CHAPTER 13

TOWORDS A SECURE AND SUSTAINABLE LIVELIHOOD

This chapter is in two parts. The first part describes the system that was used for researching this study. The second part describes the potential outcome which could be achieved after analyzing the farm and the watershed level results and using these results as input for participatory planning groups in the Fang watershed.

13.1 System research method

The agricultural system in the Fang watershed is complex with different physical, biological, social and economic relationships which interact with each other. A change in one will affect the others in the system. The Fang watershed comprises mostly of small farms with limited resources; the economic and environmental factors for these farms can vary substantially. The farmers need to work both on and off the farm in order to maintain a reasonable standard of living. They adapt according to their resources and their individual situation. Each activity has many objective goals and priorities. The farming systems can change at any time depending on the socio-economic situation which leads to the development of complex agricultural systems. This is why a system for agricultural research and development is important for the Fang watershed. This study used the system research method as described below:

1. The system boundaries and hierarchies in the Fang watershed

The systems boundaries are imaginary lines that separate the internal endogenous variables from the external endogenous variables (Jongkaewwattana, 1995). The study determined that the boundary for the study area was the Fang watershed within which were hierarchical systems with smaller units or subsystems which “nested” in the larger systems (Wilson and Morren, 1990). The researcher divided the system boundary and the hierarchy of the Fang watershed at both the farm and the watershed levels. The farm level was further classified according to a system "type" into 4 farm types based on the size of the farm (small farm (SF) ≤ 30 rai and large farm (LF) > 30 rai) and the use of chemicals or chemicals and bioextract. Both the farm size and chemical usage was classified according to Resource Management Unit (RMU) as follows:

RMU type 1: Small farms using chemicals (SFC)
RMU type 2: Small farms using chemicals and bioextract (SFCB)
RMU type 3: Large farms using chemicals (LFC)
RMU type 4: Large farms using chemicals and bioextract (LFCB)

Each RMU type or farm type deals with the resources within their own agricultural system. This helps us to understand the relationship between the farm and the watershed levels in the biological hierarchy. The farm level consists of farm types, the farm types consist of resources and so on (Figure 13.1).

Each farm type not only controls itself within the system but is also interactive between all the farm types and the watershed itself as the highest level in this hierarchy. The systems at the watershed level which influence and affect the environment feed down to the farm level as the watershed systems have the ability to control or force adaptations on the activities for all of the farms. At the farm level, all the farm types may influence the environment with their own activities such as water storage projects, but they cannot control the larger environmental factors such as temperature, rainfall and the overall quantity of water in the watershed. This shows that uncontrollable external forces can influence the performance and outputs of the systems both at the farm and the watershed level.

