CHAPTER 7

OPTIMAL RESOURCE MANAGEMENT AT THE FARM LEVEL

This chapter deals with the results of the optimal resource management at the farm level. Two different methods were used; the equal weight and the AHP methods. The equal weight method used data from the field survey and gave the weighted objective goals an equal value. The AHP method used the weighted objective goals as determined by the stakeholders. In each method, the results will explain the optimal resource management such as land use management, off-farm work, hired labor, loan and interest repayments, net annual revenue from crop production and the achieved objective goals.

7.1 Optimal resource management for the small farms using chemicals

7.1.1 The equal weight method for the small farms using chemicals

1. Optimal land use management

An analysis by the equal weight method assessed the optimal land use management for the small farms using chemicals as shown in Table 7.1.

- The optimal land use for the irrigated upland was assessed as being best suited for coffee production at 5.17 rai (0.82 hectare) and sweet corn followed by sweet corn at 2.63 rai (0.42 hectare).
- The optimal land use for the rainfed upland was assessed as being best suited for coffee at 1.23 rai (0.2 hectare).
- The optimal land use for the irrigated lowland was assessed as being best suited for citrus production at 3.91 rai (0.63 hectare) and rice followed by sweet corn at 1.21 rai (0.19 hectare).

- The optimal land use for the rainfed lowland was assessed as being best suited for lychee production at 0.87 rai (0.14 hectare) and rice production at 0.18 rai (0.03 hectare).

Table 7.1 Optimal land use management by the equal weight method
for the small farms using chemicals

Land unit	Crop activities	Optimal land use (rai)	Existing land use (rai)
Irrigated upland	Citrus		7.80
	Coffee	5.17	
	Sweet corn-sweet corn	2.63	
Rainfed upland	Coffee	1.23	
	Sweet corn-sweet corn		1.23
Irrigated lowland	Citrus	3.91	1.06
	Rice-sweet corn	1.21	
	Rice-onion		2.57
	Rice-onion- sweet corn		1.49
Rainfed lowland	Rice	0.18	
	Lychee	0.87	1.05
Total area		15.20	15.20

When the results from the equal weight method were compared with the existing land use, the results found that for the rainfed lowland, the results were similar as they both recommended lychee for optimal use. The results for the other land units diverged as the equal weight method results recommended that both of the upland areas were optimal for the environmentally-friendly production of coffee and the irrigated lowland was optimal for citrus with a small area being used for rice and sweet corn. The existing land use pattern used the irrigated upland area for citrus only and the irrigated lowland area was planted was a mix of annual crops (Figure 7.1)
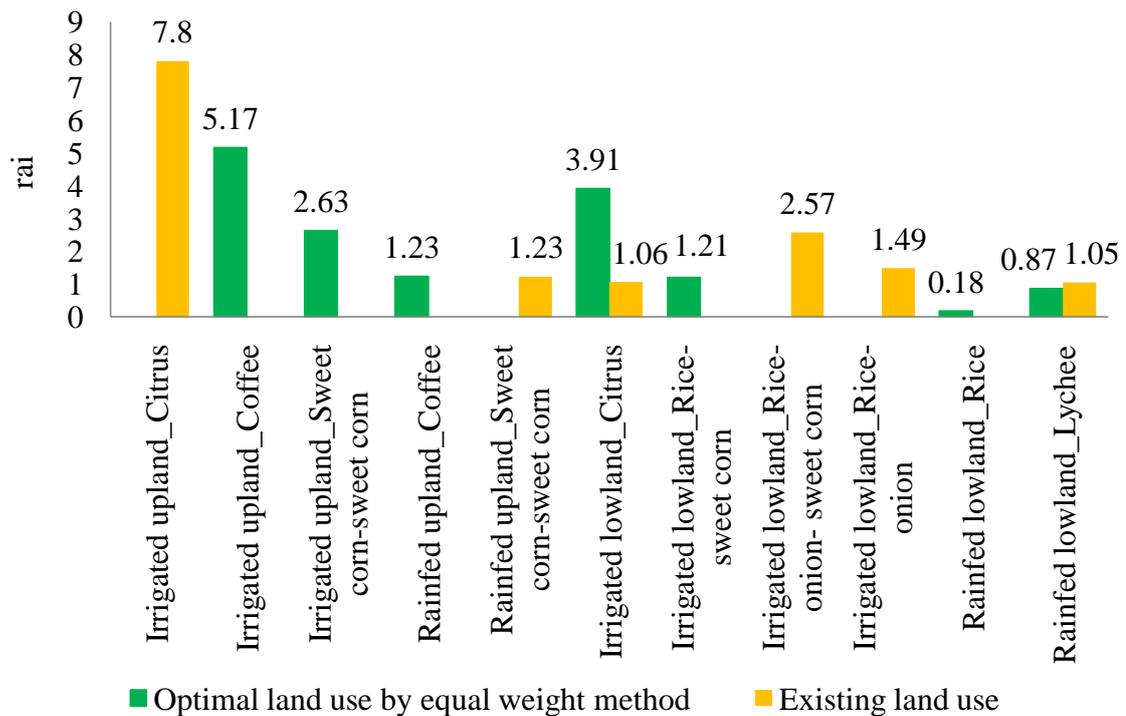
Figure 7.1 Optimal land use by the equal weight method and the existing land use
for the small farms using chemicals

2. Off-farm work and hired labor

The results found that the optimal household labor management for the small farms using chemicals was total off-farm work at 67.2 man-days per year (10.8% of total household labor per year). This was primarily using household labor for crop activities. However, the household labor was not sufficient for all the production activities especially during the planting and harvesting periods. This included some activities the household would not want to do such as chemical spraying, fertilizer distribution, mowing and pruning. These were activities which used hired labor. In this study, the model recommended employing hired labor for 50 man-days per month during March, May, June, July, October and December (Table 7.2). In each month, hired labor was used as follows:

Table 7.2 Optimal household labor and hired labor by the equal weight method

for the small farms using chemicals

Activities	Household labor /hired labor (man-days)
Off-farm work	67.2
Hired labor	
January	43.6
February	43.7
March	50.0
April	30.4
May	50.0
June	50.0
July	50.0
August	33.6
September	39.4
October	50.0
November	46.7
December	50.0

- In March, there was full employment for the household labor and hired labor in citrus pruning on the irrigated lowland (3.91 rai or 0.63 hectare) and harvesting the second crop of sweet corn after the rice harvest in the irrigated lowland (1.21 rai or 0.19 hectare).

- In May, there was preparing and planting the first crop of sweet corn in the irrigated upland (2.63 rai or 0.42 hectare). It took a lot of labor to take care of the citrus when it was flowering such as fertilizer distribution and water and chemical spraying every 4-5 days. If this was not carried out, or carried out insufficiently, it would lead to a decline in the quality of the fruit.

- In June, there was preparing the rice crop in the lowland area, (both irrigated and rainfed totaling 1.39 rai or 0.22 hectare) and harvesting the lychee crop in the

rainfed lowland (0.87 rai or 0.14 hectare). There was also continuing care of the growing citrus fruit.

- In July, there was planting rice, pruning the lychees and harvesting the first crop of sweet corn in the irrigated upland as well as the continuing care of the growing citrus fruit.

- In October, there was harvesting the second crop of sweet corn in the irrigated upland (2.63 rai or 0.42 hectare), lowland rice (1.39 rai or 0.22 hectare) and coffee in the upland totaling 6.40 rai (1.02 hectare). There was also the start of the citrus harvest.

- In December, the majority of the citrus was ripe, so a lot of labor was needed for harvesting. Meanwhile, the second crop of sweet corn was ready to be harvested in the irrigated upland.

- The need for hired labor was at its lowest in April at 30.4 man-days. During this month the Songkran festival is celebrated and many people in the rural areas stop for several days to visit their family home and relatives.

3. Loan and interest repayments

The small farms using chemicals had a total capital investment of 57,721 baht but this was not sufficient. The model recommended having a loan from the Bank for Agriculture and Agricultural Co-Cooperatives (BAAC) of 89,519 baht. The BAAC had an interest rate of 7.5 percent per year with total repayments of 96,233 baht.

4. Net annual revenue from crop production

The optimal resource management gave the small farms using chemicals a revenue after loan and interest repayments of 158,437 baht minus the household consumption of 78,279 baht which gave a net annual revenue from crop production of 80,158 baht.

7.1.2   The AHP method for the small farms using chemicals

1.   Optimal land use management

The weight using the AHP method provided for the optimal land use management for the small farms using chemicals as shown in Table 7.3.

Table 7.3 Optimal land use management using the AHP method
for the small farms using chemicals

Land unit	Crop activities	Optimal land use (rai)	Existing land use (rai)
Irrigated upland	Citrus	7.80	7.80
Rainfed upland	Sweet corn-sweet corn	1.23	1.23
Irrigated lowland	Citrus		1.06
	Rice-sweet corn- sweet corn	4.10	
	Rice-garlic- sweet corn	0.91	
	Rice-onion- sweet corn	0.11	2.57
	Rice-onion		1.49
Rainfed lowland	Rice	1.05	
	Lychee		1.05
Total area		15.20	15.20

- The optimal land use for the irrigated upland was for citrus production at 7.80 rai (1.25 hectare).
- The optimal land use for the rainfed upland was for sweet corn followed by sweet corn at 1.23 rai (0.2 hectare).
- The optimal land use for the irrigated lowland was for rice followed by sweet corn and sweet corn at 4.10 rai (0.66 hectare), rice followed by garlic and sweet corn at 0.91 rai (0.15 hectare) and rice followed by onions and sweet corn at 0.11 rai (0.02 hectare).

- The optimal land use for the rainfed lowland was for rice at 1.05 rai (0.17 hectare).

