4. RESULTS AND DISCUSSION

4.1 The Communities

The study area covers the area of four villages in Watchan subdistrict namely Watchan, Den, Nong Jed Nuai and Huai Bong. It has a monsoonal climate, with a rainy season beginning in May or June and lasting until October or November. The period of December to January is cool season which has almost no rain. The summer season begins in mid-February and lasts until the rains start in May or June. The annual rainfall measured in 1993-94 was about 1,170 mm (Jintrawet et al., 1994).

The communities in Watchan have been settled down for more than 100 years. Total population of four villages were 1,495 people in 263 households. The average household size was 5.68 (Table 4.1). The people in this area were Karen whose religions were Christian and Buddhism. The education among the young Karen generation in watchan community was relatively good. There were a government primary school, a local private-run secondary school and a secondary school which was supported by missionary in Nong Jed Nuai (Ekasingh et al., 1995).

Table 4.1 Population in Watchan, 1993.

Village	Total population	No. of household
Chan	441	81
Den	428	72
Nong Jed Nuai	443	76
Huai Bong	183	34
Total	1,495	263

The landscape in Watchan was dominated by hill evergreen mixed with pine forest. The pine forest and dry dipterocarp mixed with pine forest covered about 30% of the study area. Farmers in the community cultivated paddy rice in the valleys along the streams and practiced shifting cultivation which was mainly for upland rice production. There were several rice varieties that farmers used to cultivate in the study area, all were local varieties. Farmers selected the rice varieties that suit to particular cultivated areas. For instance, *Por Moh* variety which was slightly sticky, short growing period and could be grown in non water logging area, was cultivated in the higher or supra-paddy area. *Pi I* and *Poh Loh* were late varieties which required more water and would be grown in a lower paddy or the area that was easily accessible to water.

Farmers maintained local rice varieties for both paddy and upland rice. Some varieties were introduced by neighbors or relatives who had visited to other places and brought back the promising rice varieties such as *Lisu*. According to the key informants, there was no new variety introduced by any government agency in the study area.

Almost every farm household occupied upland rice fields and practiced shifting cultivation. The farmers used to leave the upland field fallowed after harvesting for the period of 10 to 15 years to replenish soil fertility before re-cultivated the same patch again. However, informal survey with key informants indicated that farmers had shortened the fallow period in recent years.

The Royal Project played the active role in introducing new cash crops to farmers in Watchan. These new cash crops were temperate vegetable such as lettuce, carrots, red cabbage as well as some exotic flowers like gladiolus and statis. The project provided knowledge, training, seed and fertilizer to the farmers who joined the program. However, there were limited number of farmers who could participate with the Royal Project due to the quota system to control the production.

Beyond the agricultural activities, farmers in the study area gained extra income from labor waging such as farm waging, construction, and working with the Royal Project as local staff.

All of the farmers who responded to the informal interview indicated that rice deficiency had occurred every year. This depended on rain and/or water availability, rice area owned, diseases and damage done by animals. Farmers coped with this situation by borrowing from neighbors or relatives, supplemented their diets with taro, maize, pumpkin, yam, and wild nut (*Kor*), apart from earning cash from labor waging, and gathering forest products.

4.2 Household Labor, Land Holding, and Farm Practice

The survey carried out under this study revealed the average household size of 6.6 persons with the labor force of about 4 persons per household. There were 12 respondents who cultivated and shared rice product with their relatives. This was described by Shinawatra *et al.* (1994) who found that it was common for Karen family to extend with more than two generations in the same household.

Ninety-five percent of respondents owned paddy fields with the average size of 4.13 rai (0.66 ha) (Figure 4.1). Sixteen percent of paddy lands were under rainfed condition while the rests were traditionally irrigated.

Forty-four out of 95 respondents owned upland rice area and 33 out of those owned both upland rice and paddy rice fields. Upland rice holding size ranged from 1 to 65 rai with the average size of 12.85 rai (2.06 ha) per household. Generally, upland rice fields occupied by each household was not the single patch but scattered in many locations. Number of upland rice plots per household ranged from one to ten plots with the average number of 3.2 plots. Upland rice areas cultivated in 1993 crop year was about one to six rai per household with the average size of 2.67 rai (0.43 ha) per household (Figure 4.2).

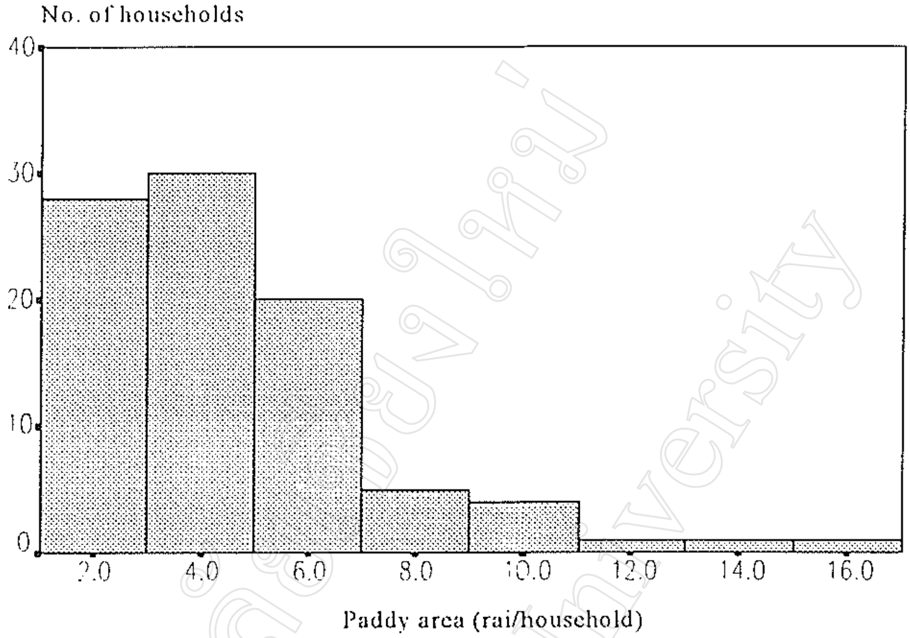

Figure 4.1 Paddy area owned by farmers in 1993.

The formal survey showed the fallow period was shortened to an average of 3.2 years. There was about 34% of respondents who had cultivated their upland area repeatedly in the same plot every year. The reasons for shortening fallow period were given by key informants as the increase in population which resulted in decreasing rice area holding size. It was also caused by the difficulty in expanding upland field due to the restriction of forest laws.

This was evidenced by the correlation between number of upland plots that the farmers occupied and the length of fallow period with the correlation coefficient (***r***) value of 0.80 (Figure 4.3).

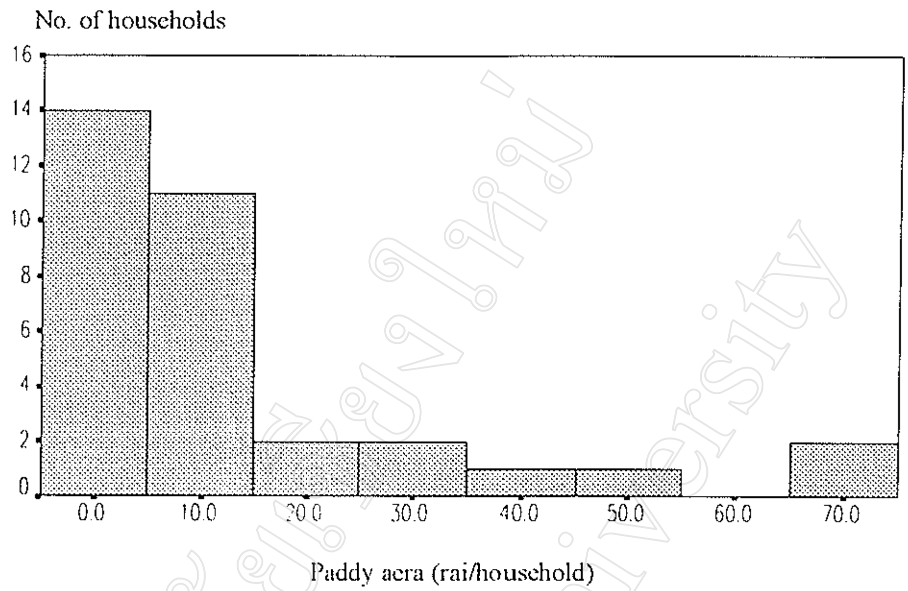

Figure 4.2 Upland rice area owned by farmers in 1993.