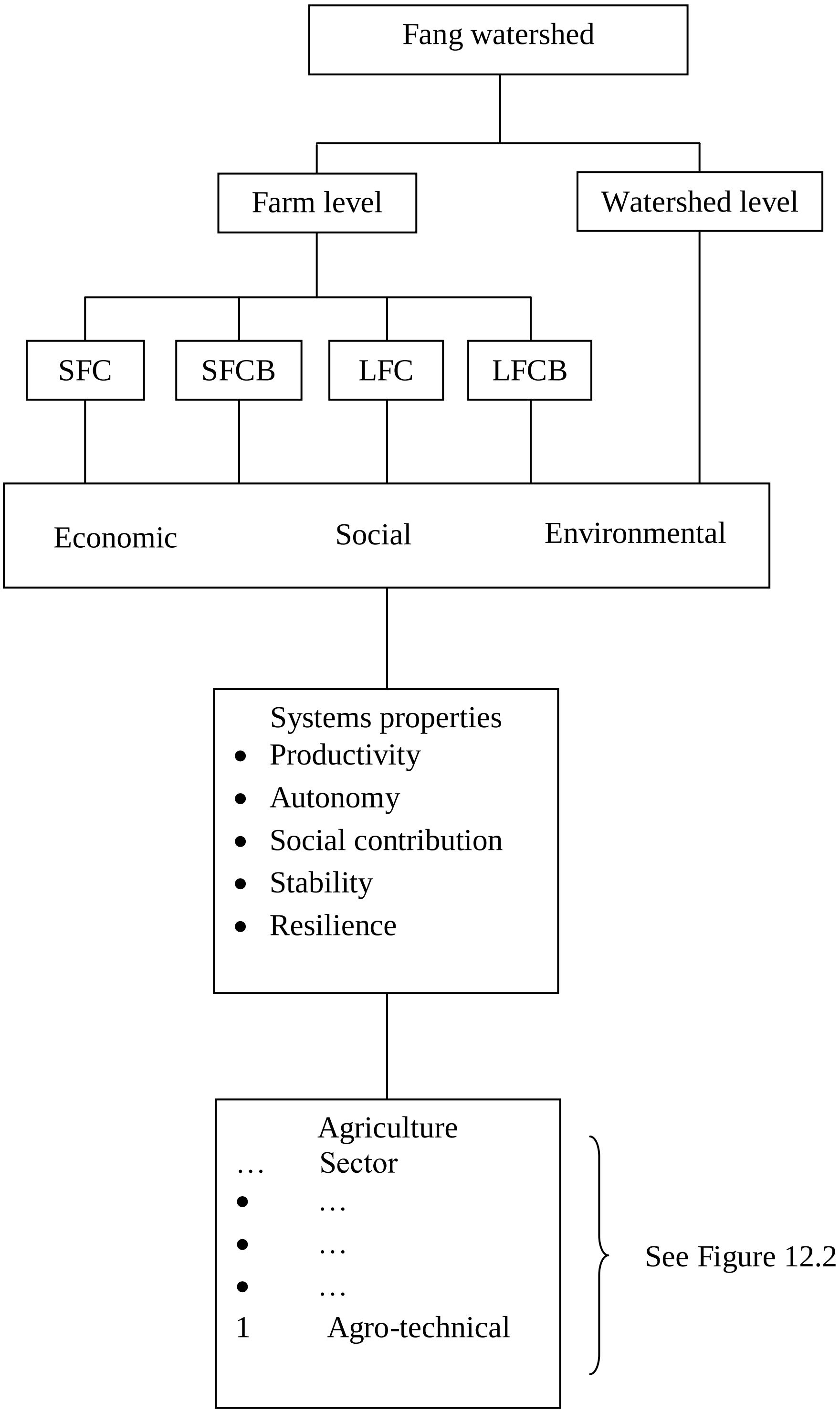

Figure 13.1 The hierarchy in the Fang watershed

The study divided the Fang watershed into the watershed level and the farm level. The farm level was then subdivided into 4 farm types. This study was similar to Zander and Kachele's study (1999) but different to the other studies in which only one or two levels such as farm and district or district and region were identified. The advantage of this study is that the design included single farm models as well as a watershed model. The modeling system is a highly flexible tool with respect to the number and type of farms, sites and production techniques. Environmental objectives can easily be included and different levels of goal achievement can be simulated. It is well suited for single farm analysis as well as for watershed models. It is suitable for use in interactive environments with users who are interested in repeat runs with little change in the goal function, prices, subsidies or technical coefficients. The results can be used for policy decisions as well as for the strategic planning of individual farmers.

2. Sustainability and system properties

Both the farm and the watershed levels need a sustainability evaluation of the natural resource management systems. A measurement of the sustainability of natural resources at any level focuses on the sustainability of the economic, social and environmental dimensions. Each dimension has differences in the details for measuring the efficiency and sustainability of the system at the farm and the watershed levels. The number of indicators should not be exclusive but need to be effective and efficient for the system being studied. For this study, the researcher determined six main properties a system might possess, thus requiring a set of six criteria by which these system properties may be assessed. Each of these properties and its associated assessment criterion apply to both the farm and the watershed levels. The six properties assessed are:

Productivity: both the farm and watershed levels were measured by the annual equivalent value which was similar to the study done by Ekasingh B. et al (2011). The researcher analyzed the net annual revenue from fruit trees such as citrus, longan, lychee, coffee and tea. The average cost and net revenue was calculated over a 12 year period from planting which gave an average figure that could be used for the life of the tree. The aim was to maximize the goal of the annual equivalent value at the both the farm and the watershed levels.