The optimal land use results from the AHP method and the existing land use showed similar results. They both recommended that the irrigated upland was optimal for citrus and the rainfed upland was optimal for a double crop of sweet corn. The other land units were optimal for a mix of annual crops (Figure 7.2). This was due to the importance that the farmers gave to the economic objective which gave a high weight value to the annual equivalent value (Chapter 6 Figure 6.1).
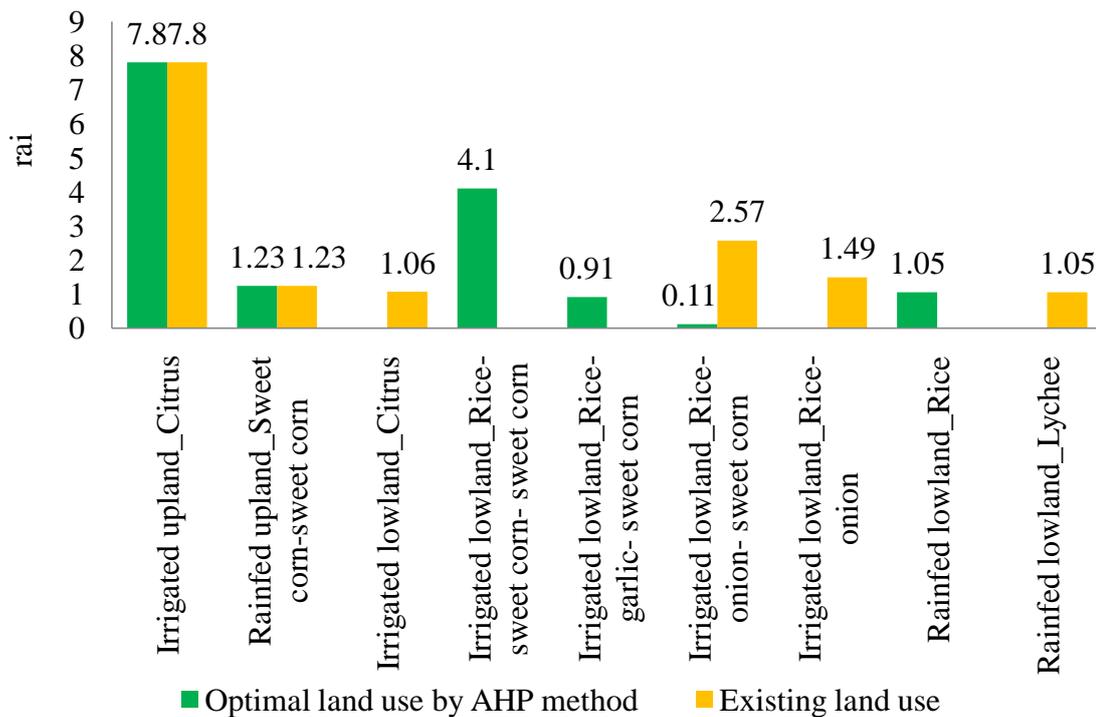

Figure 7.2 Optimal land uses by the AHP method and existing land use
for the small farms using chemicals

2. Off-farm work and hired labor

The results found that the small farms using chemicals had an off-farm work potential of 34.9 man-days per year or 5.6 percent of the total household labor per year. This showed that there was a greater benefit in the time spent on their farm over off-farm

work which also resulted in less investment in hired labor. When comparing an analysis with the equal weight and the AHP methods, the study found that the AHP method which used the farmers own priorities placed more importance on a higher level of household labor than the equal weight method. However, the household labor was not sufficient for the optimal resource management especially during the peak periods of planting and harvesting. The model recommended the use of hired labor at 50 man-days per month in the labor-intensive months of February, March and December. In each month, the hired labor was used as shown in Table 7.4.

Table 7.4 Optimal household and hired labor using the AHP method
for the small farms using chemicals

Activities	Household labor /hired labor (man-days)
Off-farm work	34.9
Hired labor	
January	37.4
February	50.0
March	50.0
April	19.3
May	39.4
June	35.8
July	33.8
August	11.4
September	13.7
October	47.1
November	30.6
December	50.0

- In February, on the irrigated lowland, the hired labor was used for harvesting the second crop of sweet corn (4.10 rai or 0.66 hectare), garlic (0.91 rai or 0.15 hectare) and onion (1.05 rai or 0.17 hectare) after the first rice harvest.

- In March, on the irrigated lowland, the hired labor was used for preparing and planting a third crop of sweet corn (5.12 rai or 0.82 hectare) and for pruning the citrus crop (7.80 rai or 1.25 hectare).

- In December, on both the irrigated and the rainfed areas, the hired labor was used for the rice harvest (6.17 rai or 0.99 hectare) and to start harvesting the citrus crop.

- In August, the model recommended a lower hired labor figure of 11.4 man-days per month as this was the maintenance period for all the crops where the main activities were watering, weeding, fertilizer distribution and chemical spraying.

3. Loan and interest repayments

The optimal loan management was analyzed by the AHP method which recommended that the small farms using chemicals have a loan from the Bank for Agriculture and Agricultural Co-Cooperatives. The amount suggested was for 67,647 baht at an interest rate of 7.5 percent per year with total repayments of 72,721 baht.

4. Net annual revenue from crop production

The optimal resource management for the small farms using chemicals suggested a potential revenue after loan and interest repayments of 259,804 baht. When the household consumption of 78,279 baht had been deducted, this gave a net annual revenue from crop production of 181,525 baht.

7.1.3 Goal achievement rate for the small farms using chemicals

The results from the equal weight and the AHP methods showed similar goal achievement rates. These were highest in the annual equivalent value followed by off-farm work. The goal achievement rate was lower in yield variance and revenue variance. When comparing the equal weight and the AHP methods, the results found that the AHP method achieved 95 percent of the target goal for the annual equivalent

value while the equal weight method only achieved 72 percent. However, in all other areas, the achievement rates arrived at by using the equal weight method were between 40 to 70 percent of the target goals while the AHP method only achieved between 8 to 37 percent of the target goals, (Figure 7.3).
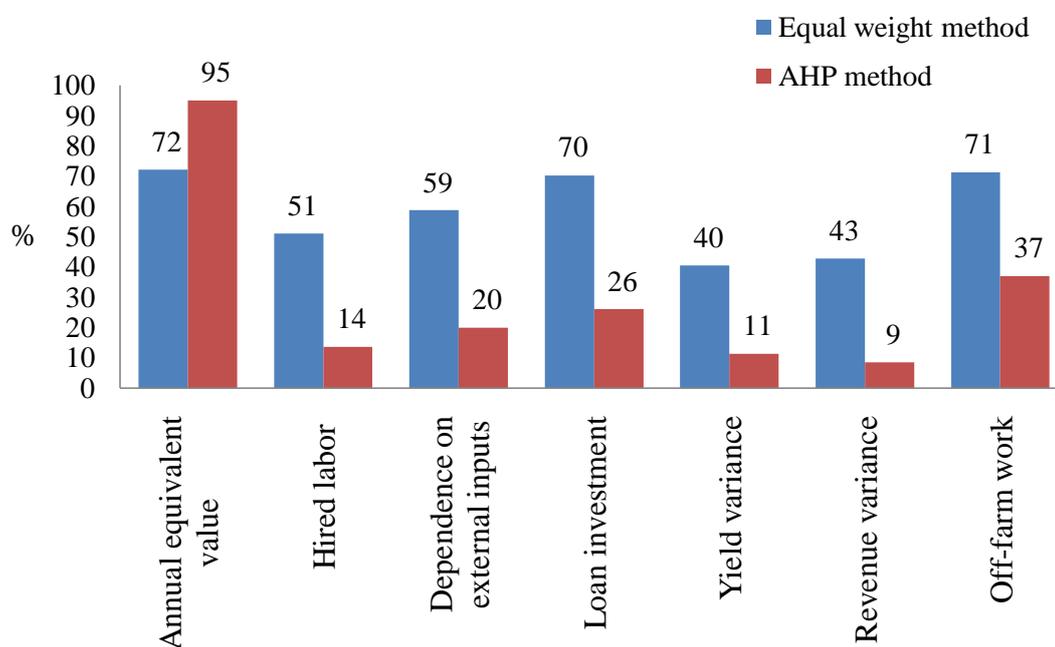

Figure 7.3 Objective goals achieved using the equal weight and the AHP methods for the small farms using chemicals

7.2 Optimal resource management for the small farms using chemicals and bioextract

7.2.1 The equal weight method for the small farms using chemicals and bioextract

1. Optimal land use management

An analysis of the optimal land use management for the small farms using chemicals and bioextract found the following results as shown in Table 7.5.

Table 7.5 Optimal land use management by the equal weight method
for the small farms using chemicals and bioextract

Land unit	Crop activities	Optimal land use (rai)	Existing land use (rai)
Irrigated upland	Citrus		4.18
	Coffee	1.12	
	Sweet corn- sweet corn	3.06	
Rainfed upland	Sweet corn- sweet corn		1.91
	Coffee	1.91	
Irrigated lowland	Citrus	1.50	2.46
	Longan	1.13	
	Rice-sweet corn- sweet corn	3.83	
	Rice-onion- sweet corn		3.00
	Rice-onion		1.00
Rainfed lowland	Lychee	1.25	1.25
Total area		13.80	13.80

- The optimal land use for the irrigated upland was for citrus production at 1.12 rai (0.18 hectare) and sweet corn followed by sweet corn at 3.06 rai (0.49 hectare).
- The optimal land use for the rainfed upland was for coffee production at 1.91 rai (0.31 hectare).
- The optimal land use for the irrigated lowland was for citrus production at 1.50 rai (0.24 hectare), longan production at 1.13 rai (0.18 hectare) and rice followed by sweet corn and sweet corn at 3.83 rai (0.61 hectare).
- The optimal land use for the rainfed lowland was for lychee at 1.25 rai (0.2 hectare).