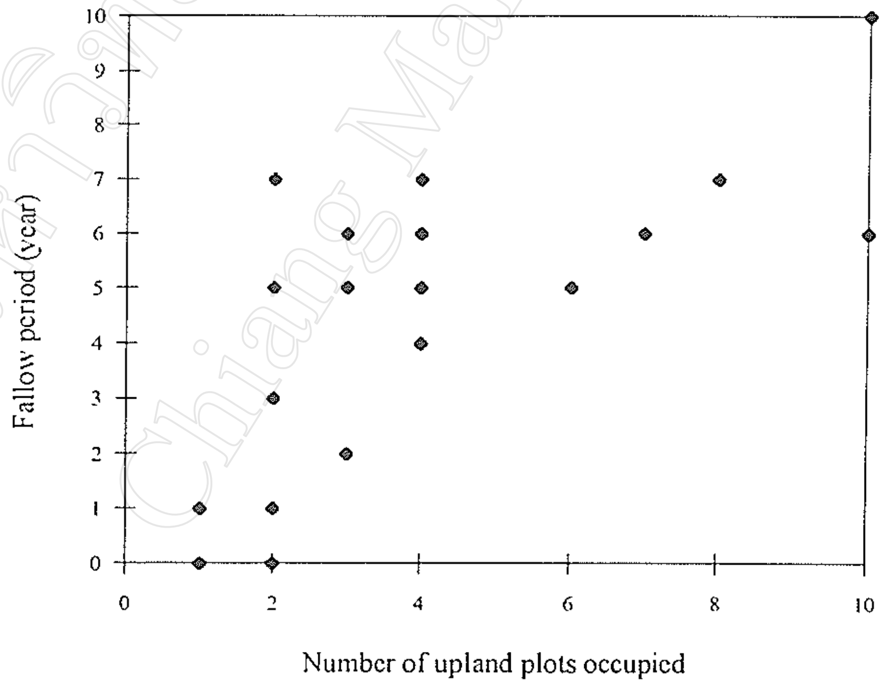

Figure 4.3 Correlation between number of upland rice plots owned by a farmer and the fallow period.

4.3 Land Use and Land Use Changes

4.3.1 Orthophoto Mosaics and Interpretable Characteristics of Land Use Types

4.3.1.1 Orthophotograph and Mosaicking

Each aerial photograph was scanned into a digital TIFF image file using a drum scanner. The result was one image file for each photo. Each raw aerial photograph image file was then geocoded to UTM map projection, so that it could be referenced to other aerial photographs when producing a photo mosaic. It was found that 40 GCPs could be collected from the ground survey, additional 13 GCPs were read from topographic map in the area where ground survey was not feasible. The group of GCPs were selected and applied to each aerial photograph image to cover over each photo (Figure 4.4).

Each of aerial photo image, after the orthophoto process (Figure 4.5), covered only a portion of the study area. It was necessary to mosaic each individual orthophoto to cover the entire study area. The example of orthophoto mosaics is shown in Figure 4.6, it illustrates the image which was derived from two adjacent aerial photographs number 8655 and 8656 taken in 1983.

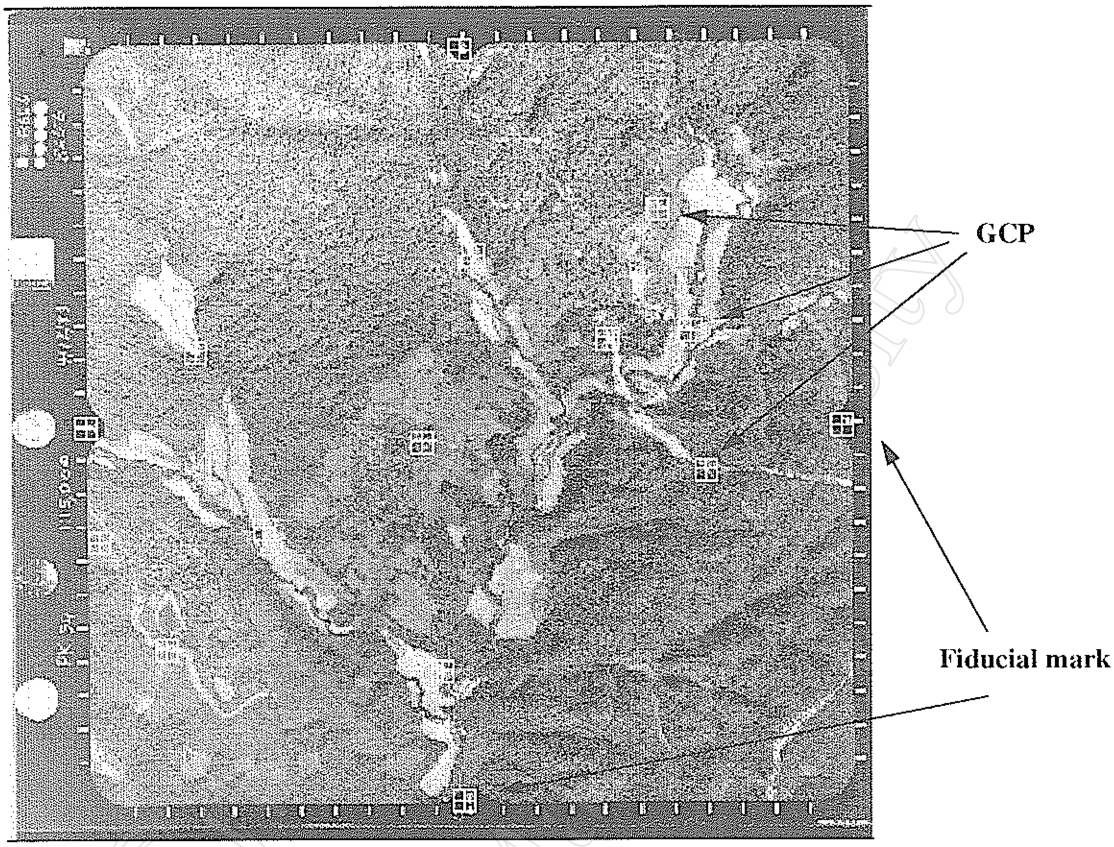

Figure 4.4 GCPs distribution over an original aerial photograph.

Orthophoto process removed all the tilt and relief displacement of each aerial photograph image and resulted in orthophoto image as shown in Figure 4.5. It was clearly seen that the features' positions on the orthophoto image were adjusted and different from the original photo image. This illustrates the usefulness and the need for creating orthophotos before masaicking aerial photo images, this is hardly achieved by the manual process (Figure 4.7).

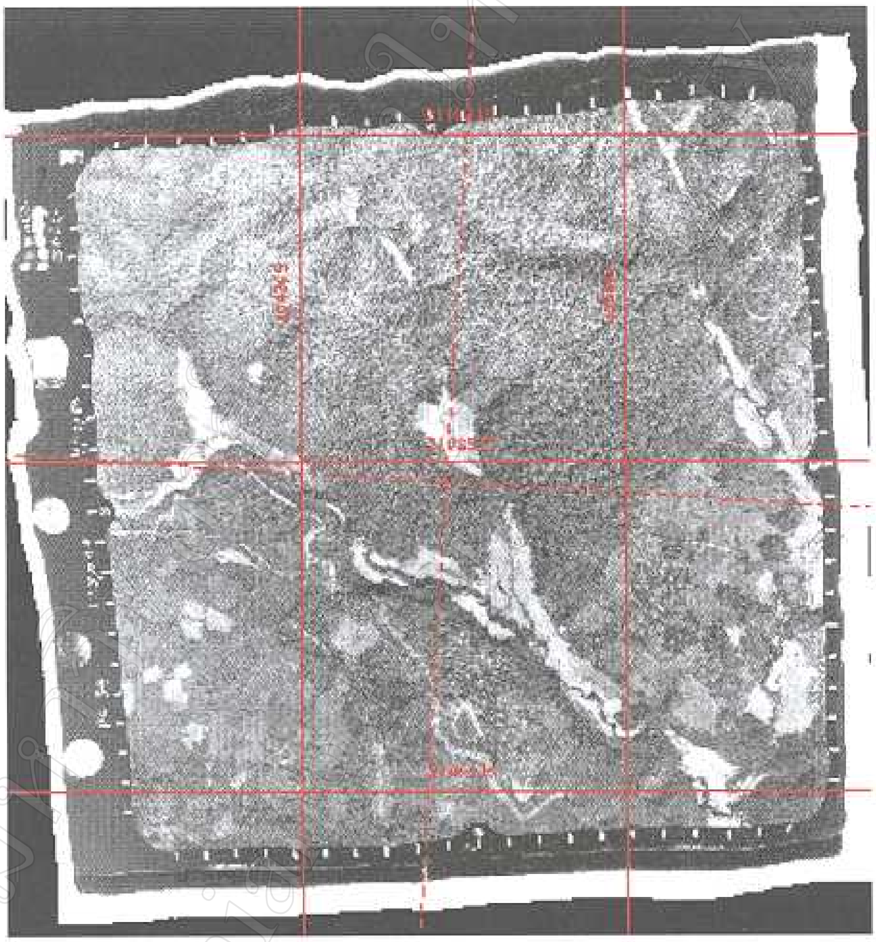

Figure 4.5 An orthophoto image.