The social contribution was measured by the hired labor at the farm level and employment opportunities at the watershed level. At the farm level, the aim was to minimize the hired labor goal objective as the farmers wished to decrease their production costs. At the watershed level, the aim was to maximize the employment goal objective in order to increase employment opportunities in the region. Similarly, Acosta-Alba et al. (2011) used the employment indicator goal at the regional scale in their study of dairy farming.

Autonomy was measured by the dependence on external inputs at both the farm and the watershed levels. External inputs include pesticides, fertilizers and chemicals incorporated into the soil and non-renewable energy use. At the farm level, another indicator used for measuring autonomy was loan investment. Loans were important for crop production and small farms had a disadvantage when compared with large farms in this area as large farms have large land holdings, access to many sources of loans and can borrow large amounts of capital. They can also get a high price for their crop which gives them a high revenue (Chapter 4: Table 4.11, Table 4.12, Figure 4.1, Figure 4.20 to Figure 4.23). The small farm is disadvantaged as usually the quality and the quantity of their crops are lower, they lack power when it comes to marketing and they find it difficult to obtain loans at low interest rates which lead to restrictions on their sources of borrowing. The aim was to minimize all the indicators for these goal objectives.

Stability was measured by revenue variance at both the farm and the watershed levels with yield variance being another indicator at the farm level. Both these indicators have not been used previously in other studies and have been included here as the results showed a large variation in the annual yields and prices, especially for citrus production (Figure 4.11 and Figure 4.13).

Sustainability was measured only at the watershed which three indicators; the amount of nitrogen fertilizer used, soil erosion and the expenditure on pesticides. The nitrogen fertilizer use and the soil erosion indicators followed the pattern used by Lopez-Ridaura et al (2005a). The measurement of the expenditure on pesticides differed from the other study as citrus production has high chemical usage that affects the environment of the Fang watershed and this was taken into account in this study. The aim was to minimize all the indicators for these goal objectives.

Resilience was measured by off-farm work at the farm level and was measured by the revenue from non-timber forest products at the watershed level. The access to alternative sources of income is important, especially for the small farmer as this helps to smooth out variations in the income gained from farming. If the area designated as forest is protected or increased, there will be benefits for the environment as well as the farmer who will have an alternative food source as well as an alternative income.

However, sustainability also depends on their objectives and the participation of the stakeholders at each level. At the farm level, natural and human resources are managed with the aim of improving their standard of living and to increase the generation of income. This means that farmers give more importance to the economic objective than the social and environmental objectives. At the farm level, the stakeholders are farmers who know the environmental problems and resource limitations. Their participation in the planning of future strategy is needed to help combat these problems. At the watershed level, the stakeholders are the government and NGOs who coordinate with the farmers in the citrus activities with their perceptions of the system and their objectives. The stakeholder at the watershed level has to conserve and improve the environment by reducing chemical use, soil loss, diseases, water pollution, air pollution, protecting the wildlife and increasing the forest area. This means that the stakeholders in the watershed level give a higher priority to the environmental objective than the social and economic objectives. This study took all the stakeholders into account by inviting them to participate in a survey which included 4 groups of stakeholders from each farm type from the farm level and 1 group of stakeholders from the watershed level. These results were then put through pair-wise comparisons using the AHP method.

3. Agricultural system classification and order hierarchy

An “agricultural system” is an assemblage of components which are united by some form of interaction and interdependence and which operate within a prescribed boundary to achieve a specified agricultural objective on behalf of the beneficiaries of the system (McConnell and Dillon, 1997).

Figure 13.2 elaborates on the “Order Level” box shown in Figure 13.1 and relates specifically to the agricultural systems in the Fang watershed. These are listed in a hierarchical order as far as possible and encompass 11 order levels. The order level 1 to 11 could have been depicted, reflecting their nested character, as a set of concentric circles with order level 1 as the innermost and order level 11 as the outermost circle.