The optimal land use results from the equal weigh method and the existing land use gave similar results in the rainfed lowland while the rainfed upland and irrigated areas, both upland and lowland, differed. The rainfed upland, the optimal result recommended

only for coffee but the existing gave for double crops of sweet corn. For the irrigated upland, the existing land use was for citrus production while the equal weight method results were optimal for a mix of citrus and annual crops. For the irrigated lowland, the existing land use and the equal weight method results were similar for a mix of annual crops but differed in the equal weight method recommended an area be planted with longan (Figure 7.4)
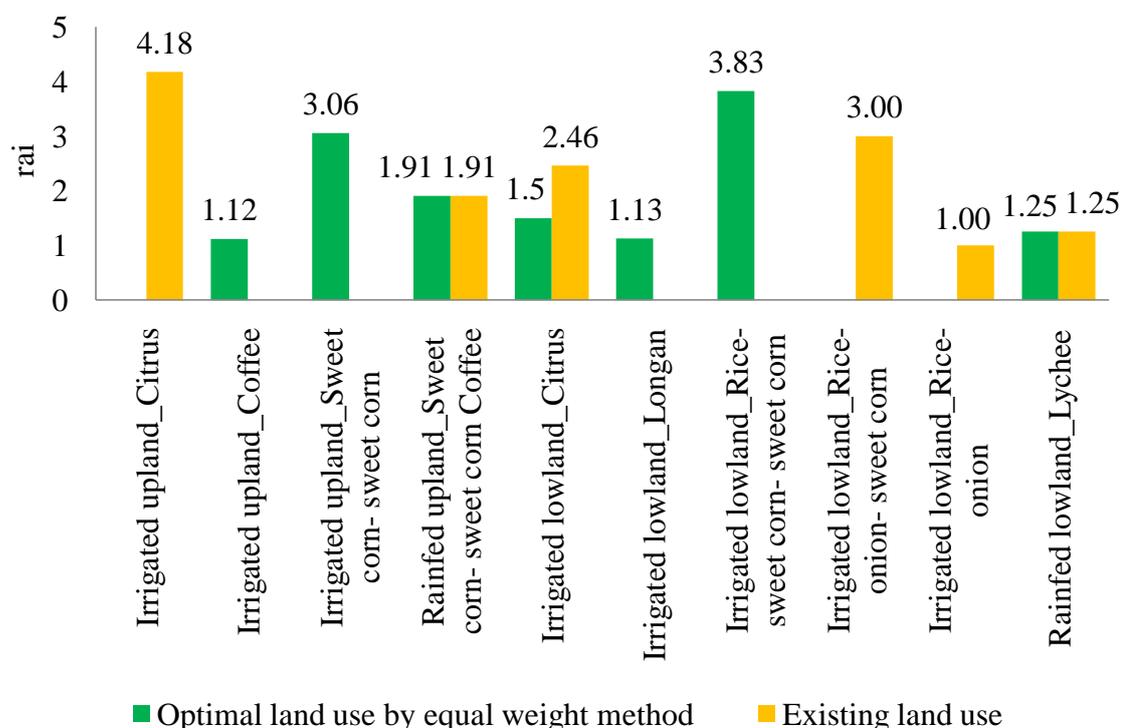

Figure 7.4 Optimal land use by the equal weight method and the existing land use
for the small farms using chemicals and bioextract

2. Off-farm work and hired labor

An analysis by the equal weight method suggested that the household in a small farm using chemicals and bioextract could work off-farm for a total of 62.8 man-days per year or 10.27 percent of the total household labor per year. That would mean that the household labor would spend 89.73 percent of their time working on their own farm but they would need to employ hired labor at the peak times for optimal resource management. The model assessed a maximum of 50 man-days per month hired labor

during March, May, July, August, October and December. The details are as shown in Table 7.6.

Table 7.6 Optimal household labor and hired labor by the equal weight method
for the small farms using chemicals and bioextract

Activities	Man-days
Household off-farm work	62.8
Hired labor	
January	34.2
February	30.8
March	50.0
April	26.9
May	50.0
June	49.6
July	50.0
August	50.0
September	38.4
October	50.0
November	29.9
December	50.0

- In March, in the irrigated lowland, there was the pruning of citrus trees (1.13 rai), harvesting the sweet corn crop after the rice crop and preparing the area for a third crop (3.83 rai).
- In May, in the irrigated lowland, there was the preparation for the rice crop (3.83 rai). In the irrigated upland, there was preparing and planting the land for a sweet corn (3.06 rai). The citrus crop needed watering as well as applying fertilizer, pesticides and supplements during this period to stimulate the branches and the flowers.

- In July, in the rainfed lowland, there was planting rice, harvesting and pruning the lychee crop (1.25 rai) as well as the continuing care of the immature citrus trees during their growth period and the care of the new crop on the mature trees.

- In August, in the irrigated lowland, there was harvesting the longan crop and pruning the trees for next year (1.13 rai) and the continuing care of the mature and immature citrus trees. In the irrigated upland, there was the planting of the second crop of sweet corn (3.06 rai).

- In October, in the irrigated upland, there was harvesting the second crop of sweet corn. In the irrigated and rainfed upland, there was harvesting the coffee crop (3.03 rai) and in the irrigated lowland, there was harvesting the rice crop (3.83 rai) and the start of the citrus harvest.

- In December, in the irrigated lowland, there was the main harvesting of the citrus crop.

- The model shows that the need for hired labor was at its lowest during April with only 26.90 man-days per month being required. This is because the Thai New Year (Songkran) is celebrated during this month.

3. Loan and interest repayments

The optimal loan management suggested by the equal weight method recommended that the small farms using chemicals should have their loans from the Bank for Agriculture and Agricultural Co-Cooperatives with an average figure of 124,870 baht with an interest rate of 7.5 percent per year. The total repayment would be 134,235 baht.

4. Net annual revenue from crop production

The optimal resource management gave the small farms using chemicals and bioextract a net annual revenue from crop production of 0 baht. This shows revenue as equal to the repayment for the loan, loan interest and the household consumption. This result of 0 baht net annual revenue was due to the criteria used in the model to minimize the

deviation for the 7 goals. This was the optimal result with the economic, social and environmental criteria being equal.

7.2.2 The AHP method for the small farms using chemicals and bioextract

1. Optimal land use management

The model assessed the optimal land use management for small farms using chemicals and bioextract as shown in Table 7.7.

Table 7.7 Optimal land use management by weight using the AHP method
for the small farms using chemicals and bioextract

Land unit	Crop activities	Optimal land use (rai)	Existing land use (rai)
Irrigated upland	Citrus	3.28	4.18
	Sweet corn- sweet corn	0.90	
Rainfed upland	Sweet corn- sweet corn	1.91	1.91
Irrigated lowland	Citrus		2.46
	Rice-sweet corn- sweet corn	5.92	
	Rice-garlic- sweet corn	0.54	
	Rice-onion- sweet corn		3.00
	Rice-onion		1.00
Rainfed lowland	Rice	1.25	
	Lychee		1.25
Total area		13.80	13.80

- The optimal land use for the irrigated upland was for citrus production at 3.28 rai (0.52 hectare) and sweet corn followed by sweet corn at 0.90 rai (0.14 hectare).

- The optimal land use for the rainfed upland was for sweet corn followed by sweet corn at 1.91 rai (0.31 hectare).

- The optimal land use for the irrigated lowland was for rice followed by sweet corn and sweet corn at 5.92 rai (0.95 hectare) and rice followed by garlic and sweet corn at 0.54 rai (0.09 hectare).

- The optimal land use for the rainfed lowland was for rice at 1.25 rai (0.2 hectare).

When the results from the equal weigh method were compared with the existing land use, the results were similar for the irrigated upland and the rainfed upland. For the irrigated lowland, the existing land use was citrus and a mix of annual crops while the equal weight method recommended only a mix of annual crops. The other results are shown in Figure 7.5.
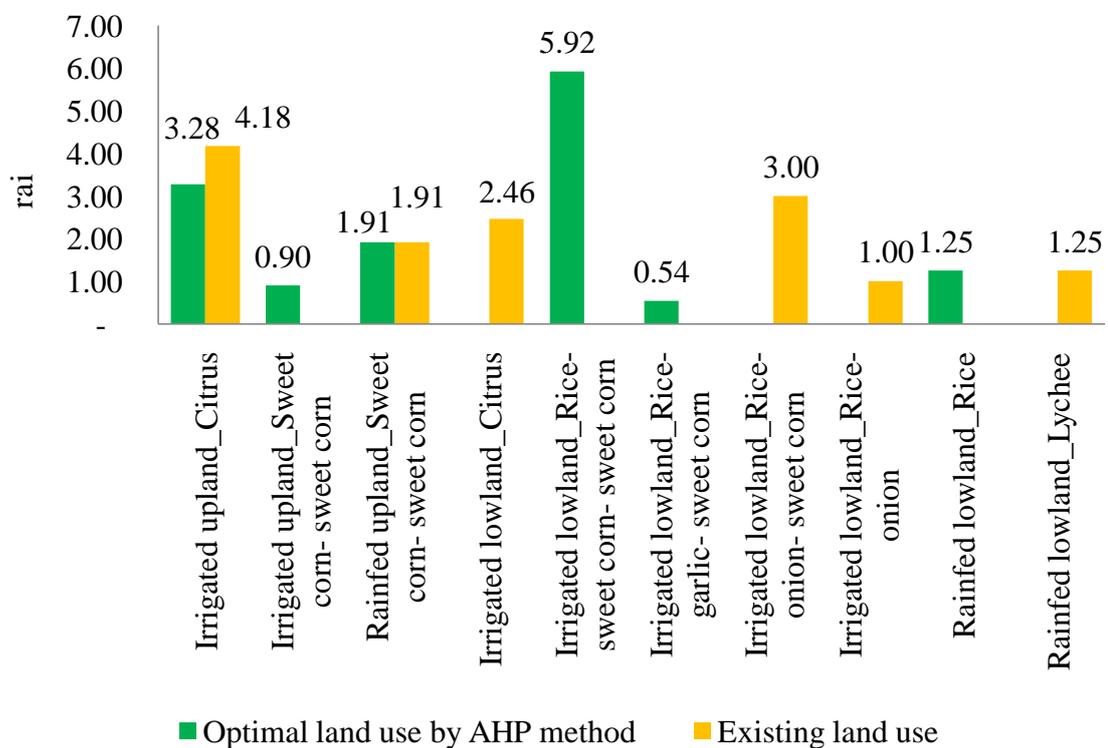

Figure 7.5 Optimal land use by AHP method and the existing land use
for the small farms using chemicals and bioextract

2. Off-farm work and hired labor

The results found that household labor was best used to work their own farm with only 42.6 man-days per year for off-farm work or 6.96 percent of total household labor per year. The household labor was not sufficient during the peak periods of planting and harvesting. The model assessed 50 man-days per month for hired labor in March, May, October and December. The details are shown as shown in Table 7.8.