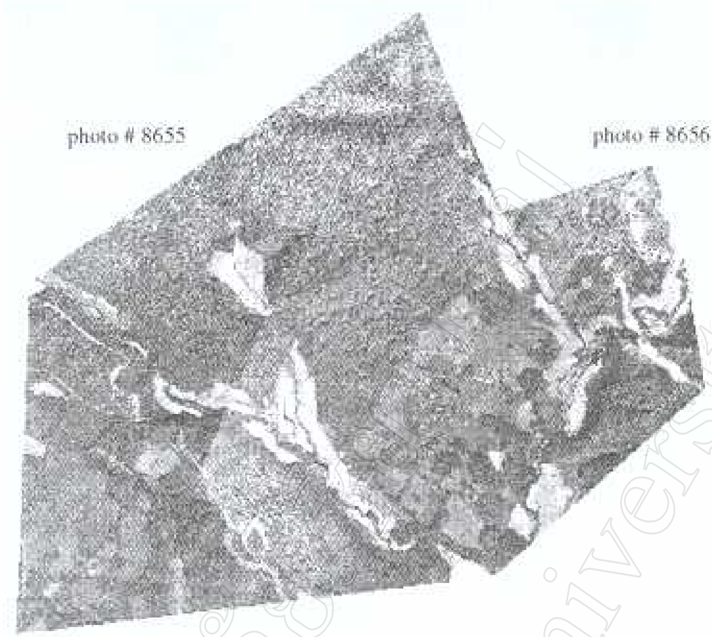

Figure 4.6 Orthophoto mosaic of two adjacent aerial photo images.

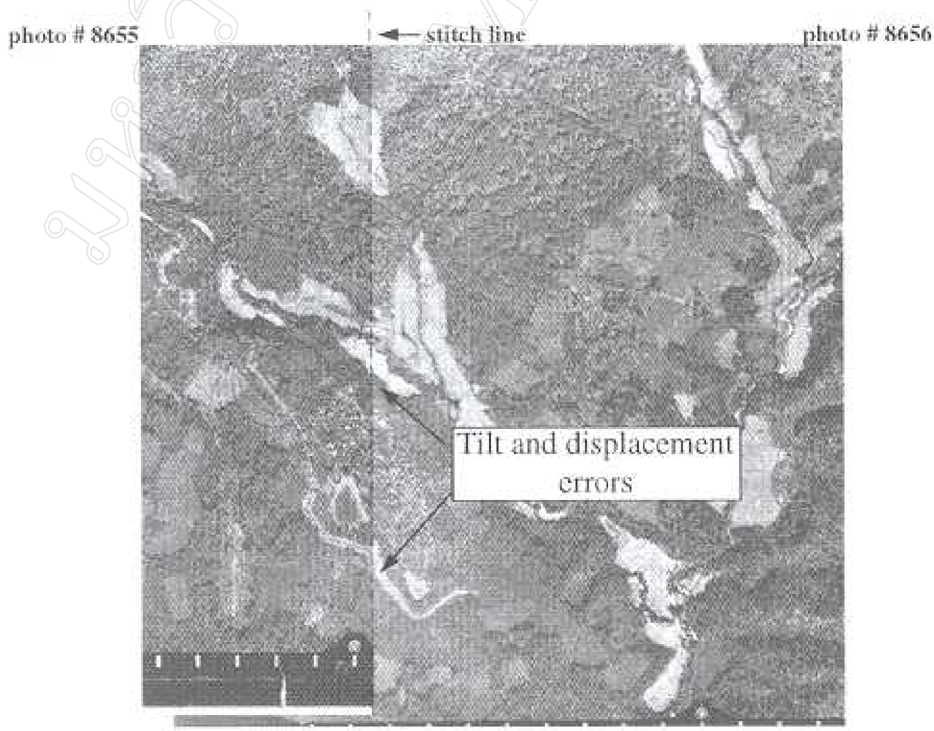

Figure 4.7 Manual photo mosaicking without orthophotograph.

Theoretically, orthophotograph can correct the aerial photograph image and provide the accurate result for the area within the given GCPs. The area beyond given GCPs still contained some errors. The GRID module in ARC/INFO was employed to clip out the area outside GCPs. Then mosaicking was done using MERGE command in the GRID to stitch orthophoto images together. The final orthophoto image of the entire study area in 1954 and 1983 are shown in Figure 4.8 and Figure 4.9.

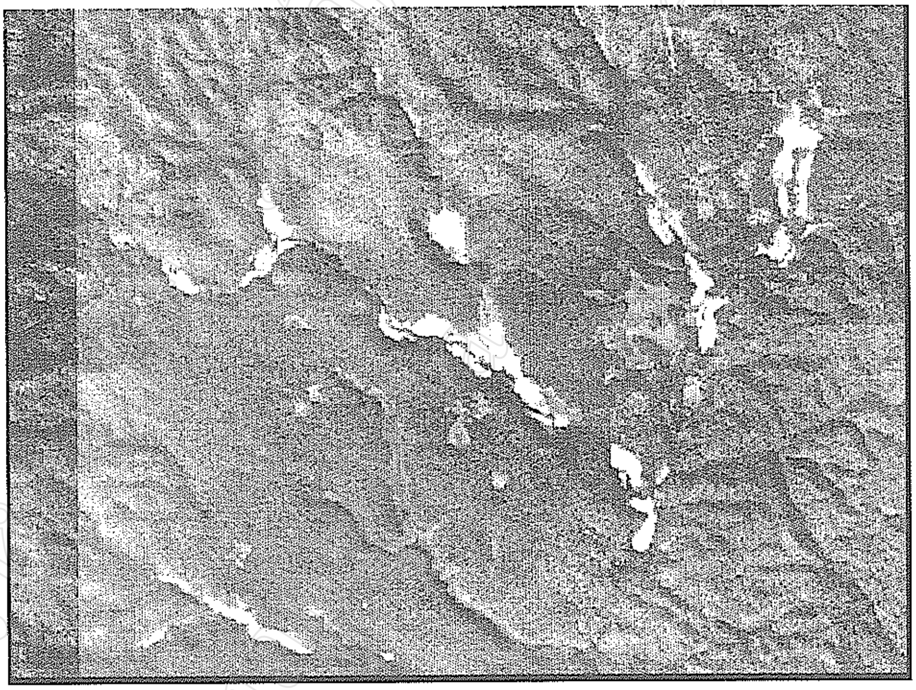

Figure 4.8 Orthophoto image of the study area in 1954.

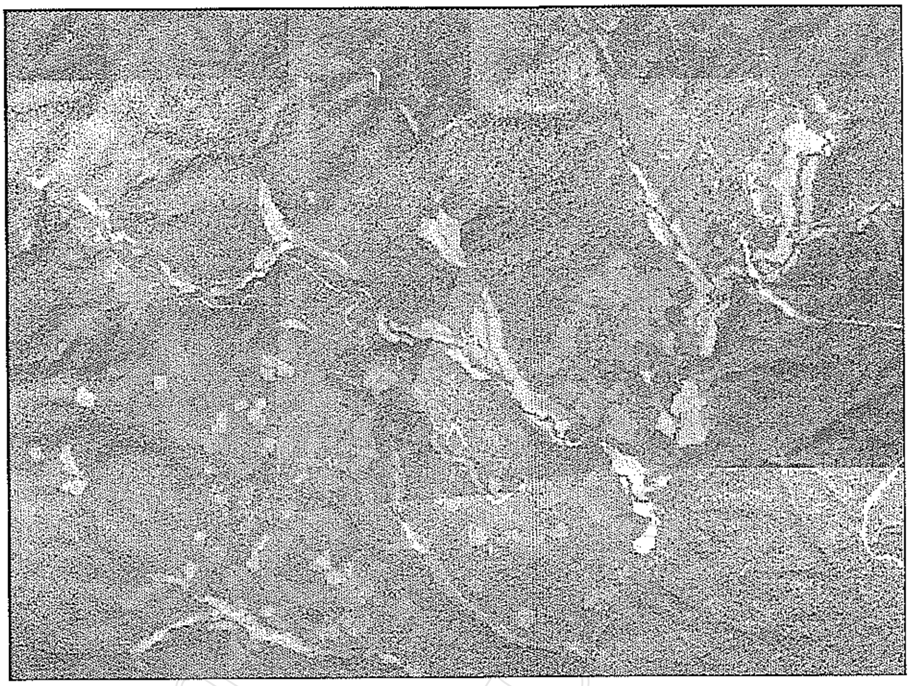

Figure 4.9 Orthophoto image of the study area in 1983.

4.3.1.2 Interpretable Characteristics of Land Use Types

Paddy rice could be distinguished on the orthophotos from the paddy bund pattern which were clearly seen when zoom into the image on the screen. Generally, the paddy fields in the rugged terrain area locates in the valley, along the stream. They also located at the lowest part of the landscape compared to other land uses. With the presence of the steep slope along the stream, the paddy field in the rugged terrain was hardly expanded towards the sloping land. This made paddy's shape become long and narrow.

Typically, upland crop cultivation that has been practiced by Karen people in this community was for staple food. Therefore, it was assumed that most of the upland fields interpreted from the aerial photographs and remote sensing data in study area were upland rice. The shape of upland field was not uniform, but depended on the size of ownership and the amount of labor used in slash and burn cultivation in that particular year. However, the upland field patches that were cultivated and harvested at time an aerial photograph was taken, were brighter or reflected more than the adjacent land use patches. Eventhough its reflectance was close to the paddy field, its patches had no bunds, and mostly located on the higher toposequence than the paddy. This association could be used in differentiating the upland field from the paddy field.

