

CHAPTER 14

CONCLUSIONS AND RECOMMENDATIONS

14.1 Conclusions

This study has examined citrus production in the Fang watershed which has suffered from excess chemical use, the effects of which have caused air and water pollution, soil degradation and illnesses. The Ministry of Natural Resources and the Environment has sought the cooperation of other agencies and has since drafted a declaration to protect the environment of the Fang watershed. This area is popular for citrus production and farmers are planting increasing areas with citrus with the aim of increasing revenue without taking into account the consequences to the environment or the social structure. In order to understand the transformations in the area, the researcher conducted a series of interviews with farmers to keep up to date with the current situation. The study set a series of 7 goals for the 4 farm types involved in citrus-based farming at the farm level, and set a different set of 8 goals for the watershed level. The study used *IMGPlan* software developed by Ekasingh et al (2011) to evaluate the optimal resource management at each level. This chapter provides the key conclusions of the study as follows:

14.1.1 Optimal resource management at the farm level

The researcher analyzed the optimal resource management of the 4 farm types by using the equal weight and the AHP methods. The equal weight method determined the weight value of all the goals equally at 0.1428 (1 divided by 7 = 0.142857) at the farm level and the watershed level determined the weight value of all the goals equally at 0.125 (1 divided by 8 = 0.125). The AHP method enabled different weight values for each goal to be given by participatory stakeholders. At the farm level, the stakeholders

gave high weight to economic goals. In the small farm using chemicals, the highest weight value was given to yield variance (0.2297) followed by revenue variance (0.1731), annual equivalent value (0.1520), dependence on external inputs (0.1395), loan investment (0.1212), hired labor (0.1162) and off-farm work (0.0683). In the small farm using chemicals and bioextract, the highest weight value was for yield variance (0.2247), annual equivalent value (0.1696), revenue variance (0.1649), hired labor (0.1367), dependence on external inputs (0.1258), loan investment (0.0923) and off-farm work (0.0861). In the large farm using chemicals, the stakeholders gave more importance to yield variance (0.2085) followed by the revenue variance (0.1722), annual equivalent value (0.1525), dependence on external inputs (0.1404), hired labor (0.1231), off-farm work (0.1024) and loan investment (0.1009). In the large farm using chemicals and bioextract, the yield variance had the highest weight value (0.2137) followed by revenue variance (0.1877), annual equivalent value (0.1542), dependence on external inputs (0.1352), hired labor (0.1214) and off-farm work (0.821). For the watershed level, the stakeholders gave high weight value to goals in the environmental objective. The highest weight value was revenue from non-timber forest products (22.67) followed by nitrogen use (0.2008), soil erosion (0.1610), revenue variation (0.1339), employment (0.0857), expenditure on pesticides (0.0667), dependence on external inputs (0.0649) and equivalent value (0.0603).

This study employed system analysis which emphasizes that a change in one part of the system will affect the other parts in the system. The farming systems can change at any time depending on the socio-economic situations which lead to the development of complex agricultural systems. The researcher analyzed the Fang watershed both at the farm and the watershed levels. The farm level was further classified into 4 farm types based on the size of the farm (small farm (SF) \leq 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: 1) small farms using chemicals (SFC); 2) small farms using chemicals and bioextract (SFCB); 3) large farms using chemicals (LFC) and large farms using chemicals and bioextract (LFCB). Each RMU type or farm type deals with the resources within their own agricultural system.

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 system property 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 included the productivity, this was both the farm and watershed levels were measured by the annual equivalent value. Social measured by the hired labor at the farm level and employment opportunities at the watershed level. Autonomy measured by the dependence on external inputs at both the farm and the watershed levels. Stability measured by revenue variance at both the farm and the watershed levels with yield variance being another indicator at the farm level. Sustainability measured only at the watershed level which included the amount of nitrogen fertilizer used, soil erosion and the expenditure on pesticides. Resilience measured by off-farm work at the farm level and was measured by the revenue from non-timber forest products at the watershed level.