Table 7.8 Optimal household labor and hired labor using the AHP method
for the small farms using chemicals and bioextract

Activities	Man-days
Household off-farm work	42.6
Hired labor	
January	31.4
February	32.0
March	50.0
April	18.6
May	50.0
June	41.7
July	39.8
August	14.8
September	19.3
October	50.0
November	18.1
December	50.00

- In March, in the irrigated upland, there was pruning the citrus trees (3.28 rai or 0.52 hectare). In the irrigated lowland, there was harvesting the sweet corn crop (5.91 rai or 0.95 hectare) and the garlic crop (0.54 rai or 0.09 hectare) after the previous rice harvest. The land was then prepared for a third crop.

- In May, in the irrigated and rainfed upland areas, there was planting sweet corn (2.81 rai or 0.45 hectare) and preparing for the rice crop (7.70 rai or 1.23 hectare). The citrus crop needed watering as well as applying fertilizer, pesticides and supplements during this period to stimulate the branches and the flowers.
- In October, in the irrigated and rainfed upland areas, there was harvesting the second crop of sweet corn (2.81 rai or 0.45 hectare). In the irrigated upland, there was the start of the citrus harvest. In the irrigated and rainfed lowlands, there was the rice harvest (7.70 rai or 1.23 hectare).

- In December, in the irrigated upland, there was the major harvest of the citrus crop. In the irrigated lowland, there was the continuing care of sweet corn and garlic.
- During August, the need for hired labor was at its lowest at 14.8 man-days because there were no major planting or harvesting activities taking place.

3. Loan and interest repayments

The small farms using chemicals and bioextracts had enough owner investment for crop production. The model did not recommend a loan.

4. Net annual revenue from crop production

The optimal resource management assessed the revenue of the small farms using chemicals and bioextract at 198,668 baht. When the household consumption of 79,906 baht had been deducted, this gave a net annual revenue from crop production of 118,762 baht.

7.2.3 Goal achievement rates for the small farms using chemicals and bioextract

The results from the equal weight and the AHP methods showed different results. The highest results were achieved in the annual equivalent value followed by loan investment and off-farm work. The results were lowest in the yield variance.

When comparing the equal weight and the AHP methods, the results found that the AHP method gave a better result for the annual equivalent value (91.56 %) than the equal weight method (76.12 %). The equal weight method achieved between 40 to 75 percent in all the other objective goals whereas the AHP method achieved between 22 to 48 percent (Figure 7.6).
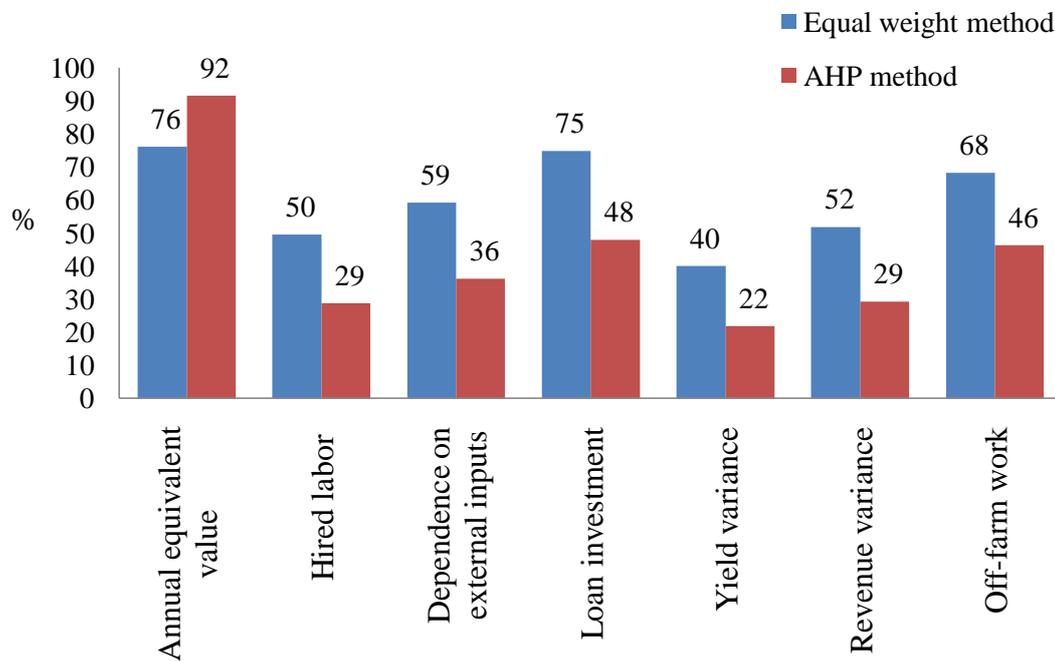

Figure 7.6 Objective goals achieved using the equal weight and the AHP methods
for the small farms using chemicals and bioextract

7.3   Optimal resource management for the large farms using chemicals

7.3.1   The equal weight method for the large farms using chemicals

1.   Optimal land use management

An analysis of the optimal land use management for the large farms using chemicals found the following results as shown in Table 7.9.

Table 7.9 Optimal land use management by the equal weight method
for the large farms using chemicals

Land unit	Crop activities	Optimal land use (rai)	Existing land use (rai)
Irrigated upland	Citrus	85.21	85.21
Rainfed upland	Longan		7.96
	Coffee	0.48	
	Sweet corn- sweet corn	7.48	
Irrigated lowland	Citrus	43.55	45.81
	Rice-sweet corn	2.26	
Rainfed lowland	Lychee		3.52
	Rice	3.52	
Total area		142.50	142.50

- The optimal land use for the irrigated upland was for citrus production at 85.21 rai (13.63 hectare).
- The optimal land use for the rainfed upland was for coffee production at 0.48 rai (0.08 hectare) and sweet corn followed by sweet corn at 7.48 rai (1.2 hectare).
- The optimal land use for the irrigated lowland was for citrus production at 43.55 rai (6.97 hectare) and rice followed by sweet corn at 2.26 rai (0.36 hectare).

- The optimal land use for the rainfed lowland was for rice at 3.52 rai (0.56 hectare).

The results from the equal weight method and existing land use gave similar results for the irrigated upland and lowland but the other land units differed (Figure 7.7). The large farms using chemicals are a major factor in citrus production, producing several crops per year by stimulating branch initiation to obtain continuous production thus generating a higher income. The farms at this scale are businesses or limited companies with a high investment in machinery such as processing plants for the citrus crop and the cost of hired labor. They want a quick return from their investment and citrus production generates a higher return than other crops which therefore leads to a majority of their land being used for citrus production with only a small proportion of land being used for other crops.
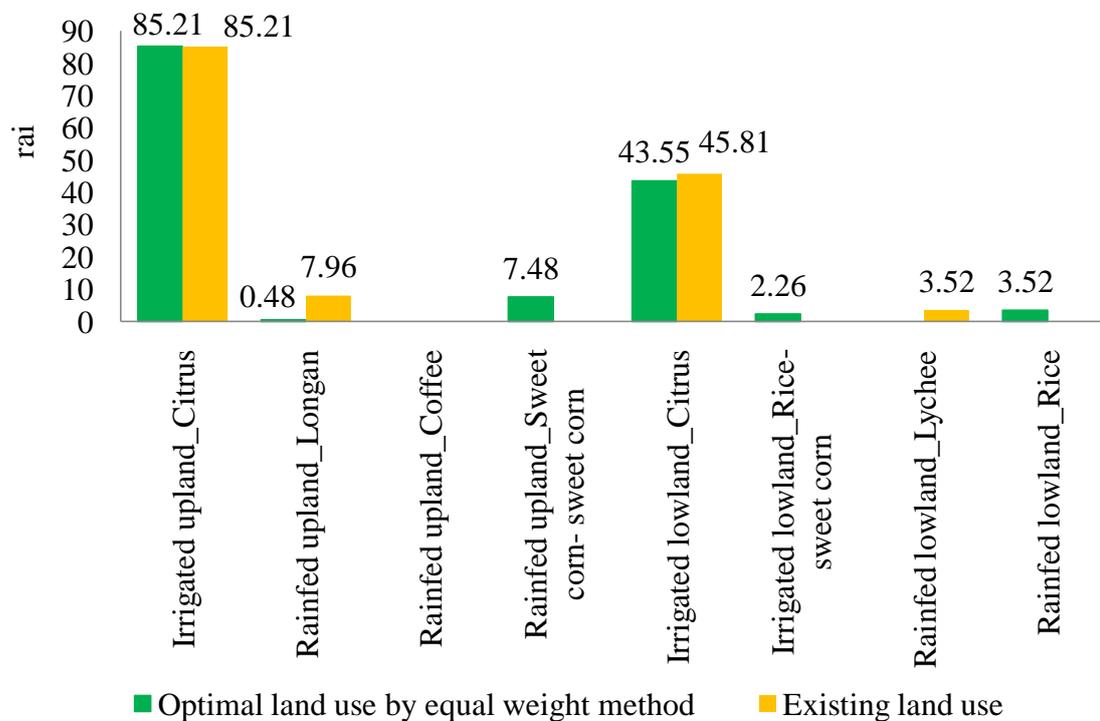

Figure 7.7 Optimal land use by equal weight method and existing land use for the large farms using chemicals

2.   Off-farm work and hired labor

The results found that the optimal resource management using household labor was to work on the farm for 276.9 man-days per year and to work off-farm for 347.1 man-days per year (Table 7.10).

Table 7.10 Optimal household labor and hired labor using the equal weight method for the large farms using chemicals

Activities	Man-days
Household off-farm work	347.1
Hired labor	
January	721.2
February	750.0
March	750.0
April	664.3
May	578.3
June	567.9
July	588.5
August	568.5
September	555.4
October	600.7
November	631.8
December	750.0

In many cases, the farm had a manager who organized the work activities. On the large farms using chemicals, hired labor could be diversified and some of the labor force could be trained for specialist tasks such as mixing the chemicals for spraying. The owners would come to visit their farm 1 or 2 times per week and more frequently during the harvesting season, in some cases, they might be resident during the harvest. On some farms, the owner would manage the marketing and send the produce for sale in Bangkok. This might not be the only business as many farms have off-farm businesses such as a furniture business, run a trucking service or deal in agricultural chemicals and equipment. This accounts for the relatively short time they spend working on the farm.

