CHAPTER 7

CONCLUSIONS AND RECOMMEDATIONS

7.1 Conclusions

Assessment of spatial land use change was conducted in 3 villages namely: Phonsavang, Sanghai and Thinchaleon village of Pak Ou district, Luang Prabang province, Lao PDR which have the objectives to assess the spatial land use change pattern in the last two decades from 1990 to 2010 and to determine factors affecting on land use change and their effects on farmers' livelihoods of the study area.

The use of Landsat5 TM data to detect land use changes has been generally a success and the digital image classification accompany with GIS has demonstrated its ability to provide comprehensive information on the direction, nature, rate and location of land use changes as a result showed on the map. The integration of satellite remote sensing and GIS provides a means of moving the emphasis of land use change studies from patterns to processes. The most compelling research issues may be a lack of appreciation of the power of the integration and understanding of how to incorporate existing knowledge in useful for land use change assessment.

Based on information of local inhabitants, land use types can be categorized into 7 classes for the date 1990 and 9 classes for the date 2010 image. The land use map for 1990 and 2010 were produced from Landsat5 TM images that acquired on 15th January 1990 and on 7th February 2010. Land use classification accuracy assessment found that in 1990 was determined to be 89.96% and 84.38 % for 2010, the kappa indices 0.88% and 0.83% for 1990 and 2010 respectively. Overall of the

user's and producer's accuracies of individual classes were high, ranging between 73.68% and 100% for 1990 and 77.77% and 100% for 2010. The accuracy is therefore sufficient for evaluation of land use classification. Although the land use change classification has a reasonably high overall accuracy, the accuracy of different classes varies. Mixed deciduous forest class can be mistaken as several other classes due to their diversity.

Land use change transition matrix of the study area during the last 2 decades found that water bodies, deciduous forest, lowland field, urban area, teak plantation and mixed fruit orchard were increased while mixed deciduous forest, fallow and upland field were decreased for the last 20 period.

Deciduous forest occupied 1,138.28 ha in 1990 with a positive change of 46.16 ha or 4.06% of the total area. The increasing area lowland rice may due to the government's policy in shifting cultivation stabilization and poverty elimination, lowland field occupied 57.02 ha in 1990, increased to 92.77 ha in 2010 with a positive change 35.75 ha constituted a 62.70% during the period. Lowland rice fields have been found to be almost double those of upland rice and the cost of converting sloping lands into rice terraces can be recouped in a few years for rice cultivation as lowland field to diversify production and generate income. So reducing the area under shifting cultivation. Lowland rice can play an important role in improving livelihoods for farmers, helping to satisfy basic food needs while also protecting natural resources and the environment.

Urban area has also been rapidly expanded as commercial zone. The change in urban area has impact in negative and positive way as many of the local people

were changed their livelihood activities due to fear of their land taken by the local government for expansion of industrial factories. This further forced aggravated the farmers to sell part or their entire farm land to land seeker and land speculator. But still some of the local people were doing some activities such as crops production and husbandry for the local supply. Urban area was also increased; in 1990 it just occupied only 14.25 ha to 62.64 ha in 2010 with highly positive change of 48.40 ha (339.89% increase), many factories emerged and create new job for local people, industrial sector contribute substantially to employment and income generation activities as non farm income for people and has helped the district achieve a a higher economic development.

As a result, teak plantation has to be intensified on a reduced area of shifting cultivation. Teak plantation and mixed fruit orchard were considered as severe changes during the last 2 decades, these 2 types of land use did not existing in 1990. The change of teak plantation in 2010 occupied 514.69 ha, mixed fruit orchard occupied 111.03 ha or 100% increased from 1990. Large scale teak planting is attractive farmers due to immense economic benefits from this timber (US $300 per cubic meter and 900 trees can be harvested from one hectare area) and assertion of a stronger claim for long term use of lands not only for the economic gain, there is also a socially pragmatic reason behind the increase of teak plantation.