The bush fallow field had similar characteristics to the upland field, its boundary could be clearly recognized, showing smooth-grain texture on the photograph. However, its darker tone could be used to separate it from the upland field.

Different forest types were located on the similar toposequence as the upland fields. They appeared as darker tone (low reflectance) due to their high biomass and thick canopy. Furthermore, the texture shown on the aerial photograph were less smooth than the upland fields.

The building structures in the village and road network helped delineate the village compound from other land use types.

The thinness ratio, defined as $4\Pi A / P^2$ where A and P are area and perimeter, was calculated for paddy, upland field, bush fallow and forest areas. This ratio was used as an index to quantify the shape of spatial objects (Bonham-Carter, 1994). The results of the thinness ratio for land use types in 1954 and 1983 are illustrated in Table 4.2. This analysis did not include the land use data in 1994 because it was processed from Landsat TM data.

Table 4.2 The thinness ratio values of different land use patterns in 1954 and 1983.

Land use	1954		1983	
	Mean	S.D.	Mean	S.D.
Paddy	0.38	0.15	0.42	0.19
Upland field	0.51	0.23	0.68	0.15
Bush fallow	-	-	0.54	0.26
Forest	0.44	0.00	0.38	0.22

Paddy area possessed the lowest thinness ratio in both 1954 and 1983 except that of the forest in 1983. This was affected by the small number of forest patches (3 patches). One or two tiny fragmented forest patches could contributed to lowering the thinness mean. The upland field revealed the highest value of mean thinness ratio due to its regular blocky shape.

The digital number (DN) of orthophoto image was also analyzed to illustrate the brightness characteristic of each land use type. The results in Tables 4.3 clearly revealed the different DN value among land use types. The mean DN value of paddy rice was highest thus the brightest among other features in photo image. The descending order of mean DN values for other land use types were upland field, bush fallow and forest.

Table 4.3 The DN value of major land use types in 1983.

Land use	Mean	S.D.
Paddy	182.3	46.5
Upland field	172.8	37.0
Bush fallow	132.1	29.4
Forest	116.2	38.7

Entropy or diversity of DN value (equation 1) for each land use type were also investigated to determine their texture characteristics. This analysis employed the diversity value (Eastman, 1997) calculated from every 3 x 3 pixel window of each land use type in the orthophoto image in 1983. The histogram analysis was applied to provide the summary statistic. Table 4.4 shows the entropy (diversity) of the 4 major land use types.

Table 4.4 Entropy value of 4 major land use types in 1983.

Land use	Mean	S.D.
Paddy	1.34	0.65
Upland field	4.76	3.09
Bush fallow	1.61	0.63
Forest	1.95	0.69

Paddy and bush fallow revealed the low diversity values which referred to their smoother image texture comparing to other land use types. In general, the upland field should provide the similar figure but it gave the highest diversity value instead. This was influenced by its small patches, when the 3x3 pixels window was applied to calculate diversity, the DN value of the adjacent pixels contributed to the higher diversity value.

An example of orthophoto image and digitized land use features using on-screen digitizing is shown in Figure 4.10. Land use maps as the result of interpretation of the orthophoto images and on-screen digitizing in 1954 and 1983 and from image analysis of Landsat TM data in 1994 were save as ARC/INFO coverages and displayed in Figures 4.11, 4.12, and 4,13 using IDRISI software.

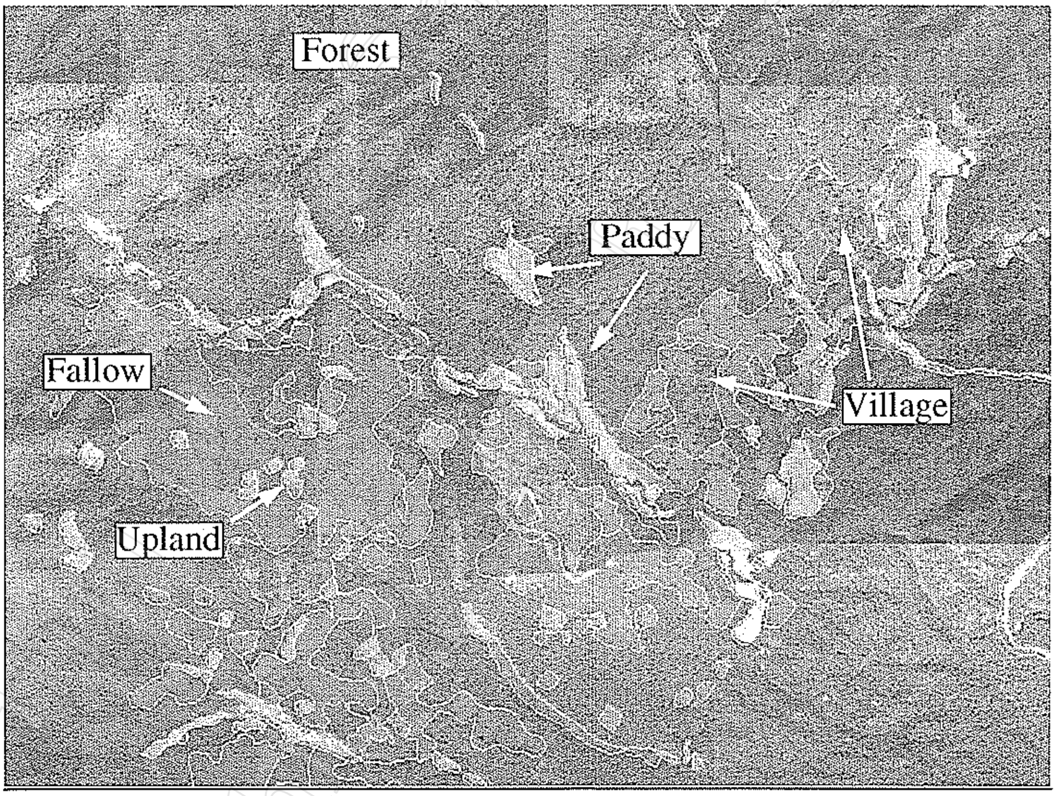

Figure 4.10 Orthophoto image and on-screen digitized features.

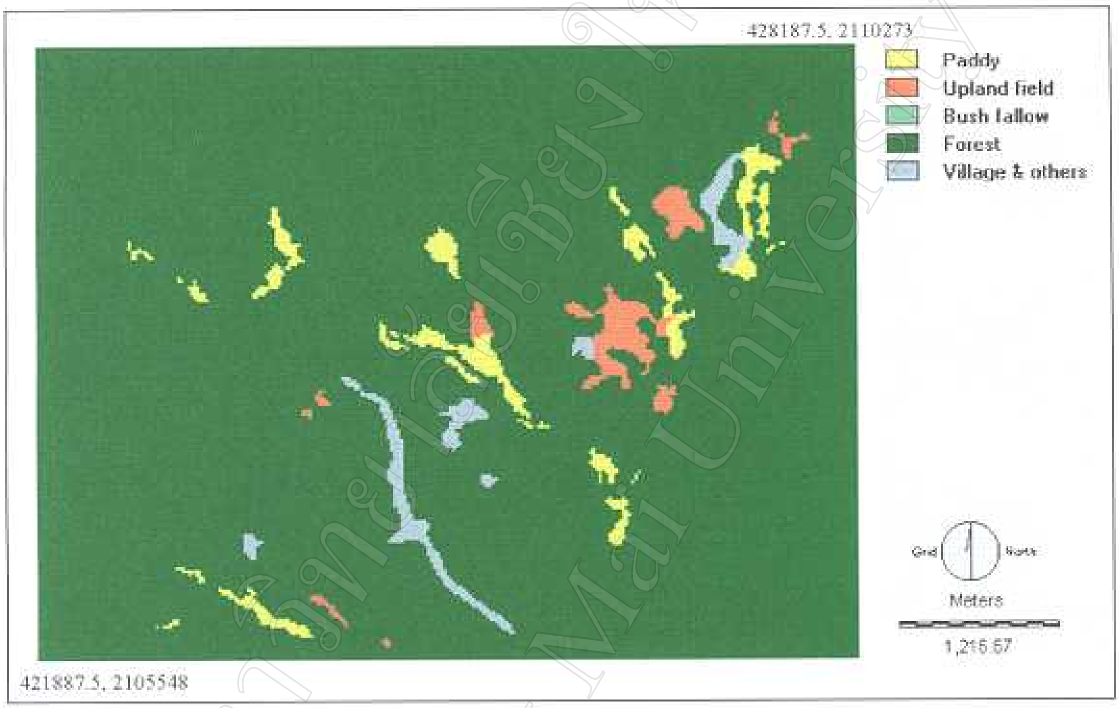

Figure 4.11 The land use map of Watchan in 1954 as classified from aerial photographs.