In addition, this study deals with the results of the comparative agro-ecosystems management at the watershed level. The results were extrapolated to the watershed level from the farm-level results obtained by the equal weight and AHP methods. The farm level results of the optimal land use for each method were extrapolated to the watershed level based on the proportion of land occupied by each farm type. However, optimal land use for the farm level was not always optimal for the watershed level but this study would compare patterns of land use management between the equal weight and AHP methods. The farmers gave higher the priority and high weight value to economic objective while the stakeholders at the watershed level gave high importance to the environmental objective. The different weight given to each objective by stakeholder

led to differences of land use patterns. These results can be used as a basis for discussion between the farmers and the watershed officials so that some changes to land use can be achieved in order to attain sustainability in the Fang watershed.

This optimal land use results were compared with the existing land use. In order to obtain a comprehensive overview, the researcher also compared farm sizes and production technologies as well as conducted sensitivity and trade-off analyses. Regarding farm sizes and production technologies (using chemicals and chemicals and bioextract), it was the comparison of goal achievement rates between the small farm using chemical and the small farm using chemical and bioextract.

1. The small farms using chemicals

The AHP method was calculated with weight values agreed by the participatory stakeholders. This would give the exact weight values which were important for the stakeholders, rather than the set equal values used by the equal weight method. The results showed that the equal weight method gave a more environmentally-friendly pattern of land use than the AHP method when evaluated under the multiple goals objective. Meanwhile, the existing land use is more in line with the optimal land use analyzed by the AHP method. Both recommended that the irrigated and rainfed upland optimal for citrus, double crop of sweet corn, and mixed annual crops. It recommended higher planted areas of citrus while the equal weight method recommended higher area of coffee mixed with sweet corn. Citrus was recommended by the AHP method to be planted in irrigated lowland.

The AHP method was more in keeping with the farmers' wishes in terms of annual equivalent value and gave better results in terms of household labor in that it recommended an increased use of household labor on the farm, resulting in a decrease in hired labor. There was also a decrease in the loan amount from the BAAC compared with the equal weight method. The AHP method gave higher net annual revenue compared with the equal weight method.

The trade-off analyses showed that a decrease in the goals of dependence on external inputs, loan investment or revenue variance by 70 percent would only reduce the annual equivalent value by 15 to 20 percent. If hired labor were decreased by 60 percent, the annual equivalent value would be reduced by 20 percent. This shows that a large decrease in these goals will have a small negative effect on the annual equivalent value. A trade-off between hired labor and off-farm work would show that hired labor could be reduced to zero with only a 20 percent reduction in off-farm work.

2. The small farms using chemicals and bioextract

The results showed that the equal weight method gave a better pattern of land use than the AHP method although the land was assessed as being in need of more crop variety. There was a fruit production area of approximately 5 rai from a total area of 13.80 rai. This was mixed cropping with coffee, longan, and lychee, with only 1.50 rai being used for citrus. The AHP method recommended citrus as being the only fruit crop, covering an area of 3.38 rai with the rest of the land being used for cash crops.

When comparing the existing land use of the farmers with the optimal land use analyzed by the equal weight method, the results showed there was difference among the rainfed upland, irrigated upland and irrigated lowland. In term of the rainfed upland, the goal weight method recommended coffee. Meanwhile, the existing land use was devoted to double crops of sweet corn. For the irrigated upland and lowland, the equal weight method recommended only for citrus with a small area being used for annual crops.

Regarding the comparison of existing land use and result of an analysis of land use by AHP method, it was found to have a similar pattern of land use in the irrigated and rainfed upland. The irrigated upland was recommended by the AHP method to plant citrus and the rainfed upland was optimal for double crops of sweet corn. For the irrigated and rainfed lowland, AHP method recommended rice followed by cash crops e.g. onion, sweet corn but did not recommend many citrus. The AHP method for the small farm using chemicals and bioextract recommended a reduction in citrus areas.