Since 1993, the fruit tree such as lemon has been introduced to the study area, mixed fruit orchard system has clearly emerged as one of the most promising interventions for upland farmers in northern Laos as economic corridors, post-harvest processing facilities and marketing opportunities, this system may become even more

attractive and profitable alternatives for upland farmers as a means of decreasing slash-and-burn agriculture. Fruit tree cultivation is often promoted as being one of the most sustainable and viable alternatives to slash-and-burn agriculture.

On the other hand, mixed deciduous forest, fallow and upland field area showed negative change. They were decreased and converted to other types of land use in 2010. Mixed deciduous forest occupied 1,518.75 ha constituted 46.45%, in 2010 occupied only 976.40 ha (29.86%) with negative change of 542.35 ha (35.71% decrease). Fallow in 1990 covered 200.09 ha or 6.12% of the total area, decreased 100.53 ha or 50.24% reduction from 1990 and remain 99.56 ha in 2010 (3.40% decrease). Upland field in 1990 occupied 300.30 ha (9.18%) of the total area, in 2010 remain 170.72 ha (5.22%) with a negative change of 129.58 ha (43.15% decrease).

The land use change has resulted in the transition of a subsistence based economy to a market economy; the traditional upland rice-based system has been replaced by teak plantation and mixed fruit orchard based system. It caused by policy interventions in addition to socio-economic change. The changes in government policies and planning related to land tenure, forestry, swidden agriculture and taxation that have stimulated the expansion of teak plantation and mixed fruit orchard in this area. It can be concluded that upland field in the last 2 decades has been reduced by half. The reduction of upland field is due to the government of the Lao PDR's policy to eliminate the cultivation of upland rice by means of "slash-and-burn" cultivation and to replace it with more ecologically stable systems based on sustainable land use at the village and household level.

The results of spatial analysis using logistic regression found that 5 variables have relationship to the land use change, but the most significance of spatial factors are slope and distance from urban area have influence and higher relationship to the change. It can be concluded that higher or steepest slope has less tendency to be changed in land use and has no cultivation plot while lower slope or flat land has higher tendency to be changed and converted to agriculture. Land closer to urban area has also a higher probability of change.

Logistic regression analysis of socio-economic factors showed that among 12 independent variables in the model, 5 variables are found statistically significant. The most important variables influencing land use change is LSH (Land Size Holding) and OL (Ownership of Livestock). The model indicates that farmers who have more land is less likely to trickle land use change while farmers who have less of land parcel tend to open and expand more new land and farmers who have fewer number of livestock as their family property and source of income will be more likely to go to open the new land for crops production.

Other 3 variables is FL (Family Labor), ETH (Ethnicity) and NFIC (Non-Farm Income) are also influencing to land use change. It indicates that farmers who have less family labors tend to open and clear more land such as expand more parcel of upland and lowland fields for sufficient food consumption larger size of family labor does not automatically lead to them clearing more land. Khmu people have less likelihood than Lao people to clear some of their lands in new village and farmers who have less non farm income will go to open and expand new land for industrial and cash crops production to earn more income from their farm land.

On the other hand, 7 variables such as HHA (Head of Household Age), ED_1 (Secondary School), ED_2 (High School), ED_3 (Vocational or University), HHS (Household Size) OFIC (On Farm Income) and RYP (Rice Yield Production) have no relationship and no affect to the land use change.

The changes of land use of the study area also related due to many causes of the local farmers converted some of those land use types to fish ponds for aquaculture and small dam for crops production, the need of permanent agricultural production to increase productivity of agricultural production for commercial and market orientation increasing population and the need of sufficient rice for home consumption and residential for living.

The causes of implementation of the government policy on shifting cultivation stabilization, policy on relocation and resettlement of upland small villages merged to cluster village development, effected from forest and land allocation since 1990 to 1995 to strengthening of forest recovers and also falls within teak plantation boom era of 1993 to 1997 and this attracted a lot of people to the area thus contributing to the physical expansion of teak plantation area for long term benefits as evident in its increased, emerging of small and medium industrial factories such as baked clay, metal, tobacco, tile oxygen and drinking water factory were installed in the study area.