In Figure 13.2, the agricultural system in the Fang watershed is organized into 11 levels. As we have seen, the sub-sectors at Level 10 in the Fang watershed consist of credit, extension, production, research etc. The farm unit at Level 9 consists of 4 farm types: the small farm using chemicals (SFC), the small farm using chemicals and bioextract (SFCB), the large farm using chemicals (LFC) and the large farm using chemicals and bioextract (LFCB). Level 8 is the household which applies to all the farm types and include systems such as off-farm work and non-timber forest products. Level 7 deals with the farm as an entity and includes general capital and all cropping systems. The general capital includes fixed farm capital (Level 6) and the resource pool (Level 5) which is made up of household labor, hired labor and land use (irrigated upland, rainfed upland, irrigated lowland and rainfed lowland). The capital could be increased by credit from BAAC, village funds, agricultural co-operatives and commercial banks. For the crop types (Level 4), the researcher takes into account 24 different cropping systems which can involve combinations of citrus, longan, lychee, rice, sweet corn and sweet corn, rice followed garlic and sweet corn etc. Level 3 consists of the individual crop item. Level 2 consists of any resource generating activity. Level 1 is the domain of applied agricultural sciences such as fertilizers, pesticides, machinery etc. Agricultural sciences have sufficiently developed over a broad area for each farm type to benefit in some way from technology.