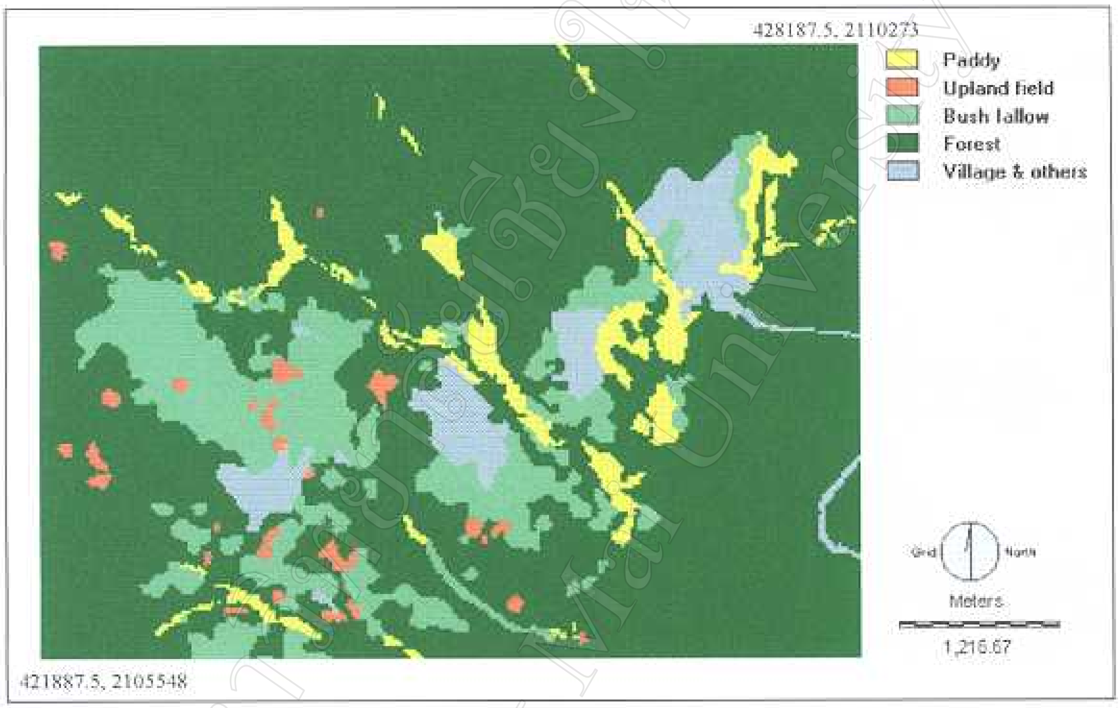

Figure 4.12 The land use map of Watchan in 1983 as classified from aerial photographs.

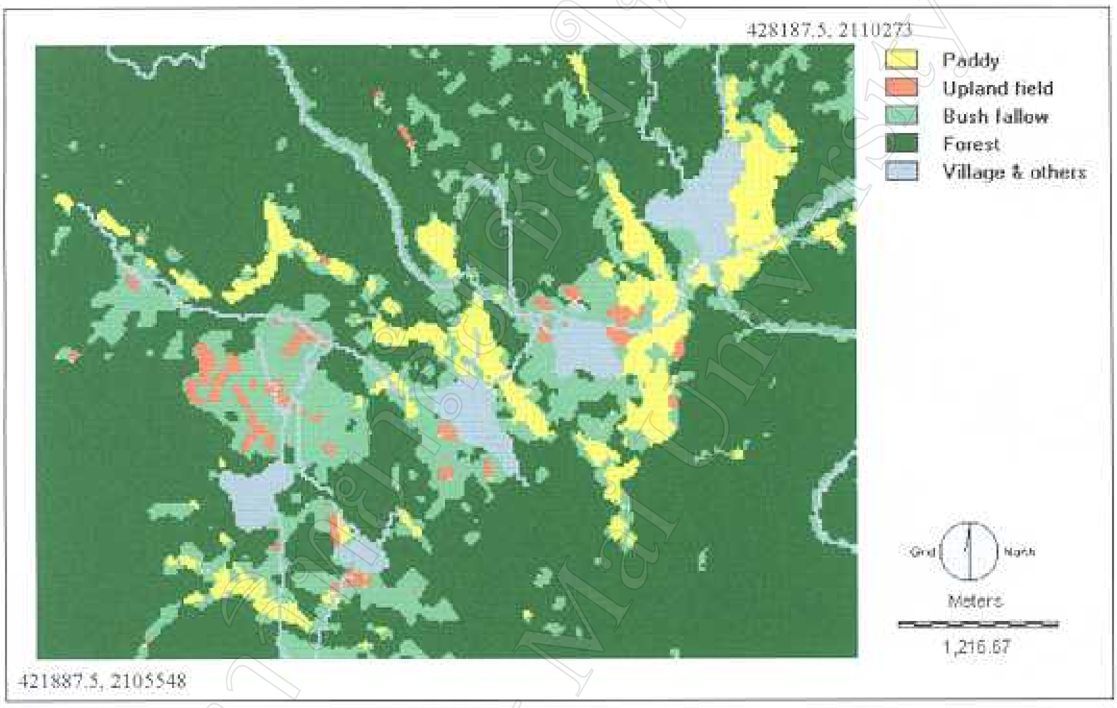

Figure 4.13 The land use map of Watchan in 1994 as classified from Landsat TM.

4.4 Land Use Changes

The summary statistics of land use cover and changes from 1954 to 1994 in the study area which were obtained by using AREA command in IDRISI are displayed in Table 4.5.

Paddy rice area expanded about 3 folds from 74.1 ha (2.49% of the total area) in 1954 to 148.2 ha (4.98%) in 1983, and to 205.56 (6.91%) in 1994. Likewise, bush fallow, village area and other land use types were increased over time except active upland field that tended to be unchanged over the past 40 years. The farmers utilized about 41.0 ha in total or 0.16 ha per household each year for upland rice cultivation. This figure is very consistent with the result of socio-economic study of the same area as reported earlier (Ekasingh et al., 1995). In that formal interview, the average upland per household was reported to be 0.2 ha. This study revealed that the average size of upland rice field cultivated in the study period (1992-93) was 0.43 ha which is slightly higher than the earlier report and from remote sensing data in 1994.

This might be described by the nature of upland rice cultivation that required more labor for land preparation and management than paddy rice. In the year that the household lacked of labor or water was abundant, most of household resource would be put to paddy rice and might ignore some of upland rice area.

Forest area declined from 2,813.2 ha (94.51%) in 1954 to 2,237.9 ha (75.18%) in 1983 and to 2,097.3 ha (70.46%) in 1994. The rate of decline from 1954 to 1983 was about 19 ha/year and was about 14 ha/year during 1983 to 1994. It should be noted that the percentage of forest area in 1954 might include bush fallow because the scale of 1954 aerial photograph was 1:50,000 which was much smaller than 1954. This made classification difficult for differentiating bush fallow from other vegetation types.

Table 4.5 Land use distribution and changes in the study area between 1954 to 1994.

Land use	Year	Total area (ha)	% of area
Paddy	1954	74.1	2.5
	1983	148.2	5.0
	1994	205.6	6.9
Upland field	1954	45.6	1.5
	1983	36.4	1.2
	1994	41.1	1.4
Bush fallow	1954	NA	NA
	1983	402.0	13.5
	1994	454.9	15.3
Forest	1954	2813.3	94.5
	1983	2237.9	75.2
	1994	2097.3	70.5
Village and others	1954	43.8	0.5
	1983	152.2	5.1
	1994	177.9	6.0

The village and other areas covering village settlement, road, bare land and other constructions was increased from 43.8 ha (0.5%)to 177.9 (6.0%) during 1954 to 1994. This could be an indirect indication of the expansion of residential area and other infrastructures in this community to support the increase in population.

The land use and change over 3 period of times as shown in Table 4.5 was derived from different data source and classification techniques. Land use in 1954 and 1983 were obtained from orthophoto images interpretation whereas the land use in 1994 was obtained from Landsat TM data and unsupervised classification technique. Thus, the concept and definition used to defined the boundary of each land use type was different particularly the village settlement. Ekasingh et al. (1995) reported that the Landsat TM data interpretation could not satisfactorily distinguish the village site because the mixture of trees, bushes and physical structures in the village settlement contributed to the difficulties in identifying the signature of this land use category. However, Landsat TM data that was acquired at the proper date could be employed to yield satisfactory land use categories in the highland area.

4.5 Rice Productivity

4.5.1 Crop Cutting

All the rice varieties found in the study area were local varieties both paddy and upland rice. Nine varieties of paddy rice were identified, however, only three varieties were commonly used by farmers namely *Poh Loh, Por Moh, and Mo* (Table 4.6). Six rice varieties were found on the upland rice areas, but only one variety named *Pho Pri* was widely grown (Table 4.7).

Table 4.6 Paddy rice varieties found in Watchan, 1993 growing season.

Local name	No. of samples
Poh Loh	34
Por Moh	11
Mo	10
Pi I	3
Wabo	3
Suki	2
Others	7
Total	70

Table 4.7 Upland rice varieties found in Watchan, 1993 growing season.

Local name	No. of samples
Pho Pri	40
Kha	4
Thor Lah	2
Pi I	1
Lisu	1
Lor Pae	1
Ka	1
Unknown	1
Total	51

Crop cutting method was conducted in November 1993 to determine the average rice grain yield and other yield component of the study area. Each sample plot was checked to confirm that it belonged to farmer in the study area.