The AHP method suggested an increase in the number of days the household worked on the farm which would result in a decrease in hired labor. It did not recommend taking a loan. Net annual revenue from crop production of 118,761 baht could be obtained. The equal weight method however recommended a loan of 134,234 baht, with net annual revenue of zero baht.

The trade-off analyses showed that a decrease in the goals of dependence on external inputs by 60 percent or a decrease in loan investment or revenue variance by 80 percent would only reduce the annual equivalent value by 16 percent. If hired labor were decreased by 60 percent, the annual equivalent value would be reduced by 20 percent. This shows that a large decrease in these goals will have a small negative effect on the annual equivalent value. In a trade-off between hired labor and off-farm work, hired labor could be reduced to zero with only a 20 percent reduction in off-farm work.

3. The large farms using chemicals

The optimal land use pattern from the equal weight and the AHP methods were similar with the existing land use pattern. The pattern of land use recommended the irrigated areas on the upland and the lowland for citrus production (90.35%) and annual crops (9.65%). For the other optimal results by the equal weight and the AHP methods, both gave similar results. This means that both patterns of resource management are optimal for the large farms using chemicals. The household off-farm work was assessed at approximately 340 man-days per year. The maximum amount of hired labor was needed during the peak periods of planting and harvesting in February, March and December. A loan from the commercial banks of 984,908 baht was recommended with repayments of approximately 1,100,000 baht. The results suggested that net annual revenue from crop production of 5,900,000 baht could be expected. The goal achievement rate was highest in the annual equivalent value goal (GA) followed by the off-farm work goal (GS). The other goals had a lower achievement rate at between 2 to 10 percent.

If there were a decrease in the dependence on external inputs, loan investment or revenue variance, it would have a small negative effect on the annual equivalent value, but further decreases would have a proportionally greater impact. If there were a decrease in hired labor by over 10 percent, it would have a proportionally greater impact on the annual equivalent value. If hired labor was reduced to zero, there would be a 15 percent reduction in off-farm work.

4. The large farms using chemicals and bioextract

The results of the equal weight method gave a more environmentally-friendly pattern of land use than the AHP method. The equal weight method recommended a mixed crop of citrus and coffee at 63.72 percent and annual cropping systems at 36.27 percent. The AHP method recommended that the optimal use was for citrus production (85.85%) and the remainder should be used for annual crops. The equal weight method gave better results and had a narrower spread for the goal achievement rates than the AHP method. However, the optimal land use by the equal weight method gave similar results with the existing land use in the irrigated and rainfed lowland which recommended optimal for citrus and rice. This was different from that of the upland area. The irrigated upland, the existing land use was planted with twice the area of the citrus crop than the equal weight method suggested. The rainfed upland, the existing land use gave total area for double crop of sweet corn with contrast from the optimal results assessed for coffee. For the optimal land use by the AHP method, it gave similar result with the existing land use pattern for all land units. It is noticeable however that both the equal weight method and AHP method recommended citrus be more planted in irrigated lowland than the irrigated upland.

The AHP method which used the farmers' priorities, favored more household work on the farm with a decrease in hired labor. It also recommended an increase in the loans from the commercial banks which increased the net annual revenue from crop production to 1,220,260 baht when compared with 1,004,696 baht by the equal weight method.

If there were a decrease in the dependence on external inputs, loan investment, revenue variance or hired labor by 10 percent, it would have a large negative effect on the annual equivalent value. If the hired labor was reduced to zero, there would be a 19 percent reduction in off-farm work.