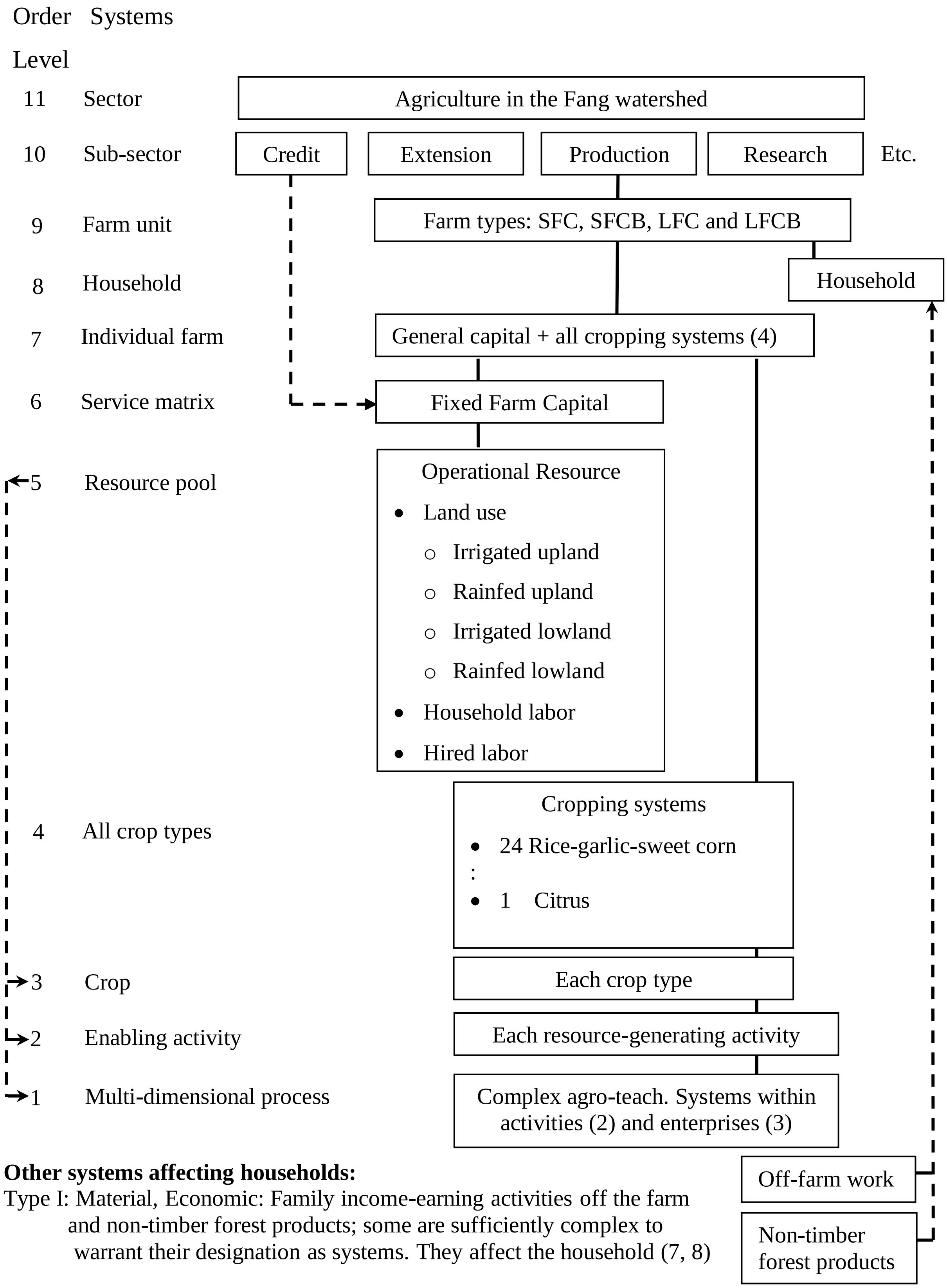

Figure 13.2 The hierarchy of agricultural systems in Fang watershed

4. Optimal resources management analyses

The qualitative and the quantitative model of agricultural research has improved along with the degree of participation from the farmers. This has been helped enormously by the use of computers, especially for technical simulations, which provide the information needed to make the decisions used in the farming hierarchy at the farm and the regional level. Technical simulation models are currently being used to study issues such as agricultural development and natural resource management.

The quantitative model could be classified into two groups: mathematical economic models and biophysical models. The mathematical economic models such as the linear programming models have been used to analyze farms either by themselves or in conjunction with other tools such as GIS. For example, Lu (2005) explored a scenario of strategic land uses in northern China using ecological production principles. Senthikumar et al. (2011) developed a multi-objective linear programming (MGLP) model to explore the impact of modified rice cultivation including the effects of water-saving irrigation on farm profit. To evaluate government water pricing and quota policies on rice cultivation, Hijmans and Van Ittersum (1996) used aggregated spatial units in an Interactive Multiple-Goal Linear Programming (IMGLP) model. These were analyzed for both a schematized and existing IMGLP model (GOAL) exploring land use options for the European Union. Ekasingh M. et al.(2011) designed and developed an integrated project for a decision support system for multi-objective agricultural land use planning using interactive multiple goal programming (IMGP). A software program called Interactive Multiple Goal Programming for Land Use Planning (IMGP-*LPlan*) was developed and has been used for optimal resource management in this study. In the past, linear programming was frequently used as a planning tool at a provincial level together with multiple objective programming but there was no interaction with the users in the field. There had been no attempt to link the results from the IMGP models with geographic information systems to facilitate makers in visualizing the model results spatially. This research project has developed the capability to make agricultural land use planning more dynamic and efficient.

This study used a linear programming model to evaluate the optimal resource management which took into account the multiple goals of citrus-based farming systems at the farm and the watershed levels in the Fang watershed. At the farm level, the researcher used annual equivalent value, hired labor, independence from external inputs, loan investment, yield variation, revenue variation and off-farm work as the goals in this study. At the watershed level, the 8 goals were annual equivalent value, employment, independence from external inputs, nitrogen use, expenditure on pesticides, soil erosion, revenue variation and revenue from non-timber forest products. These goals were then used to analyze the optimal resource management using the equal weight and AHP methods. A sensitivity analysis was then conducted using the optimal results from the equal weight method to see how changes would affect the results. The AHP method results were influenced by the stakeholder's opinion. The second part of the sensitivity report examined how a change to resource availability affected the optimal solution with the following 4 sensitivities:

a. An increase in the annual equivalent value goal (GA) by as much as 20 percent from the weight value in the equal weight method.
b. A decrease in the off-farm work goal (GS) by as much as 30 percent from the weight value in the equal weight method.
c. An increase in the wage rate coefficient from 200 to 300 baht per day.
d. An increase in the hired labor constraint by 30 percent. For the small farms, the hired labor constraint had an increase from 50 to 65 man-days per month and from 750 to 975 man-days per month for the large farms using chemicals. For the large farms using chemicals and bioextract, the labor constraint increased from 150 to 195 man-days per month.

