoes and cassava. While the monogarden after harvesting annual crops can be developed either into immature secondary forest (RMA1) or it can be developed into mixed garden, particularly if the monogarden are planted by perennial crops, such as coffee, clove and fruit crops. Furthermore, immature secondary forest will be developed into mature forest after the lands are fallowed enough time, such as 4 years. Some land use systems, such as monogarden and mixed garden can also be developed into settlements and man-made forest areas, if the houses are constructed at those land use systems (Figure 4).

In this model, the changes of each land use type in Baduy can determine agricultural production, which is furthermore can also effect food supply. More detailed mathematical equations are presented in Appendix 2.

III.3.4. SOIL FERTILITY

Agricultural land productivity is mainly determined by soil fertility, while soil fertility is determined by forest fallow time relative to crop time. The long term success of shifting cultivation depends on how well the fallow period restores or maintains soil fertility (Christanty, 1986; Kuyuma and Pairintra, 1983; Nye and Greenland, 1969; Okigbo, 1984; Sanchez, 1976). If the fallow period is shortened, the annual addition of organic materials will be reduced, leading to soil fertility deterioration. Land productivity can also be determined by rainfall systems and occurrence of pests. However, because of lack quantitative data of rainfall systems and pests, those aspects will not be included in the model.

In this model, input to beginning soil fertility in ladang phase (SFRTO) considered to be derived from mature secondary forest of fallow time four years (SFRT4) (Figure 4 and 5). During cropping time of ladang phase, soil fertility is used by crops and lost by erosion is 50 per cent of initial of soil fertility of fallow time four years (SFRT4). The increment of soil fertility during fallow time four years annually is 1.25, 1.15, 1.15, and 1.15 of SFRT0, SFRT1, SFRT2, and SFRT3, respectively.

More detailed mathematical equations are presented in Appendix 2.

Fertility input can be determined by biomass of mature forest, while output from soil fertility will be determined by losses of nutrients caused by erosion, crop uptake and crop removal.

In this model, soil fertility is assumed to be determined by each type of agricultural production. Production in ladang, reuma of fallow time one year, reuma of fallow time two years, reuma of fallow three years, and reuma of fallow four years production can be determined by reduction of soil fertility of fallow time four years, zero r, one year and three years, respectively. Monogarden and mixed-garden are assumed to be subject to the same reduction in soil fertility as in ladang area. While, the man-made forest production is assumed subject to the same reduction the same as in fertility as in reuma of fallow time four years.