The hired labor was at a maximum of 750 man-days per month in January, March and December. The details are as follows:

- From January to March, for the irrigated upland and irrigated lowland, there was pruning the citrus crop (128.76 rai or 20.60 hectare). Pruning starts early on the large farms as they have a large area to cover and it needs to be completed by the end of March in order to maximize the growing season. In the irrigated lowland, March also saw the harvesting of the sweet corn which had been planted after the rice (2.26 rai or 0.36 hectare).
- In December, there was the citrus harvest.
- In September, hired labor was at its lowest at 555.4 man-days per month. This was because there was no planting or harvesting but only the continuing care of the citrus, rice and sweet corn crops on the rainfed upland.

3. Loan and interest repayments

The optimal loan management was analyzed by the equal weight method which recommended that the large farms using chemicals should borrow 984,908 baht from the commercial banks at an interest rate of 8.0 percent per year. This would mean a total repayment of 1,063,700 baht.

4. Net annual revenue from crop production

The optimal resource management assessed the revenue for the large farms using chemicals at 6,003,783 baht minus the household consumption of 83,403.81 baht. This would give us a figure of 5,920,380 baht for the net annual revenue from crop production.

7.3.2 The AHP method for the large farms using chemicals

1. Optimal land use management

The model recommended the optimal land use management for the large farms using chemicals as shown in Table 7.11.

Table 7.11 Optimal land use management using the AHP method
for the large farms using chemicals

Land unit	Crop activities	Optimal land use (rai)	Existing land use (rai)
Irrigated upland	Citrus	85.21	85.21
Rainfed upland	Longan		7.96
	Coffee	0.28	
	Sweet corn- sweet corn	7.68	
Irrigated lowland	Citrus	45.81	45.81
Rainfed lowland	Lychee		3.52
	Rice	3.52	
Total area		142.50	142.50

- The optimal land use for the irrigated upland was for citrus production at 85.21rai (13.63 hectare).
- The optimal land use for the rainfed upland was for coffee production at 0.28 rai (0.04 hectare) and sweet corn followed by sweet corn at 7.68 rai (1.23 hectare).
- The optimal land use for the irrigated lowland was for citrus production at 45.81 rai (7.33 hectare).
- The optimal land use for the rainfed lowland was for rice at 3.52 rai (0.56 hectare).

The results from the AHP method and existing land use gave similar results which were also similar to the results by the equal weigh method as it recommended the irrigated upland and irrigated lowland for citrus production only. The other land units were recommended for other fruit trees and annual crops (Figure 7.8).
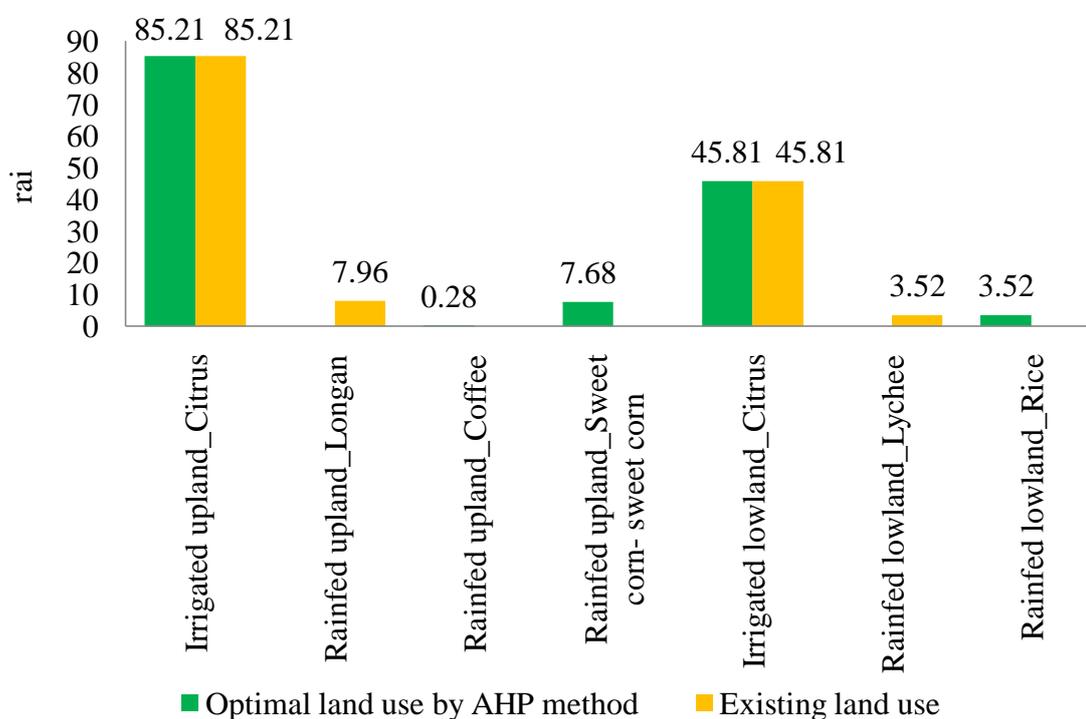

Figure 7.8 Optimal land use by the AHP method and existing land use for the large farms using chemicals

2. Off-farm work and hired labor

The results found that the optimal resource management using household labor was to work on the farm for 285.32 man-days per year and to work off-farm for 338.7 man-days per year (Table 7.12). The model assessed the highest need for hired labor at 750 man-days per month in January and December. In January, there was pruning the citrus trees (131.02 rai or 20.96 hectare) and in December, there was harvesting the citrus crop.

Table 7.12 Optimal household labor and hired labor using the AHP method
for the large farms using chemicals

Activities	household labor /hired labor (man-days)
Off-farm work	338.7
Hired labor	
January	720.5
February	750.0
March	739.8
April	657.7
May	564.1
June	553.5
July	574.8
August	562.6
September	549.8
October	586.7
November	629.3
December	750.0

3. Loan and interest repayments

The optimal loan management was analyzed by the AHP method which recommended that the large farms using chemicals should borrow 1,040,662 baht from the commercial banks at an interest rate of 8.0 percent per year. This would mean a total repayment of 1,123,915 baht.

4. Net annual revenue from crop production

The optimal resource management assessed the revenue for the large farms using chemicals at 6,071,300 baht minus the household consumption of 83,403.81baht. This would give us a figure of 5,987,897 baht for the net annual revenue from crop production.

7.3.3   Goal achievement rates for the large farms using chemicals

The goal achievement rate from the equal weight method and the AHP method gave similar results. The highest results were achieved in the annual equivalent value followed by off-farm work. The results were lowest for yield variance and revenue variance.

When comparing the equal weight and the AHP methods, the results found that the AHP method gave slightly better results for the annual equivalent value (98.98%) than the equal weight method (98.04%). For all the other objective goals, the equal weight method gave slightly higher results than the AHP method (Figure 7.9).
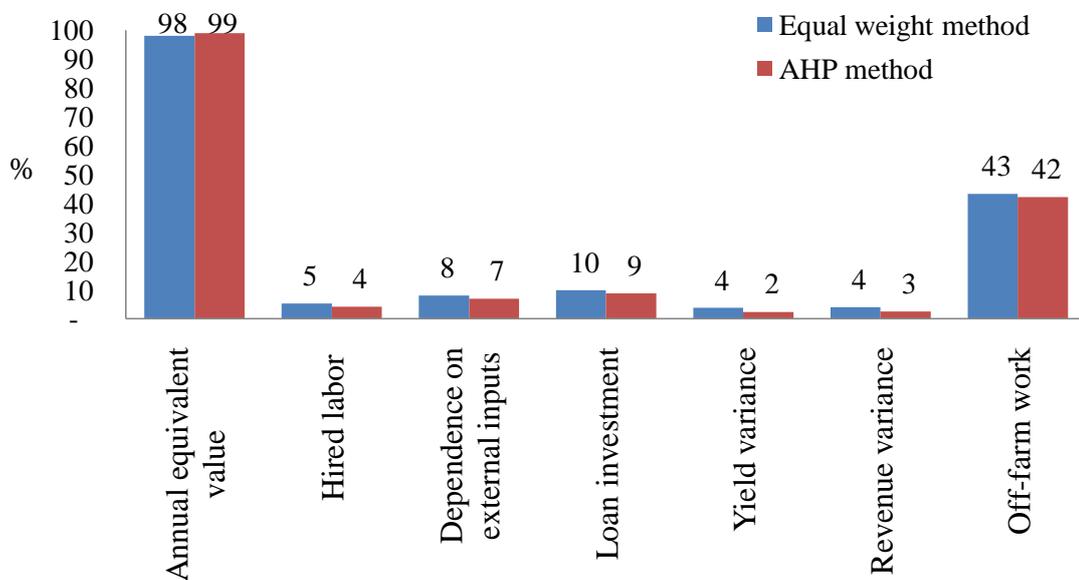
Figure 7.9 Objective goals achieved using the equal weight and the AHP methods for the large farms using chemicals

7.4   Optimal resource management for the large farms using chemicals and bioextract

7.4.1   The equal weight method for the large farms using chemicals and bioextract

1.   Optimal land use management

An analysis of the optimal land use management for the large farms using chemicals and bioextract gave the following results as shown in Table 7.13.

Table 7.13 Optimal land use management using the equal weight method
for the large farms using chemicals and bioextract

Land unit	Crop activities	Optimal land use (rai)	Existing land use (rai)
Irrigated upland	Citrus	7.58	16.75
	Sweet corn- sweet corn	9.17	
Rainfed upland	Coffee	2.32	
	Sweet corn- sweet corn		2.32
Irrigated lowland	Citrus	15.99	11.85
	Rice- sweet corn	0.11	
	Rice- sweet corn- sweet corn		4.25
Rainfed lowland	Rice	5.46	5.46
Total area		40.63	40.63

- The optimal land use for the irrigated upland was for citrus production at 7.58 rai (1.21 hectare) and sweet corn followed by sweet corn at 9.17 rai (1.47 hectare).
- The optimal land use for the rainfed upland was assessed for coffee at 2.32 rai (0.37 hectare).
- The optimal land use for the irrigated lowland was assessed for citrus production at 15.99 rai (2.56 hectare) and rice followed by sweet corn at 0.11 rai (0.02 hectare).