The study obtained results at both the farm and the watershed level from the equal weight and AHP methods. The farm level results of optimal land use in each method were extrapolated to the watershed level based on the proportion of land occupied by each farm type. These extrapolated results were then compared with the original results from the watershed level to help understand optimal land use management differences between the different objectives of the stakeholders at the farm and the watershed levels.

This study evaluated the trade-offs between the economic, social and environmental objectives for optimal resource management. With agricultural land use, conflicts between objectives are likely when planning to optimize the benefits using multiple goal linear programming modeling. A trade-off analysis is used to find the relationships between objectives. A trade-off between relationships will help to understand how to adjust the target value of each objective in order to find the optimal outcome. At the farm level, the trade-off analyses were as follows:

Between the annual equivalent value and the dependence on external inputs

a. Between the annual equivalent value and loan investment
b. Between the annual equivalent value and revenue variance
c. Between the annual equivalent value and hired labor
d. Between off-farm work and hired labor

For the watershed level, the trade-off analyses were as follows:

a. The trade-off between the economic and the environmental objectives:
    (i) Between the annual equivalent value and the expenditure on pesticides.
    (ii) Between the annual equivalent value and nitrogen use.
    (iii) Between the annual equivalent value and soil erosion.
b. The trade-off between the economic and social objectives was comparing employment and revenue variance.
c. The trade-off between the social and environmental objectives
    (i) Between employment and the expenditure on pesticides
    (ii) Between employment and nitrogen use
    (iii) Between employment and soil erosion

The study used the *IMGP-LPlan* which assessed the optimal resources management with multiple goals at both the farm and the watershed level for the Fang watershed.

The results of comparative agro-ecosystems management and the trade-off analyses gave more understanding for the optimal resources management. These results could be usefully applied in participatory land use planning for a secure and sustainable future for the Fang watershed.

13.2 Towards a secure and sustainable livelihood

This section looks at how the benefits of this research which were summarized in the previous sections can be driving force for a secure and sustainable livelihood in the Fang watershed:

13.2.1 Development of the comparative advantages for the small farms through establishing groups and networks

The results show that the large farms had an advantage over the small farms. They have large land holdings, access to many sources of loans and can borrow large amounts of capital. They can also get a high price for their crop which gives them a higher revenue than the small farms (Chapter 4: Table 4.11, Table 4.12, Figure 4.1, Figure 4.20 to Figure 4.23). The small farms are disadvantaged as usually the quality and the quantity of crops are lower, they lack power when it comes to marketing and they find it difficult to obtain loans at a low interest rates which leads to restrictions on their sources of loans. Changes in production and marketing will lead to increased competition, especially with the introduction of the ASEAN community in 2015 which will inevitably impact on production and marketing in the Fang watershed. As the small farmers find themselves increasingly disadvantaged, there is an urgent need to find a proper solution to improve competitiveness for the small farms.

One solution that is widely accepted is the establishment of groups of small farms. They will have the potential to promote and develop sustainable agriculture throughout the groups. This will lead to the groups learning and gaining mutual support from each other as well as building strong networks between the groups and communities with the possibility for worldwide links as well. The groups and networks could supply the small farms at low cost by large volume purchasing while it could help them in negotiating marketing with the middlemen who buy the crop. This could have large financial savings within the groups or networks which should lead to low interest loans for the membership.

An important factor for the integrated groups to succeed is the government, which would be a key driver for the development of successful programs. The government must have an understanding and be able to support the small farms to develop their true potential. The local authorities should adjust their attitude before they start to promote and develop new processes to the farmers. The farmers need to see the authorities not as "the commander" but as an "an enabler". This means that new ideas are not dictated by the authorities but come from collaboration between the farmers and the authorities. The farmers will then be able to complete any potential development by themselves. Other factors that are pressing is the need for the authorities to promote process-oriented speakers to encourage the farmers participation in development. As well as being a mentor to establish groups, organizations and networks for interdependence within the larger groups, this will lead to strong communities. The capacities of the authorities in this field are rather weak and would need development, especially by the authorities in the local area. In the current move towards government decentralization and policy formulation, the newly forming Tambon (or sub-district) Administrative Organization (TAO) can create lines of communication between the villagers and government agencies. This office would work closely with the community and will know the problems in their area, especially regarding agricultural production. The promotion of learning processes for self-reliance in the rural sector would be of key importance for sustainable development.