Seventy samples of paddy rice were collected, and measured the grain yield. Paddy rice yield ranged from 84 kg/rai (0.52 t/ha) to 878 kg/rai (5.50 t/ha). The average paddy rice yield was 419 kg/rai (2.62 t/ha).

Fifty-one samples from upland rice areas were also taken and measured. The upland rice grain yield ranged from 150 kg/rai (0.94 t/ha) to 740.8 kg/rai (4.63 t/ha). The average upland rice grain yield was 346 kg/rai (2.16 t/ha).

The number of sample plots and grain yield measurement are shown in Table 4.8.

Table 4.8 Estimated rice yield in 1993 growing season.

Rice	No. of plots	Average yield (kg/rai), (t/ha)	S.D. (kg/rai)
Paddy rice	70	419 (2.62)	157.89
Upland rice	51	346 (2.16)	143.88

4.5.2 Yield Component

The rice samples were further analyzed to investigate the yield component including total biomass, seed yield, percentage of empty spikelets, 1,000 grains weight, and harvest index. The result of analysis is shown in Table 4.9.

Table 4.9 Rice yield component analysis in Watchan, 1993 growing season.

Rice	No. of plots	Total biomass (t/ha)	Emptly spikelets (%)	1,000 seeds weight (g)	Harvest Index	Seed yield (t/ha)
Paddy rice	70	6.02	8.99	31.01	0.43	2.62
S.D.		2.27	2.39	2.18	0.06	0.99
Upland rice	51	5.87	0.06	26.79	0.38	2.16
S.D.		2.87	0.04	1.66	0.05	0.89

4.5.3 Rice Productivity : Result from the Formal Survey

The average grain yield of paddy rice obtained from the formal survey was 454.6 kg/rai (2.84 t/ha), and the highest grain yield was 1,155 kg/rai (7.22 t/ha). This reported yield was unusually high. It might be partly due to the misconception about what size is a rai by many respondents. However, the obtained average grain yield is not much different from the result of crop cutting method.

what size is a rai by many respondents. However, the obtained average grain yield is not much different from the result of crop cutting method.

Eight varieties of paddy rice were cultivated bv the respondents, only two varieties were commonly used namely *Por Moh* and *Poh Loh* which were consistent with the results of the crop cutting method.

The average grain yield of upland rice taken from 44 respondents was 197.4 kg/rai (1.22 t/ha). The yield was quite low compared to the result obtained from the crop cutting method. There was also reported that some of rice grain were destroyed by wild animals and some were suppressed by weed. However, average grain yield was similar to the study done by Ekasingh et al.(1995). The study reported that average upland rice grain yield was 1.83 t/ha for Watchan community and 1.25 t/ha for another highland community. Thirteen local upland rice varieties were reported but only one variety named *Pho Pri* was the most common.

4.6 Rice Consumption

Approximate annual rice requirement of the household was investigated based on farmer's rice production and purchased rice. Total amount of rice consumed by all respondent households was 191.5 t/ha (unthreshed rice). This is equivalent to 320 kg/person/year. This figure is slightly less than Ekasingh et al. (1995) who reported that the rice requirement of Kae Noi and Watchan communities were about 320 and 366 kg/person/year respectively.

4.7 Rice Sufficiency Level

The total rice of all the respondents could produce was about 157.8 t. When compared to the rice consumption need, it can be concluded that rice production in this study area could meet only 82% of total consumption. This conclusion was based on rice productivity investigated in 1993 crop year by using formal interviewing with 95 sampled households.

Further investigation was done concerning the number of years rice shortage occurred during the last ten years. Only twelve households (13%) were rice self-sufficient and never experienced this problem. Sixty-seven percent of respondents had faced this problem for five years or more, 38% never produced enough rice for their own consumption need (Figure 4.14). They had to purchase milled rice on the average of 333.4 kg/year mostly from the market outside the communities.

When the respondents were asked about the reasons that caused rice deficits, pest and diseases, erratic and/or low rainfall, limited rice area, infertile soil, were mostly cited. Sixty-four percent of respondents mentioned the problem of pest and diseases (Table 4.10, Table 4.11). This could be related to the experience of rice blast diseases that just occurred in 1992 crop year and more than 50 % of rice crop was damaged.

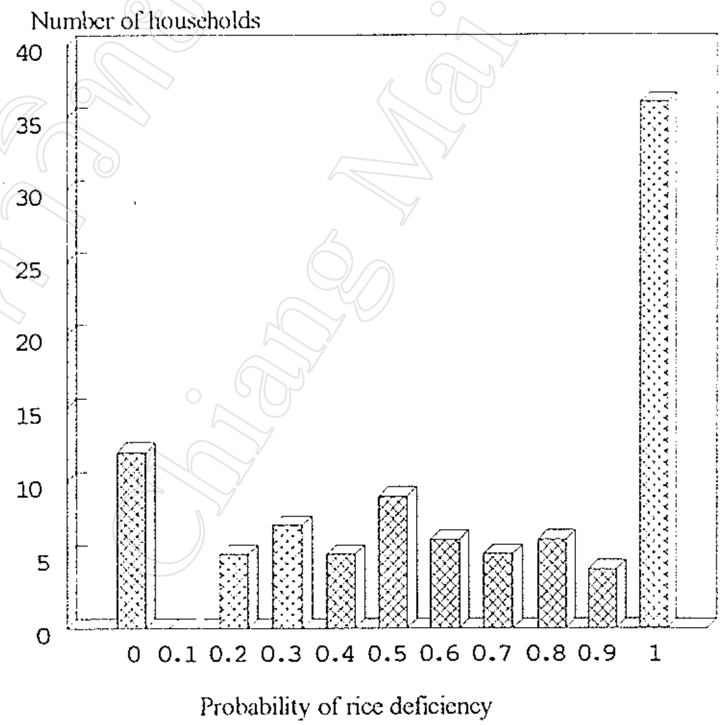

Figure 4.14 Number of households experiencing different probability of rice deficiency.

Table 4.10 Severity of causes that contributed to rice deficiency in Watchan.

Causes	Severity level	Number of cases	% of cases
Limited rice area	1	29	31
	2	8	8
Low rainfall	1	30	32
	2	14	15
Water source scarcity	1	2	2
	2	4	4
Infertile soil	1	7	7
	2	19	20
Less labor	1	5	5
	2	1	1
Animal destroy product	1	1	1
	2	2	2
Pest and diseases	1	7	7
	2	23	24
Other :- weed, flooding	1	2	2
	2	8	8
Inadequate management	1	1	1
	2	-	-

Table 4.11 Frequency of causes that contributed to rice deficiency in Watchan.

Causes	No. of cases	% of cases
Limited rice area	55	58
Low rainfall	59	62
Water source scarcity	14	15
Infertile soil	47	49
Less labor	12	13
Animal destroy product	29	31
Pest and diseases	61	64
Other :- weed, flooding	21	22
Inadequate management	1	1

4.8 Adaptive Strategies

Farmer tried different ways to cope with rice deficit. Seeking off-farm employment (87%), borrowing from rice bank (65.%), sell of animals (51%), borrow rice from relatives (47%). and growing cash crop (43%) were among the common strategies (Table 4.12).

Table 4.12 Adaptive strategies of farmers to cope with rice deficit problem.

Applied Strategies	No. of Household	% of total
1. Try to improve rice productivity	24	28.9
2. Grow cash crop	36	43.4
3. Sell of animals	42	50.6
4. Substitute with other food sources	24	28.9
5. Gather and sale forest products	12	14.5
6. Produce handicrafts	28	33.7
7. On-site employment	72	86.7
8. Off-site employment	2	2.4
9. Borrow from relatives and neighbors	39	47.0
10 Borrow from rice bank	54	65.1
11. Others	3	3.6

4.8.1 Off-farm Employment

Almost all of respondents who had involved in off-farm employment kept working on-site, few of them were employed in town, the major off-farm activities are shown in Table 4.13 It was noticeable that forest trees provided both wood and employment opportunity to people in this area. Farm works were also played the important role in income generation of people in the community.

Table 4.13 Off-farm employment and wage rates in Watchan.

Activities	Involved household	Min. wage (Baht/day)	Max wage (Baht/day)	Average wage (Baht/day)
1. Lumber milling	40 (43%)	40	160	105
2. Farm works	39 (42%)	30	100	45
3. House construction	5 (6%)	50	100	80
4. Others	32 (36%)	30	140	86

4.8.2 Rice Bank and Other Rice Sources

There were two rice banks giving service to people in this community. One was funded and managed by the Christians group. This rice bank allowed people to borrow rice without interest but the first priority went to the member of Christian group. Another rice bank was initiated and supported by the government agency, anyone could borrow rice with low interest. The average amount of rice borrowed from rice bank was 166.5 kg per household each year.

Data from Table 4.12 shows that 47 % of household borrowed rice from their relatives and neighbors. This reveals the strong kinship in this community.