Overall, the results for both small farms and large farms using chemicals and bioextract showed that the equal weight method gave a more environmental-friendly pattern of land use. A mix of different fruit trees was recommended and gave goal achievement rate results with a narrow spread. These results were because the AHP method weights land use goals more in line with farmers' wishes i.e. more weight given to income as compared to the equal weight method. With the AHP method, the results for all the farm types were more according to what the farmers saw as their priorities which was an increase in the use of household labor on the farm and a decrease in hired labor. This recommended a decrease in loans and an increase in the net annual revenue from crop production when compared with the equal weight method. The small farms would receive their loans from the BAAC while the large farms would have loans from the commercial banks. It is noticeable however that the AHP method for small farm using chemicals and bioextract recommended a reduced acreage of citrus compared with the existing land use. As for large farms using chemicals and bioextract, both the equal weight and AHP methods recommended citrus be planted in irrigated lowland as compared with irrigated upland. Such recommended shift in area of citrus planting was not seen in the analysis of large farms using chemicals.

The trade-off between the annual equivalent value and the dependence on external inputs, loans and revenue variance for both the small farms using chemicals and the small farms using chemicals and bioextract showed that sizable decreases in the latter would not have a serious negative impact on the annual equivalent value. For both the large farms using chemicals and the large farms using chemicals and bioextract, if the same trade-off were applied, it would have a greater negative impact on the economic objective. The trade-off between the annual equivalent value and hired labor for all farm types showed that the small farms can take a decrease in hired labor without

significantly affecting their annual equivalent value whereas it would have larger negative impact on the large farms. All farm types gave similar results for the trade-off between hired labor and off-farm work. Hired labor could be reduced to zero without having a serious negative effect on off-farm work.

14.1.2 Optimal resource management at the watershed level

The study used 8 goals to analyze resource management at the watershed level using the equal weight and AHP methods. In order to obtain a comprehensive overview, the researcher also conducted sensitivity and trade-off analyses. At the watershed in this study did not divide the land use of citrus production which used bioextract for evaluation. Most of citrus farming in the Fang watershed the farmers was used chemicals although bioextract was used, it was a small proportion.

The optimal resource management using the AHP method suggests a more environmentally-friendly pattern of land use for resource management with a mix of fruit trees (68.38 %) forest (29.76 %) and annual crops (1.86 %). The fruit trees comprised of longan, tea, lychee, coffee, with citrus comprising 33.67 percent. The equal weight method did not allow for a forest area, but recommended annual crops (12.95 %) and fruit trees (87.05 %), of which citrus and coffee were in equal proportion. The AHP method recommended doubling off-farm work, increasing employment by 40 percent per year, reducing loans from the BAAC by 16 percent and halving the net annual revenue from crop production when compared with the equal weight method. It also gave higher goal achievement rates with a narrower spread.

The researcher selected the annual equivalent value as the main economic objective to trade-off with the three goals from the environmental objective. The goals were the expenditure on pesticides, nitrogen use and soil erosion. The results showed that if there is a reduction to a certain degree in some environment, the expenditure on pesticides, nitrogen use and soil erosion, it would not have a large effect on the annual equivalent value. This conformed to a study of Senthikumar et al. (2011). Some sacrifice of economic objective will much improve several environmental objectives. To reduce

expenditure on pesticide and nitrogen will decrease production costs and make farming more environmentally friendly and not much have an effect on farmers' income. However, if there is a large reduction in these environmental goals by over 40 per cent, it will have a serious negative effect on the annual equivalent value. In the same line, if nitrogen use, soil erosion and the expenditure on pesticides will be reduced up to 30 per cent, it will not have a serious effect on employment in the watershed although a larger reduction would lead to a sharp decline in employment. A high degree of trade-off is found between employment and revenue variance. A small decrease in employment will have a serious negative effect on revenue variance. If we want to have better achievement rates for the environmental and social objectives, it would be necessary to allow for some decrease in the level of achievement rates for the economic objective. Nevertheless, these results were obtained based on assumption of proportionality in the MGLP model. In the case of strong violation of proportionality assumption, a major modification of the models is needed.