- The optimal land use for the rainfed lowland was assessed for rice at 5.46 rai (0.87 hectare).

The pattern of land use by the equal weight method and the existing land use gave similar results for the irrigated lowland and rainfed lowland. For the irrigated upland, the existing land use was planted with twice the citrus crop than the equal weight method suggested. The other results are shown in Figure 7.10.
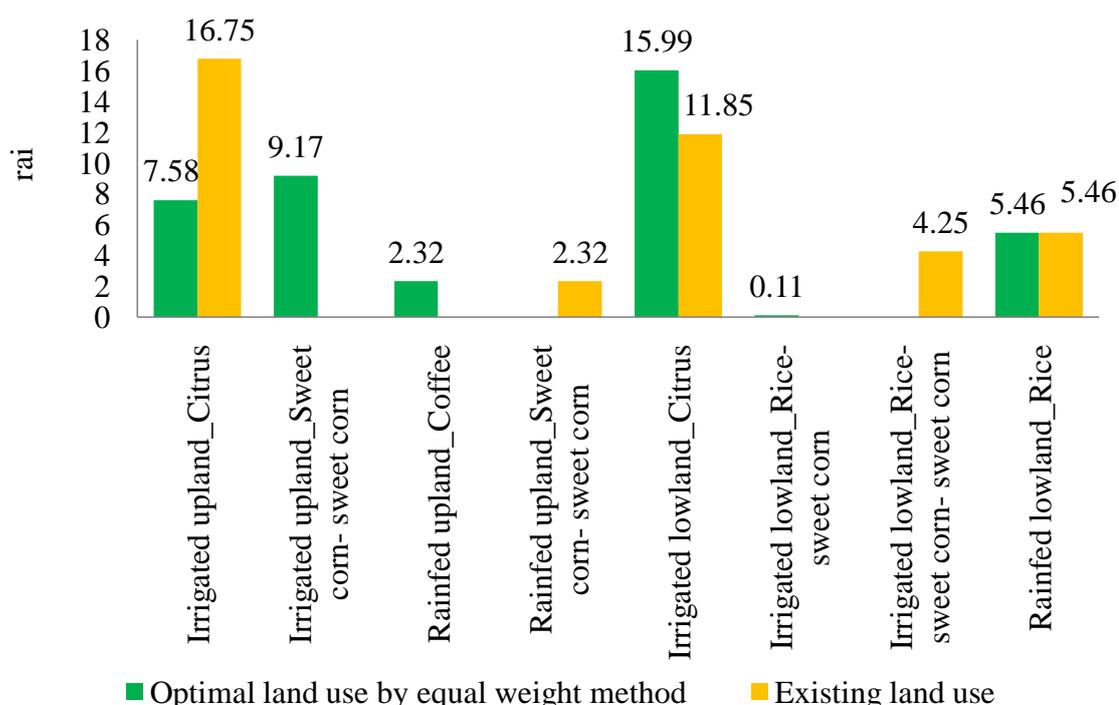

Figure 7.10 Optimal land use by equal weight method and the existing land use for the large farms using chemicals and bioextract

2. Off-farm work and hired labor

The results found that the optimal resource management using household labor was to work on the farm for 432.2 man-days per year and to work off-farm work for 92.9 man-days per year. The model assessed the highest need for hired labor at 150 man-days per month during January, May, October and December. The details are as shown in Table 7.14.

Table 7.14 Optimal household labor and hired labor using the equal weight method
for the large farms using chemicals and bioextract

Activities	Man-days
Household off-farm work	92.6
Hired labor	
January	150.0
February	147.6
March	140.8
April	134.1
May	150.0
June	132.1
July	127.6
August	117.4
September	129.9
October	150.0
November	119.9
December	150.0

- During December and January, for the irrigated upland and lowland, the citrus crop was harvested (23.57 rai or 3.77 hectare). As nitrogen can be added to the soil which postpones the fruit ripening, the farmer can extend his harvest period to take advantage of an increase in the sale price.

- In May, in the irrigated upland, the first crop of sweet corn was planted (9.17 rai or 1.47 hectare). In the irrigated and rainfed lowland, there was preparing the rice crop total (5.57 rai or 0.89 hectare). In the irrigated lowland and upland, the citrus crop needed watering as well as applying fertilizer, pesticides and supplements to stimulate the branches and the flowers (23.57 rai or 3.77 hectare).

- In October, in the rainfed and irrigated lowland, the rice was harvested (5.57 rai or 0.89 hectare). In the rainfed upland, the coffee crop was harvested (2.32 rai or 0.37 hectare) and in the irrigated upland, the sweet corn crop was harvested (9.17 rai or 1.47 hectare).

3. Loan and interest repayments

The optimal loan management was analyzed by the equal weight method which recommended that the large farms using chemicals and bioextract should have a loan of 152,580 baht from a commercial bank at an interest rate of 8.0 percent per year. This would mean a total repayment of 164,787 baht.

4. Net annual revenue from crop production

The optimal resource management assessed the revenue for the large farms using chemicals and bioextract at 1,085,415 baht minus the household consumption of 80,719 baht. This would give us a figure of 1,004,696 baht for the net annual revenue from crop production.

7.4.2 The AHP method for the large farms using chemicals and bioextract

1. Optimal land use management

An analysis of the optimal land use management for the large farms using chemicals and bioextract gave the following results as shown in Table 7.15.

Table 7.15 Optimal land use management using the AHP method
for the large farms using chemicals and bioextract

Land unit	Crop activities	Optimal land use (rai)	Existing land use (rai)
Irrigated upland	Citrus	16.75	16.75
Rainfed upland	Sweet corn- sweet corn	2.32	2.32
Irrigated lowland	Citrus	16.10	11.85
	Rice- sweet corn- sweet corn		4.25
Rainfed lowland	Rice	5.46	5.46
Total area		40.63	40.63

- The optimal land use for the irrigated upland was assessed for citrus production at 16.75 rai (2.68 hectare).
- The optimal land use for the rainfed upland was assessed for sweet corn followed by sweet corn at 2.32 rai (0.37 hectare).
- The optimal land use for the irrigated lowland was assessed for citrus production at 16.10 rai (2.58 hectare).
- The optimal land use for the rainfed lowland was assessed for rice at 5.46 rai (0.87 hectare).

The results from the AHP method and the existing land use gave similar results for all the land units. The results are shown in Figure 7.11.
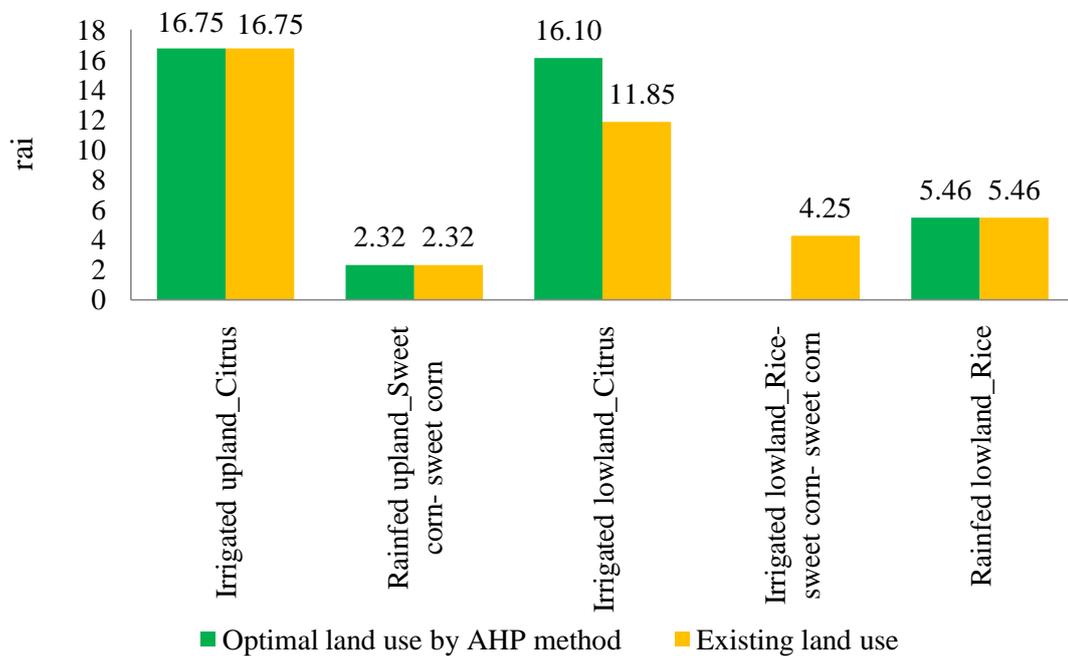
Figure 7.11 Optimal land use by the AHP method and the existing land use
for the large farms using chemicals and bioextract

2. Off-farm work and hired labor

The results found that the optimal resource management using household labor was to work on the farm for 474.1 man-days per year and to work off-farm for 50.9 man-days per year. The household was the principal source of labor on the farm but that was not sufficient during the peak periods of planting and harvesting. The model assessed the highest need for labor at 150 man-days per month in January only. This was for harvesting the citrus crop later on in the season because the farmer would get a better sale price. They used nitrogen distribution in the soil to prolong the fruit ripening by around one month. The need for hired labor was at its lowest between May and November and the details are as shown in Table 7.16.

Table 7.16 Optimal household labor and hired labor using the AHP method
for the large farms using chemicals and bioextract

Activities	Man-days
Household off-farm work	50.93
Hired labor	
January	150.00
February	145.85
March	133.81
April	129.20
May	96.69
June	89.03
July	90.25
August	83.56
September	72.22
October	91.85
November	85.89
December	127.86

- Between May and November, in the irrigated upland and lowland, there was continuing care of the citrus crop (32.85 rai or 5.26 hectare).

- Between May and July, in the rainfed upland, there was the care of the sweet corn crop and its harvest at the end of this period (2.32 rai or 0.37 hectare).