13.2.2 Participatory land use planning process

The results of this study show quite clearly that the results could be used to encourage the plans which have been developed with the participatory land use planning processes.

They can be integrated into a broader spatial information system. The researcher has showed that the results can be used for the optimal resource management at both the farm and the watershed levels by the equal weight and AHP methods. The four sensitivities and the trade-off analyses could have applications in themselves in response to the conditions and the outside pressures and tensions. However, the optimal resource management results are different at the farm and the watershed levels because of the differences in the objectives of the stakeholders. There needs to be a mutual solution for optimal land use planning for sustainability. This planning will have more importance given to the use of GIS and remote sensing tools which will help provide sufficient transparency and accountability to expect that all stakeholders at the farm and the watershed levels, national policy makers and the general public could accept official recognition of land use agreements based on all levels of stakeholder participatory land use planning in the Fang watershed. The results can be used with participatory land use planning as follows:

a. The use of optimal patterns of land use

When the results from the AHP method are compared between the watershed level and the extrapolated-to-watershed level, the study found that the watershed level analysis recommended an optimal land use plan with areas for fruit trees and forest, while the extrapolated farm level analysis recommended an optimal land use composed of mixed fruit trees and annual crops with no land allocated for forest (Chapter 11: Figure 11.2).

It can be seen that optimal resource uses in the watershed vary depending on whose points of views are being considered. Farm-level models are in contrast to the watershed model in that they have different objectives and their relative importance also varies. If farmers are making the decisions, they are more concerned with income and employment rather than the environmental objectives. If the environmental objectives in the Fang watershed are optimized as opposed to the economic and social ones, the Fang watershed would be left largely as forest with a small proportion of fruit trees. Even in such a situation, the fruit trees that were planted in the Fang watershed should be environmentally friendly such as coffee, tea or lychee rather than citrus. Nevertheless, one cannot ignore the reality in the field that farmers are the ones who make decisions on land use. Their objectives and interests should also be recognized and some balance between the economic and the environmental objectives should also be achieved. The model results can be used as a basis for discussion between farmers and watershed officials so that some changes to land use can be achieved in order that the economic, social and environmental objectives can be more balanced.

b. Possibility of land use zoning

The results of the watershed level and the extrapolated to watershed level from the farm-level results by the equal weight method, and the extrapolated results from the farm-level by the AHP method (Chapter 11: Figure 11.1 and Figure 11.2) both recommended that the optimal land use for the upland and lowland irrigated area was for citrus production. However, citrus production on the upland irrigated area was planted upstream in the forest zone as can be seen from the samples in this study, Chapter 4 Figure 4.8. Citrus farming was contributing heavily to soil and water contamination as the residue from the high chemical and fertilizer levels in the soil leached and contaminated the stream water (PCD, 2004, Jumreanma et al., 2005 and Phratnuwat et al., 1999). There was also a conflict over water resources between the large citrus farms upstream and the small citrus farms downstream. The large farms would tap and divert the water into storage for their own use, especially for the dry season (Chawprayoon, 2005).

The most important question related to further work and the management of efforts in the participatory land use planning for a secure and sustainable livelihood center on who should do it, and how should such efforts be supported.