14.1.3 Comparison results at the farm and watershed levels

1. Comparing the goal achievement rate between the farm using chemicals and chemicals and bioextract

The goal achievement rate for both the small and the large farms using chemicals and bioextract gave better results than that of the farm using chemicals from both small and large farms. The farm using chemicals and bioextract gave a higher rate of achieved goals in both the equal weight and AHP methods. The results indicated that if the crop production is increased, bioextract substitution will increase the goal achievement rate and results in more balance between the economic, social and environmental objectives. Agricultural production with reduced chemical use is possible if a decrease in chemical use can be compensated by an increase in bioextract which will have a positive impact both on the environment and the farmers' health. The government should promote the increased use of bioextracts and organic matter, training for the farmers, intensive low

interest rate of loan for farmers who shift from chemicals used to bioextracts or organic matter and increase in substitution research in the bioextracts and organic matter.

2. Comparing the goal achievement rate between the watershed level and the extrapolated results from the farm-level

The extrapolated results from the farm level had 7 goals and the watershed level results had 8 goals. This was a divergence between the stakeholder objectives as at the farm level, the farmers give priority to the economic objective than the social and environmental while at the watershed level, the stakeholders keep priority usually in the environmental objective. This study will compare the results to show the differences, and suggest the best optimal resource management for the Fang watershed. The indicators determined that the goal farm and watershed level are differed which according the studied by Lu (2005) and López-Ridaura et al. (2005a). The stakeholder can set the different indicators at the same scale or set the indicators for other scales of analysis.

The results showed that the watershed level results by AHP method gave the best goal achievement rates when compared with the other analyses. This was a close spread (23%) between the highest (69%) and the lowest goal achievement rate (46%). These results give the best optimal resources management at the watershed level as they give more balance between the economic, social and environmental objectives. This means that the set of system properties and the weight value by the participating stakeholders gave optimal resources management for the Fang watershed.

For the watershed level results the extrapolated results from the equal weight and AHP methods gave similar results. There had high goal achievement rates for the economic and social objectives. There was higher goal achievement rate for the analysis at the watershed level than the extrapolated results from the equal weight and AHP method. Nevertheless, there was some difficulty in this study to compare the sustainability at the farm and watershed level.

3. Trade-off between the farm and watershed levels

The extrapolated results and the MGLP analysis at the watershed level using the equal weight method nevertheless gave similar results, which recommended a high level of fruit trees. The extrapolated results to the watershed level recommended increased land use for fruit trees such as coffee, tea, lychee and longan. When comparing the AHP method results from the MGLP analysis at the watershed level with an extrapolated-to-watershed level, it was found that the watershed level analysis recommended an optimal land use plan being all planted in fruit trees (68.38 %) and forest (29.76 %), while the extrapolated farm level analysis recommended an optimal land use composed of mixed fruit trees (58% of total land use) and annual crops (42% of total land use).

It can be seen that optimal resource use results in vastly different patterns of land use in the watershed depending on whose points of views are being considered. Farm-level models as contrast to the watershed model are reflected in differences in objectives and their relative importance. If farmers are making decisions as they are more concerned about economic income, employment as compared to environmental objectives. If Fang watershed is managed and optimized with more priority to environmental objectives as against economic and social ones, we will see that it should be left largely as forests with some small proportion in fruit trees. Even in such situation, the fruit trees that should be planted in Fang watershed should be those friendly to the environment than citrus e.g. coffee, tea or lychee. Nevertheless, one cannot ignore reality in the field as farmers are the ones who make decisions on land use. Their objectives and interests should also be recognized and some balance between economic and environmental objectives should be met. 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 economic, social and environmental objectives can be more balanced.

Trade- offs between decisions made at the farm level and those made at the watershed level show clearly the dilemma of land use between economic objectives and

environmental objectives. Farmers would like to have more citrus farming in the watershed while the authorities would like to turn the watershed into more environmentally friendly tree crops such as tea, coffee, mixed fruit trees and forests. The model results can be used as a basis for dialogue among different groups of stakeholders. As citrus production becomes quite volatile with more marked environmental consequences and instability in market demand, alternative crops will become more attractive to farmers. Farmers are more aware of these consequences as time passes and they also look for good alternatives to citrus farming. Watershed land use planning should be done with the participation of the farmers. The model results will be a good basis for discussions among stakeholders in such a forum.