- Between August and October, in the rainfed upland, there was the care of the second sweet corn crop and its harvest at the end of this period (2.32 rai or 0.37 hectare).

- From May to November, we see a drop in the quantity of hired labor. Although there are two crops of sweet corn during this period, the area given to sweet corn is small and so the labor required is only for short periods of time, mainly for planting and harvesting. By contrast, the citrus crop during this period needed more hired labor more frequently to perform the necessary tasks of fertilizer distribution, chemical spraying and mowing. This meant that the fruit grown was of good quality with a high market demand and a high sale price.

3. Loan and interest repayments

The optimal loan management was analyzed using the AHP method which recommended that the large farms using chemicals and bioextract should have a loan of 357,947 baht from the commercial banks at an interest rate of 8.0 percent per year. This would mean a total repayment of 386,583 baht.

4. Net annual revenue from crop production

The optimal resource management assessed the revenue for the large farms using chemicals and bioextract at 1,300,980 baht minus the household consumption of 80,719 baht. This would give us a figure of 1,220,260 baht for the annual net revenue from crop production.

7.4.3   Goal achievement rate for the large farms using chemicals and bioextract

The goal achievement rate from the equal weight method and the AHP method gave different results. The highest results were achieved in the annual equivalent value followed by off-farm work. The results were lowest for yield variance and revenue variance.

When comparing the equal weight and the AHP methods, the result found that the AHP method gave slightly better results for the annual equivalent value (98.86 percent) than the equal weight method (83.64 percent). For all the other objective goals, the equal weight method gave slightly higher results than the AHP method (Figure 7.12).
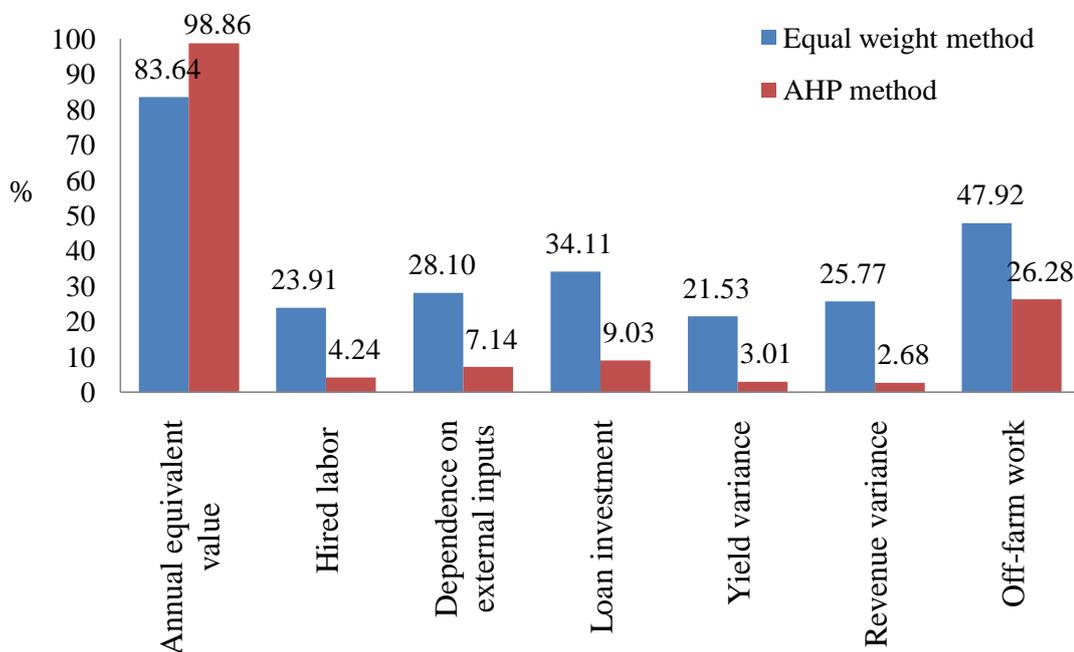
Figure 7.12 Objective goals achieved using the equal weight and the AHP methods for the large farms using chemicals and bioextract

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. All farm types showed that the equal weigh method gave a better pattern of land use which assessed the need for more crop variety especially a mixed crop of fruit trees. This would be composed of citrus, tea, coffee, loangan and lychee, while the results of the AHP method recommended citrus production only. The equal weigh method gave results within a narrow spread of the target goals when compared with the AHP method. However, the AHP method gave better results in term of household labor in that it recommended work on the farm resulting in a decrease in hired labor. There was also a decrease in the loan amount from the BAAC for small farms and commercial banks for large farms compared with the equal weigh method. The AHP method gave a higher net annual revenue compared with the equal weight method.
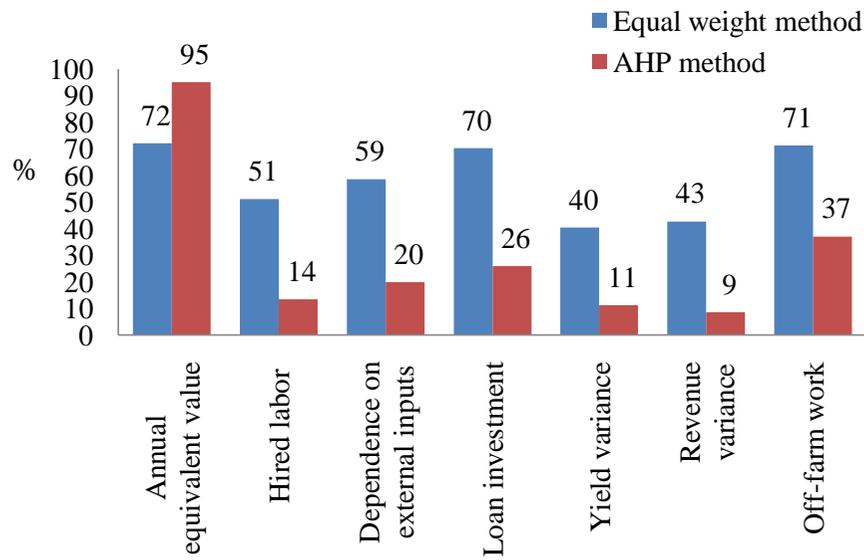
7.5 Comparison of the goal achievement rates at the farm level

7.5.1 Comparison of the goal achievement rates between the small farms using chemicals and the small farms using chemicals and bioextract
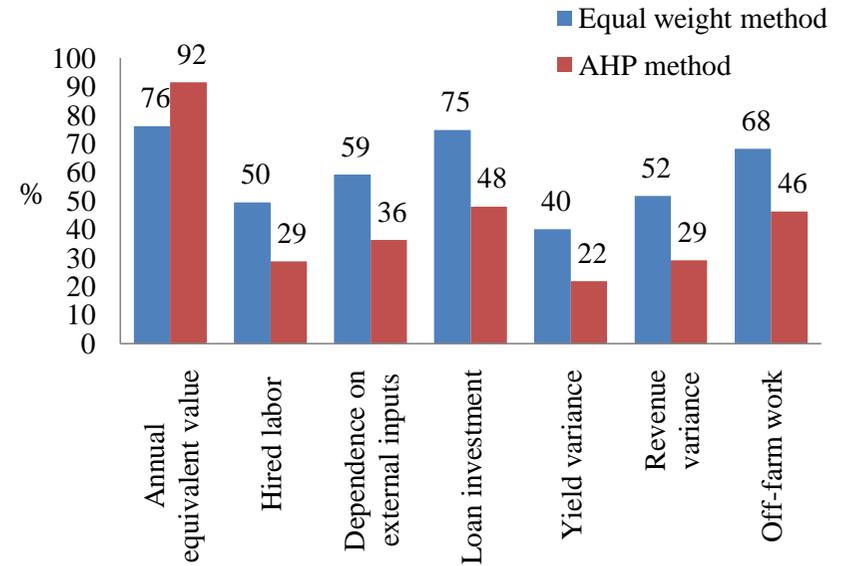
The goal achievement rate for the small farm using chemicals and bioextract gave better results than the small farm using chemicals. The small farms using chemicals and bioextract gave a higher rate of achieved goals in both the equal weight and AHP methods. This means that crop production using chemicals and bioextract gave more balance between the economic, social and environmental objectives. There was an environment-friendly pattern of land use which showed a decrease in the dependence on external inputs to 36 percent by the AHP method although the equal weight method was the same for both methods at 59 percent. There was also a high achievement rate in the results for the annual equivalent value of 76 and 92 percent for the equal weight method and AHP method respectively (Figure 7.13).

7.5.2 Comparison goal achievement rate between the large farms using chemicals and the large farms using chemicals and bioextract