4.8.3 Animals Trade

Domestic animals also played important role in solving rice shortage problem. Cattle, buffalo, and local pig could be utilized as household bank that could generate cash at the critical time.

4.8.4 Cash Crops

Cash crops were introduced to farmers in this community by the Royal Project for more than ten years ago due to the favorable temperature for temperate vegetables, flowers and fruit trees. The project provided seeds, fertilizer, management techniques, transportation, and marketing to farmers. This activity could generate about 10,000 Baht per year income to participating households. Due to the quota system of the Royal Project mentioned earlier, thus there were a small number of farmers who could practice this to mitigate their rice deficit problem.

4.8.5 Increase Rice Output and Productivity

There was only 26.7% of respondents who had tried to increase rice productivity, mostly by expanding rice area, and/or using various forms of fertilizers (Tables 4.14 and 4.15). The number of farmers who applied this strategy was smaller than expected. Possible reasons were no more land to be converted to paddy or because of the restriction over the use of forest areas. This could be confirmed by the previous investigation on land use change by using aerial photo interpretation and GIS techniques.

Tables 4.14 The methods applied to increase paddy rice output.

Method	No. of household	% of total sample
expand paddy area	18	21.7
improve & expand irrigated area	6	7.2
use new variety	4	4.8
apply inputs :- fertilizer	20	24.1
avoid damaging from animal	12	14.5
others	4	4.8

Tables 4.15 The methods applied to increase upland rice output.

Method	No. of household	% of total sample
expand upland rice area	26	31.3
use new variety	0	0.0
shorten fallow period	1	1.2
apply inputs :- fertilizer, machine	2	2.4
avoid damages caused by animal	3	3.6
others	1	1.2

The farmers who responded to the questionnaires also suggested that rice deficit problem could be alleviated by providing more off-farm opportunity, supporting and promoting household industry such as weaving and handicrafts, provide good rice varieties and management techniques and developing water resources.

4.9 Rice Supporting Capacity of the Study Area

Rice supporting capacity of the community at the study time was investigated by using the average yield of paddy rice and upland rice obtained from crop cutting, the paddy and upland rice area classified from Landsat TM in 1994, and the average fallow period and rice consumption investigated by using formal interviewing (Table 4.16)

Table 4.16 Data and sources used for determining rice supporting capacity.

Data	Quantity	Source
Paddy rice area	205.56 ha	Landsat TM
Upland rice area	41.06 ha	Landsat TM
Bush fallow area	454.88 ha	Landsat TM
Consumption need per person	320 kg/person	Formal interview
Paddy rice yield	2.62 t/ha	Crop cutting
Upland rice yield	2.16 t/ha	Crop cutting
Average fallow period	3.23 years	Formal interview

The data were applied to the formula in equation (3) and (4) mentioned earlier (Brush, 1975). The result revealed that the paddy rice supporting capacity was 1,332 persons per year , and the upland rice supporting capacity was 902 persons per year. Thus, total rice supporting capacity of the study area based on Brush's method was 2,457 persons which was almost two folds of total population of the community at the study time. It might be concluded from this line of analysis that this community could produce enough rice to support all the population.

However, the investigation on rice sufficiency level of this community was conducted by using formal interview revealed that total rice yield of all 95 respondents could produce 157.8 t, while total rice consumption was 191.5 t. Therefore, rice production could meet only 82 % of population, there was 18% rice deficit in the community. This is consistent with the earlier reported by Ekasingh <u>et</u> <u>al</u>. (1995).

Since there was discrepancy between two methods of estimating rice sufficiency, the alternative method was attempted. This was based on amount of upland and paddy rice area obtained from Landsat TM classification in 1994, total rice production calculated from the average grain yield, and rice consumption calculated from average consumption and number of total population in 1993. The result showed that total rice production was 627 t and total consumption was 478 t. There was a surplus of 31 %.

Several reasons could be used to explain the above result. The average grain yield obtained from crop cutting method might be overestimated because 1 m^2 quadrant was used to harvest rice sample, this may be too small and introduced the overestimation.

Furthermore, yield losses during and after harvesting process were also ignored. Siamwalar and Na-ranong (1976) conducted the study on yield losses of rice due to harvesting, threshing, and transporting processes, had revealed that about 17% of rice product loss occurred. Thus the actual grain production of the study area must be lower than the estimation that was made.

In addition, the calculation of rice supporting capacity in this study was based on the amount of rice consumed by the household as food. Other requirements should be considered such as rice kept for seed, rice used for feeding livestock, brewing whisky, ceremonies, or providing hospitality for visitors. Hinton (1970) mentioned that this would account for 25% of rice requirement. Ekasingh et al. (1995) conducted the formal survey in the same study area and reported the rice requirement accounted for 366 kg/person which included both household consumption and other additional requirements.

The production of both paddy and upland rice was adjusted to 83% based on the assumption of the estimated product losses mentioned above, and rice requirement per household was adjusted to 366 kg/person/year. The rice supporting capacity was re-calculated. The result revealed that the total rice production was about 520 t and total rice need was 547t (about 1,420 persons could be supported), therefore, rice deficit was approximately 5% in this community.

According to the information expressed by many respondents during informal survey, rice production in 1993 crop year was very good comparing to the previous years particularly to 1992 production when the rice diseases outbroke. The information from informal survey also indicted that rice production in this area depended on availability of water, fertility of upland rice shifting plot, and losses that might occur due to diseases and animals. This reveals the variation of rice output in this area that the farmers faced, hence, rice deficit problem occurred in the past.

Table 4.17 shows the data obtained from different sources that were used to assess rice sufficiency level of this community. Rice cultivated area and its change over time could be obtained only by using aerial photograph or satellite data interpretation whereas it could not be achieved by using formal interview method. Rice average grain yields obtained from different methods were similar except that of the upland rice obtained from formal interview was lower than the others. Rice area holding sizes were not much different from each other. The fallow period of upland rice plot obtained from two studies were slightly different. The amount of rice requirement per household investigated in this study was lower than the amount reported by Ekasingh et al. (1995) because it did not cover other uses of rice.

Table 4.17 Comparison of data obtained from different sources.

Data	Sources and methods			
	Crop cutting	Formal survey	Aerial photograph interpretation (1983)	Ekasingh et al. (1995)
Paddy rice area (ha)	-	-	148.19	205.56
Upland rice area (ha)	-	-	36.44	41.06
Paddy rice yield (t/ha)	2.62	2.84	-	2.56
Upland rice yield (t/ha)	2.16	1.22	-	1.83
Paddy rice holding size (ha/HH)	-	0.66	0.78	0.66
Upland rice holding size (ha/HH)	-	0.43	0.16	1.2
Fallow period (yr)	-	3.23	-	4.4
Rice requirement (kg/HH/yr)	-	320	-	366

4.10 Scenario Analysis

The scenario projection on rice supporting capacity during 1954 to 1994 and extended to 2000 was conducted using 2.0%, 2.5%, and 3.0 % population growth rate based on The Social Research Institute (1988), Kunstadter (1990) and Fox et al. (1994), and rice cultivated area and rice yield was considered to remain constant over the study period. The results are shown in Table 4.17. In this table, the supporting capacity was calculated from the adjusted rice output by taking into consideration of 17% loss of rice output by various reasons as discussed earlier and rice requirement at 366 kg/person/year.

Table 4.18 Scenario analysis on rice supporting capacity in 1954, 1983, 1994, and 2000.

Year	Population at different growth rate			Adjusted supporting capacity at 83% of rice output (persons)
	2%	2.5%	3%	
1954	666	543	442	530
1983	1,197	1,132	1,069	1,061
1994	1,495	1,495	1,495	1,472
2000	1,684	1,734	1,785	1,472*

* *rice cultivated area and cultural practice were assumed unchange*

The results of this analysis indicates that population increased about 2 times during 1954 to 1983 while the paddy rice area was doubled (74 ha to 148 ha) and the upland rice area remained unchanged in spite of the increased consumption need. The change in supporting capacity during this period confirmed that the expanded rice area was the strategy that the community used to cope with increasing rice consumption of the increased population.

Further scenario analysis was done under the assumption that rice cultivated area can not be expanded due to the restriction of forest laws and difficulty in converting steep slope land to paddy area. In addition, it was also assumed that farmers in this community had maintain traditional cultural practice, thus, total rice output was remained unchange. The population growth rate was also assumed constant from 1994 to 2000. The result in Table 4.18 shows that the number of population in this community would exceed the rice supporting capacity of this area during this period (Figure 4.15). Thus, the problem on rice deficiency would become more severe if there is no improvement on rice output or other income generating activities.