With the platform of *IMGP-LPlan*, modification of models can be made and the program can be made interactive with users. This study has shown that optimal watershed land use patterns depend heavily on relative weights given to different goals. Users can discuss weights of goals and can conceivably come up with an optimal watershed land use plan that can satisfy each group of stakeholders. This implies a sacrifice of one or more of particular goals to obtain better achievement of other goals. When the rates of trade-offs are not too high, there is a possibility that different parties can agree to finally come up with an acceptable optimal land use for the watershed.

14.1.4 Sensitivity analyses

This study evaluated 4 situations from the farm and the watershed levels. All the farm level, an increase in the wage, an increase in the hired labor constraint, an increase in the weight value of the annual equivalent value goal and a decrease in the goal level of off-farm work (GS), at the watershed level, a decrease in the goal of the dependence on external inputs (GI) and an increase in the goal of revenue from non-timber forest products (GF) was examined. All the sensitivity analyses results found that the goal achievement rate for both the farm and the watershed levels varied slightly from the base results.

14.2 Usefulness of this study

The study used system analyses which gave results showing that the optimal resource management was different between farm types and between the farm and watershed levels. Between farm types, the large farms had an advantage over the small farms as they had large land holdings, access to many sources of loans and could borrow large amounts of capital, get a higher price from crop production and higher obtain a revenue. There is need to improve competitiveness for the small farms e.g. establishment of groups and net work of small farms. Small farmers will have a potential to promote and develop sustainable agriculture throughout, learning and gaining mutual support from net working. The results of farm-level analysis point also a need to pay more attention to the use of bioextract as the farms using obioextract were those recommended to citrus area from irrigated upland to irrigated lowland and/or reduce citrus planting area. Deviations of existing land use from the optimal land use should be highlighted and discussed as the optimal land use recommendations take care of multiple objective especially social and environmental ones.

The optimal resource management results are different at the farm and the watershed levels because of the differences in the objectives of the stakeholders. The results 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. 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 and land use zoning.

The trade-off analysis results at the farm and the watershed levels 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. These results should be a need to promotion increase the use of bioextract and organic matter which decrease chemicals use. This was conducted with an increase in subsidy for a research fund into bioextract and organic matter.

14.3 Recommendations

14.3.1 Towards a secure and sustainable livelihood

The development for a secure and sustainable livelihood for the farmers in the Fang watershed would require establishing groups and networks, and land use planning.

1. Establishing groups and networks

- 1.1 The study recommended establishing groups and networks for the small farms. This would strengthen the farmers' position through the potential to promote and develop sustainable agriculture throughout the groups, learning, and gaining mutual support from each other as well as building strong networks between the groups and communities. The groups could benefit by reducing costs through volume purchasing, and negotiating marketing within the groups or networks. This could result in large savings, as well as having the potential to obtain low interest loans for the membership.

- 1.2 To succeed as integrated groups and networks, the government must support the development of the small farms and the local authorities who have the ability to influence local affairs. The authorities need to adjust their current perception before they start to promote and develop new processes. New ideas will come from participation between the farmers and the authorities and should result in the farmers being able to apply new ideas and methods by themselves. The authorities need to organize process-oriented speakers to promote the farmer participation, which will lead to development as well as

being a mentor to the established groups, organizations and networks. If these groups are interdependent on each other, this will result in strong communities.

2. Participatory planning of land use

2.1 Participatory land use planning processes

By using the equal weight and the AHP methods, there are clear results to show the optimal resource management at both the farm and the watershed levels with the four sensitivities and the trade-off analyses. If the farmers and stakeholders use these results, they can be used to encourage plans which have been developed with the participatory land use planning processes. These can be integrated into a broader spatial information system such as the specialist site developed by Onpraphai et al. (2011) for land use and water management in the Fang watershed.