The results showed that the goal achievement rates for large farms using chemicals and bioextract gave better results than the large farms using chemicals. This was especially true for the equal weight method which achieved a high goal achievement rate. The large farms were oriented towards a business management strategy with the aim of high revenue and profits. They gave little importance to the environmental and social objectives so that the results show low achievement rate for certain goals such as hired labor and dependence from external inputs for the large farms using chemicals. If the crop production was increased, bioxtract substitution would increase the goal achievement rate and would result in more balance between the economic, social and environmental objectives (Figure 7.14). Agricultural production with reduced chemical use is possible if a decrease in chemical use could be compensated by increase in bioextract which would have a positive impact both on the environment and the farmers' health.
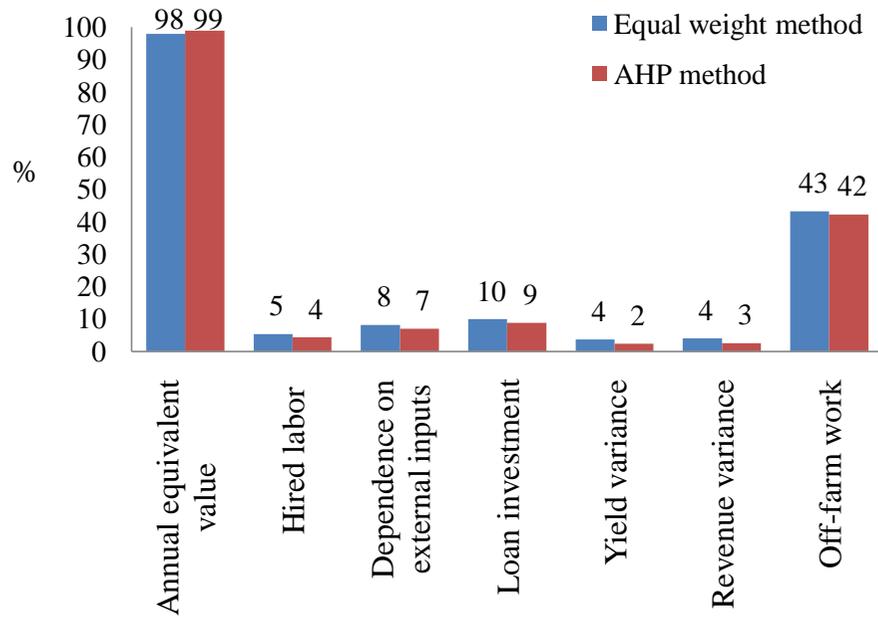
Figure 7.13 Comparison goal achievement rate between the small farms using chemicals and

the small farms using chemicals and bioextract

Large farms using chemicals

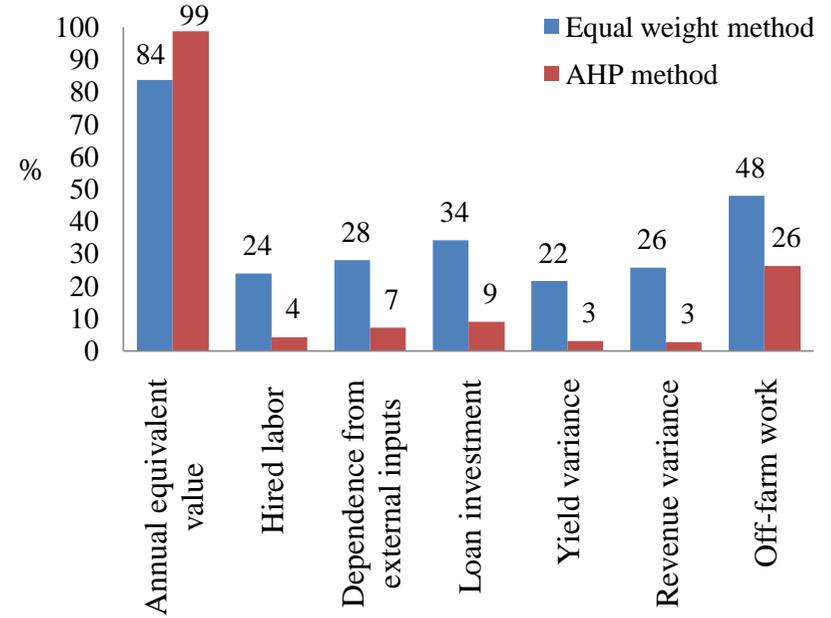**Large farms using chemicals and bioextract**

Figure 7.14 Comparison goal achievement rate between the large farms using chemicals

and the large farms using chemicals and bioextract

7.6   An extrapolation to the watershed level using farm level results

7.6.1   An extrapolation of the optimal land use to the watershed level using farm level results

The farm level results from the optimal land use were extrapolated to the watershed level based on the proportion of land occupied by each farm type. These were calculated as follows:

1. Construct a table showing the area from each farm type divided by land type and calculate the horizontal totals; i.e. total of land from all farm types in the irrigated upland, and vertical totals; total land in each farm type across the four land types.

2. Calculate the percentage of land units per total area from all the farm types.

3. Multiply the percentage with the total land units at the watershed level. The resulting figure will then be the total land units from all the farm types at the watershed level.

4. Calculate the percentage of optimal land use for all the crop activities for the total area by the equal weight method and the AHP method.

5. Multiply the percentage of optimal land use for all the crop activities with the total land units from each farm type at the watershed level.

6. Calculate the total sum of crop activities in each farm type at the watershed level by the equal weight method and the AHP method.

An analysis from the extrapolation of optimal land use at the watershed level using farm level results from the equal weight method gave the following results as shown in Table 7.17.

Table 7.17 Data extrapolated to watershed level using farm-level results
by the equal weight and AHP methods

Land use	Crop activities	Equal weight	AHP
Irrigated upland (rai)	Citrus	87,198	106,227
	Coffee	5,911	-
	Sweet corn-sweet corn	13,964	846
Rainfed upland (rai)	Coffee	114,569	5,400
	Sweet corn-sweet corn	144,272	253,440
Irrigated lowland (rai)	Citrus	107,036	102,026
	Longan	1,862	-
	Rice-sweet corn	5,990	-
	Rice-sweet corn-sweet corn	6,311	16,513
	Rice-garlic-sweet corn	-	2,390
	Rice-onions- sweet corn	-	181
Rainfed lowland (rai)	Rice	32,961	40,590
	Lychee	7,628	-
Total area (rai)		527,614	527,614

- For the irrigated upland, the recommended optimal land use was for citrus production at 87,198 rai (13,951.68 hectare), coffee production at 5,911 rai (945.76 hectare) and sweet corn followed by sweet corn at 13,964 rai (2,234.24 hectare).

- For the rainfed upland, the recommended optimal land use was for coffee production at 114,569 rai (18,331.04 hectare) and sweet corn followed by sweet corn at 144,272 rai (23,083.52 hectare).

- For the irrigated lowland, the recommended optimal land use was for citrus production at 107,036 rai (17,125.76 hectare), longan production at 1,862 rai (297.92 hectare), rice followed by sweet corn at 5,900 rai (958.4 hectare) and rice followed by sweet corn and sweet corn at 6,312 rai (1,009.76 hectare).

- For the rainfed lowland, the recommended optimal land use was for rice production at 32,961 rai (5,273.76 hectare) and lychee production at 7,629 rai (1,220.48 hectare).

An analysis of optimal land use using the AHP method was extrapolated to the watershed level from the farm level with the following results:

- For the irrigated upland, the recommended optimal land use was for citrus production at 106,227 rai (16,996.32 hectare) and sweet corn followed by sweet corn at 846 rai (135.36 hectare).

- For the rainfed upland, the recommended optimal land use was for coffee production at 5,401 rai (864 hectare) and sweet corn followed by sweet corn at 253,440 rai (40,550.4 hectare).

- The irrigated lowland, the recommended optimal land use was for citrus production at 102,026 rai (16,324.16 hectare), rice followed by sweet corn and sweet corn at 16,513 rai (2,642.08 hectare), rice followed garlic and sweet corn at 2,390 rai (382.40 hectare) and rice followed by onions and sweet corn at 181 rai (28.96 hectare).

- The rainfed lowland was assessed as being suitable only for rice production at 40,590 rai (6,494.4 hectare).

7.6.2 The extrapolation of the objective goals achieved at the watershed level using farm level results

The farm level results of objective goals achieved were extrapolated to the watershed level based on the proportion of goals achieved by each farm type. These were calculated by each achieved goal level multiplied by the total land from each farm type at the watershed level. The sum of each row was caculated for every goal for all the farm types and divided by the total area in the watershed. This gave an extrapolated figure for the objective goals achieved at the watershed level. The results found that both methods gave the highest value for the annual equivalent value goal followed by the off-farm work goal and lowest value was for the yield variance goal.

When the equal weight method and AHP methods were compared, the results were highest for the annual equivalent value goal (GA) by the AHP method and the other goals were lower than by the equal weight method. The equal weight method gave a range of achieved goals of between 90.67 and 14.20 percent or a goal range of 76.48 percent. The AHP method gave a range of achieved goals of between 97.85 and 5.34 percent or a goal range of 92.51 percent (Figure 7.15).
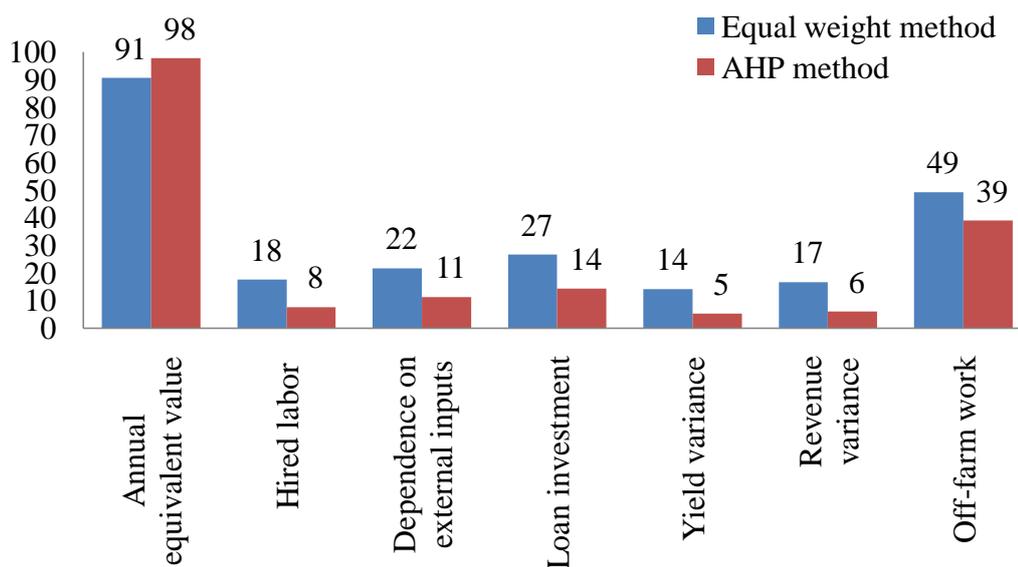

Figure 7.15 Objective goals achieved when extrapolated at the watershed level by the equal weight and the AHP methods

This chapter evaluated the optimal resource management at the farm level for the four farm types by the equal weight and AHP methods. An optimal was assessed for land use planning, household labor, hired labor, loan investment, net annual revenue from crop production and the goals achievement rate. An analysis for the extrapolation of optimal land use at the watershed level using farm level results from the equal weight and AHP methods was also conducted. This included the extrapolated results for the achieved goals to the watershed level based on the proportion of goals achieved by each farm type which led to a comparison between the results of the equal weight and AHP methods.