7.2 Recommendations

Based on the findings of this study, the author would like to forward the following suggestions to mitigate land use change and its negative consequences on the sustainability in land use including implication of the government's policy

interventions, the application of GIS and remote sensing, logistic regression analysis and several lessons have been learned and suggest as follows:

7.2.1 Policy recommendations

The outcome revealed that the study area faces some drastic land use changes which seem to be maintained in the future due to permanent anthropogenic activities. Finding a means for better management of natural resources is relevant. Local government and institutions concerned need to organize and implement future land use planning and decision support system will be transferred to local authorities and stakeholders for decision making for sustainable local land resources management more effectively. Therefore, the following suggestions and measures are importance:

1. Based on the research findings which revealed the changes and situations of the study area, the local government should design and determine of regulations and laws to control certain land use such as the expansion of cultivation plots on higher slope and elevation. This area should be conserved and protected to enable forest recovery especially in deciduous and mixed deciduous forest.

2. There should be a plan of allocating and zoning the state lands for small and medium industrial factories and an integration of different plans for environmental, infrastructure and service provision to make land use management effective.

3. The District Agriculture and Forestry Office (DAFO) and the Livestock Department should work closely and encourage farmers in animal husbandry, so that suitable zone for livestock and alternative livestock management

systems be implemented. This will also increase the productivity of livestock and increase more income of farmers.

4. The government and private sector should provide the opportunities and encouragement local labor use and farmers who have less land and cultivable plot to work in industrial factories to increase farmers' non-farm income. This can reduce shifting cultivation in this area.

5. There should be enabling mechanisms for formal accessing of land for low and middle income people who usually access land through the informal channels. The sub district administration and district land authority should establish partnership among different actors involved in land transaction and management to find a possible way of managing land in the most possible efficient way.

6. The government policies should be clear and effective with necessary institutional set up to guide for the sustainable land use of the study area and monitor the proper implementation of the land use plan.

7. There should be participatory land use management which involves all actors to minimize the negative consequences of rapid and uncontrolled land use change which affects the socio-economic and environmental sustainability of the study area. Delineating the village boundaries is a crucial issue to improve future "inter-district or inter village" partnership and development in order to avoid conflicts among neighborhood villages in land use.

8. Improve productivity of shifting cultivation by adopting selected planning fast growing trees and valuable crops combined with intensive agriculture, encourage farmers to practice fallow, crops rotation and trees plantation mainly fruit

orchard and cash crops for sustainable land use and preserving land cover for future generations.

9. Finally, the District Administrative Bureau (DAB), provincial or national level should have clear and consistent policies and directives towards legalization already existing informal settlements and put in place possible and effective controlling mechanism to prevent or minimize further informal land transaction.

7.2.2 Recommendations for further study

The following suggestions below will be useful and appreciated for the new research topics. The author would like to suggest as follows!

1. The application of remote sensing and GIS was found helpful in quantifying past and present land use change so that appropriate planning could be made for the future. It is therefore hoped that future activities will highlight land use change in better manner than the present study. Future research should make use of high resolution satellite image for distinguishing of dry season crops and also improve classification results as well.

2. To overcome the weakness of logistical regression modeling in dealing with temporal dynamics, further research will have to seek a self-modifying approach so that the model variables can update themselves automatically.

3. The model considered only land use change from 1990 to 2010. Logistic regression functions were subsequently based on this change datasets. Further investigation should use another models and results could be compared

dynamically with this model used. It is possible to predict the changes of land use in future trend.

4. Remote sensing data for this research was enough to identify land use change. However, socio-economic data was not adequate for time series data. Further investigation may concentrate on long term demographic and socio-economic data collection and analysis in large samples.