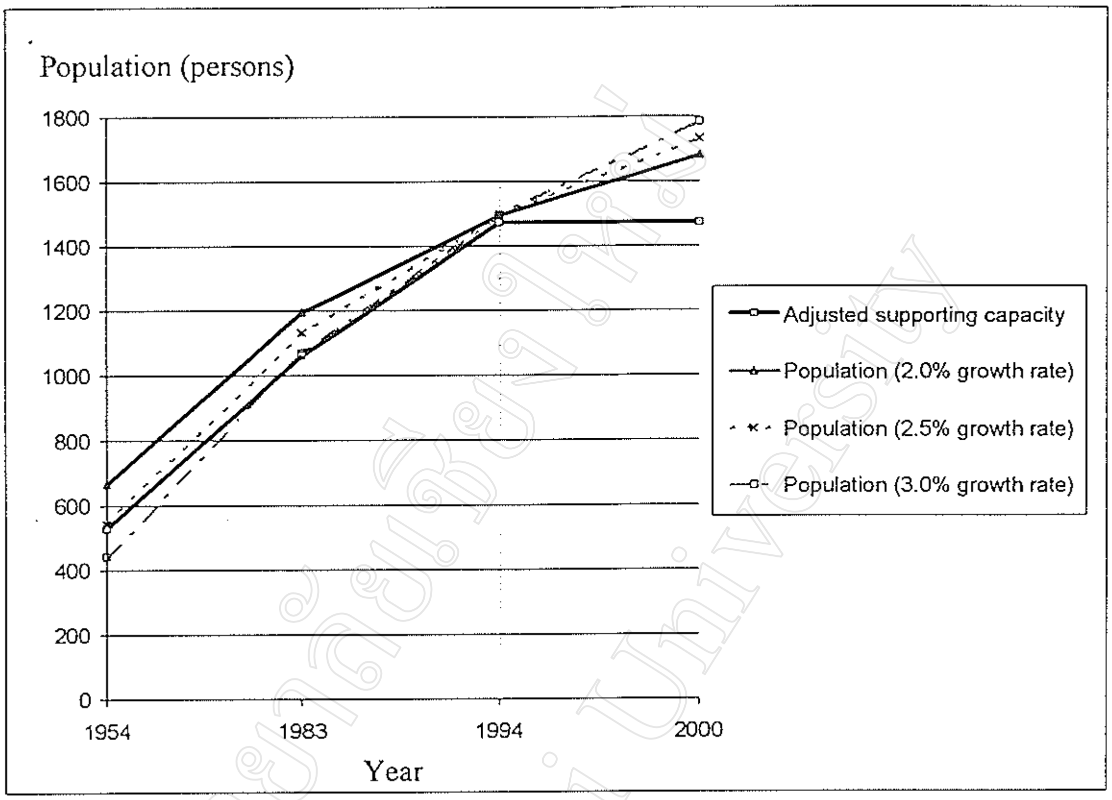

Figure 4.15 Scenario analysis of rice supporting capacity and the projected population during 1954 to 2000.

4.11 Alternative Development Plan

It is evident that the rice deficiency problem in this Karen community has been occurred in the past and will continue to be more severe if there is no development plan to help balance the rice supporting capacity and consumption. It is noticed that rice output of this community is based on the low input rice cultivation, improvement of rice output and production can be achieved by enhancing fertility, cultural practice, and high yielding variety.

Gypmantasiri and Amaruekachoke (1997) conducted field experiment in this study area by applying fertilizer in the fallow upland rice plots, the result showed that the fertility enhancement helped maintain upland rice productivity for the short fallowed upland rice plots.

Pankao (1996) had identified 34 lines of local paddy rice variety with different isozyme pattern in the same study area, and the materials were used to assess grain yield and stability with low inputs under varied environmental condition (Gypmantasiri, unpublished). The analysis showed that the average grain yield of 4 high yielding lines ranged from 3.0 t/ha (485 kg/rai) to 3.2 t/ha (505 kg/rai) with regression coefficient ranged from 0.7 to 0.87 indicating high stability. One of the farmer in the study area was also advised to apply fertilizer 16-20-0 at the rate of 156 kg/ha with weeding. These practices resulted in rice grain yield at 3.4 t/ha (537 kg/rai). The late transplanting was also experimented during July and August. The yields obtained from this trial were very low at 0.7 t/ha (117 kg/rai) and 1 t/ha (156 kg/rai) for July and August planting dates respectively. This experiment on late planting date revealed that the situation of late rainfall could contribute to the decreasing of rice grain yield in non irrigated areas.

Thus, to increase rice output in this community, the following development and/or improvement should be taken into consideration:

- Fertility enhancement such as applying organic or chemical fertilizer and green manure.
- Improve cultural practice such as weeding, spacing and water management.
- Using improved local rice varieties.
- Develop water sources.

The scenario analysis was done to project the trend of rice supporting capacity and projected population using the potential paddy rice grain yield obtained from Gypmantasiri (unpublished) at 3.0 t/ha and 3.4 t/ha which were adjusted at 83% due to potential yield loss as discussed in previous section, and 2.0%, 2.5%, and 3.0% population growth rate and maintain upland rice area and grain yield constant. The result is shown in Figure 4.16.

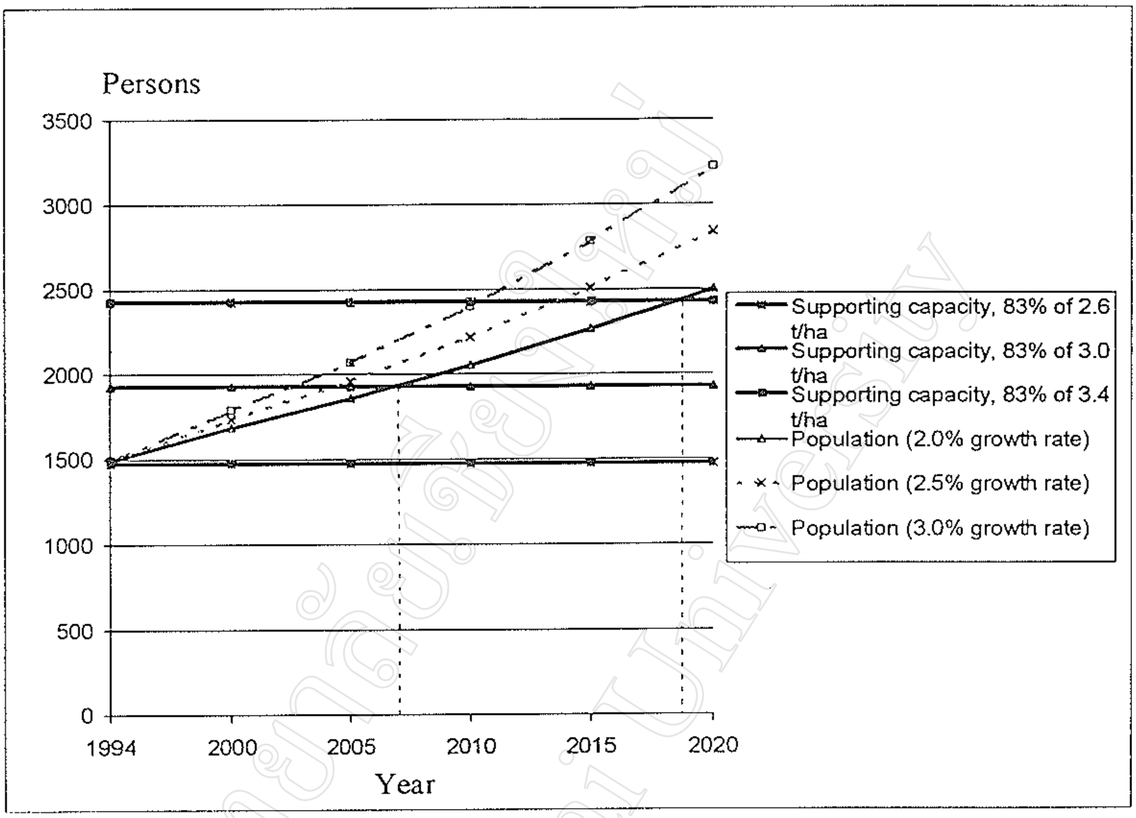

Figure 4.16 Scenario analysis of rice supporting capacity and the projected population during 2000 to 2020 using paddy rice yields from improved management practices.

The analysis indicates that this effort can provide rice output increment of about 1 t/ha based on the existing rice grain yield in this area of 2.6 t/ha. Figure 4.16 reveals that the number of population calculated from the 2.0% population growth rate would exceed the rice supporting capacity 1,973 people by year 2008 if paddy rice yield would be improved to 3.0 t/ha. This inequilibrium will be extended to year 2018 if rice yield would increase to 3.4 t/ha. To achieve the new levels of yield, new varieties should be selected and introduced to this area and the proper management practices should be followed.

Other alternative plans should be taken into the consideration to provide additional income to overcome the foreseen rice deficit problem in this community. Cash crops such as vegetables have been the good sources of household income but due to the quota system, this could be practiced by limited number of households. Fruit trees would be the other alternative for farmers in this community due to the favorable temperature.

Other activities that could be promoted to provide alternative source of income are handicraft and value added products. Traditional cotton weaving has been in exist for long time for household use, and this has been promoted by both government and non-government agencies to the outside markets. Since the perception and the campaign of green produces and traditional local products have been promoted and are widely accepted by people nowadays, thus this small-scale home industry would be another promising alternative to increase household income. Some examples of the potential value-added products or green produces are unpolished Karen local rice, pesticide-free produces which are of high demand would be promising to generate higher incomes to counter balance the household rice deficit problem.