To determine agricultural land use zoning by all the participatory stakeholders, the setting of the boundaries and maps were drawn up for local land use, with zoning for the upstream areas which would protect the forest areas and allow for environmentally friendly crops such as tea, coffee, lychee or longan. Citrus production could be promoted along the lines suggested by the study of Onpraphai et al. (2011). The local land use zoning can be translated into a digital spatial database format which can overlay village boundaries and zones on a time series of aerial photos which can reveal a lot of information about land use change. They can be overlaid on local village and land use zoning unit boundaries on land cover data interpreted from satellite imagery. This will be a strong incentive for using satellite data for monitoring compliance with actual zoning plans. However, after determined land use zoning plans, they would provide transparency and accountability in the monitoring system as follows:

I. Monitoring systems

The local communities and TOAs must be able to administer and enforce land use zoning plans with credibility, transparency and accountability. In many cases however, the local community-based land use zoning is such that even if the initial zoning plans appear acceptable to all major stakeholders, the communities and TOAs will not be able to maintain the zones all the time. In the Fang watershed, there are many cases of the large farms in the irrigated upland in the upstream of the forest zone which were planted with citrus where the land belonged to influential people both inside and outside of the communities. The influential people inside the communities have a good socio-economic and/or local position which can be beneficial or harmful to other people in the community. The influential people inside the communities are investors from other villages in the Fang watershed and other places in Thailand such as Bangkok and Ratchaburi. They have more money to invest and more experience in citrus production, especially with the investors from Ratchaburi. There was employment immigration from neighboring countries to work on the farms. The owners visit their farms infrequently, but may stay during the citrus harvest between October and January. Many farmers believe that influential people may have hidden agendas to use zoning to gain access to areas which they can subsequently exploit for their own purposes and benefits. These may be key factors of land use zoning plan failure.

These issues can usually be addressed directed by the communities which have an interest in stakeholder participatory land use zoning which uses a digital spatial database format. The communities have to make the decisions; they should have established village committees to monitor and determine penalties for offenders. Penalties could include cautions, fines or withholding access to village loans. At the same time, bringing agreed boundaries into a spatial information system that can used remotely to monitor compliance using mutually acceptable indicators and making the results available in a timely manner to the full range of stakeholders could effectively address these problems.

II. Institutional frameworks

Legal and institutional mechanisms to enforce land use zoning in the Fang watershed have clarified the zoning boundary of the two national parks of Doi Fha Hom Pok in Fang district and Doi Veaing Pha in Chai Prakan district. Both of these national parks are defined by the law but previously, some farmers have had agricultural areas within the national parks. They do not accept the zoning boundaries, and some farmers continue farming without a land certificate and increase their area every year within the national park. Although the land use zoning plan for all the stakeholders was accepted, there is still no legal means for official recognition. There will still be problems to determine the boundaries of the national park.

There are some issues which must be addressed by legal and institutional means which need to be resolved in the public policy arena through political and legislative means before official recognition of local land use zoning can be achieved. The stakeholder participation land use zoning plan which translates into a digital spatial database format could help provide concerned interests with better information about the nature and implications of types of local land use zoning in the mountain communities. However, if the information was widespread, the efforts could be packaged and presented in such a way that it could reach the widest possible range of stakeholders.

There needs to be a multi-level management organization to monitor land use zoning in the Fang watershed. This would be a new asset for the farmers and institutional organizations that already work together to develop agriculture in the Fang watershed. Monitoring does already exist but there could be further expansion of this type of activity

III. Funding

Efforts by the TAOs have resulted in approval conforming that at least 1 percent of the annual budget should be used for the monitoring of land use zoning plans, including the budgets for organizations who have clear mandates to work with natural resources and environmental issues and activities. This provides the TAOs with mandates to build on their previously constrained capacity to increase their involvement in activities related to natural resource management.

d. The use of trade-off analysis

The trade-off analysis results at the farm and the watershed levels (Chapter 11: Table 11.1 and Figure 11.16 (a)) recommended a reduction in the dependence on external inputs such as the expenditure on pesticides and fertilizers by 30 percent which will have a small negative effect on the annual equivalent value. For the trade-off analysis between the goals of annual equivalent value and nitrogen use at the watershed level, the comparable figures were a 40 percent reduction in nitrogen use which meant a 7 percent reduction in the in annual equivalent value (Chapter 11: Figure 11.16 (b)). This study clearly shows that a large reduction in inputs had a small negative effect on the annual equivalent value. It was determined that the chemical inputs were a key cause effecting the environment. If external inputs could be decreased, it will have a positive impact on the environment.