2.2 Participatory land use zoning

There needs to be a promotion of agricultural land use zoning for upstream areas by all the participatory stakeholders to protect the forest, but still allow for environmentally friendly crops such as tea, coffee, lychee or longan. Citrus production could be accommodated as shown by the study of Onpraphai et al. (2011). The zoning area should be registered with GIS so that changes in the land use over time can be easily seen which will supply important details about land use change. There will be a strong potential for the use of data from satellites for monitoring compliance with actual zoning plans. After determining land use zoning plans, the following monitoring system could be used:

i Monitoring systems

The communities should have established village committees to monitor and determine penalties for offenders such as withdrawing access to

village loans etc. The TAOs (Tambon Administrative Organisation) would be responsible for training, and provide subsidies to village committees for monitoring. This would bring agreed boundaries into a spatial information system that could be used remotely to monitor compliance using mutually acceptable indicators, and making the results available in a timely manner to the full range of stakeholders which could effectively address the failures which have happened in the past.

There needs to be a multi-level management organization to monitor land use zoning in the Fang watershed. A system for participatory stakeholders to monitor local land use zoning does exist already, but there could be further expansion of this type of activity.

ii Institutional framework

One problem is if the land use zoning plan for all the stakeholders is accepted but there is still no legal means for official recognition. This must be amended 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.

iii Funding

The TOAs would allocate budget at least 1 percent of the total funds received each year to be used for the monitoring of land use zoning plans, including the organizations which have clear mandates to work with natural resources and environmental issues.

2.3 Positive impact on the environment

The trade-off analyses results show that if the farm and the watershed levels reduce external inputs by 30 percent and nitrogen use by 40 percent, it will have a small negative effect on the annual equivalent value. If these reductions could be met, it would have a positive impact on the environment. How can we do that without reducing the farmers' revenue? The study recommends the following;

- The government should promote the increased use of bioextracts and organic matter to substitute for chemical use. There needs to be training for the farmers through the groups and networks. These processes need support and funding from the relevant organizations i.e. TAOs, local agricultural offices and educational institutes.
- There needs to be an awareness of the need for blood checking among farmers. This will give them a deeper understanding of the dangers of chemical use and demonstrate that it can prove harmful to them.
- There needs to be an increase in the subsidies for research into the benefits of bioextract and organic matter by using educational institutions, supported by the Department of Agriculture.

14.3.2 For further study

This study shows a way to more effectively deal with the optimal resource management, especially by participatory stakeholder land use planning. The study can help natural resource policy makers and managers to deal more effectively with environmental, social and economic conflicts. Its usefulness will depend on the level of the stakeholder interest and willingness to accept diversity, as well as how it views the relationship between particular forms of diversity and broader socio-economic equity. Overall, this study supports the basis for the researcher's belief that these notions could have a positive effect in the Fang watershed.

As previously mentioned, there is clearly much further work to be done by many agencies involved in natural resource policy, governance and management processes to improve the strength of this analysis. This would involve transparency and clarity of their logic and conclusions, and their ability to communicate and negotiate with other stakeholders, at least some of whom are likely to have quite different ideas. With sufficient goodwill, openness and sincerity, the researcher believe that the results of this study have a strong potential to help manage participatory land use planning, increase independent from external inputs and have a positive impact on the environment. This will secure a sustainable livelihood in the Fang watershed through the means that were described above.

Further study will be needed using GIS to classify the problems of land use, and to promote the results of the optimal land use management that would be suitable for the soil groups and soil series in the Fang watershed.

In addition, it should have need for water requirement of plants together with an analysis of optimal resource management. This will get a plan for correct resources exploitation; particularly on land use for cultivation which is consistent with an amount of existing water in the Fang watershed during the dry season.

Regarding the weight value of goals, it should have the value adaptation which is consistent with changes in economy, society and environment. Needs of stakeholder or data user should be indentified for the Fang watershed resource management planning.