

## **CHAPTER 9**

### **OPTIMAL RESOURCE MANAGEMENT AT THE WATERSHED LEVEL**

This chapter deals with the results of optimal resource management at the watershed level. Two different methods: the equal weight method and the AHP method were used. The equal weight method used data from the field survey and this study gave the weighted objective goals an equal value. The AHP method used the weighted objective goals as determined by the stakeholders.

#### **9.1 Optimal resource management at the watershed level**

##### **9.1.1 Optimal resource management by the equal weight method at the watershed level**

###### **1. Optimal land use management**

An analysis by the equal weight method assessed the optimal land use management for the watershed level. The results found that the area suitable for permanent crops such as citrus and coffee was 65,806 hectare or 77.95 percent of the total area and 22.05 percent for the cash cropping systems (18,612 hectare). The permanent crops will produce an annual income and the model recommended using the land units for the crop activities as shown in Table 9.1.

Table 9.1 Optimal land use management by the equal weight method  
at the watershed level

Land unit	Crop activities	Land use (hectare)
Irrigated upland	Citrus	17,132
Rainfed upland	Coffee	36,976
	Sweet corn- sweet corn	4,439
Irrigated lowland	Citrus	19,378
Rainfed lowland	Rice	6,494
Total area		84,418

- The irrigated upland and irrigated lowland was assessed as being optimal when the land was planted with citrus at 17,132 hectares and 19,378 hectares respectively. The harvest starts in October, reaches a peak in December and tails off in January.
- The rainfed upland was assessed as being optimal when the land was planted with coffee at 36,976 hectares and this was usually harvested in October.

The cropping systems were earning revenue every three or four months. The model recommended using the land units for the following crop activities:

- The rainfed upland was assessed as being optimal when the land was planted with sweet corn followed by sweet corn at 4,439 hectares. The first crop was planted in May and harvested in July and second crop was from August to October.
- The rainfed lowland was assessed as being optimal when the land was planted with rice at 6,494 hectares. It was planted in June and harvested from October to December.

## 2. Off-farm work and hired labor

The results found that the optimal household labor management for the watershed level was total off-farm work at 746,991 man-days per year or 5.31 percent of the total household labor per year. This was primarily using household labor in the watershed for crop activities. However, the household labor in the watershed was not sufficient for all the production activities especially during the planting and harvesting periods. In this study, the model recommended hired labor for the watershed at a total of 845,425 man-days per month during March and December. In each month, the hired labor was used as presented in Table 9.2.

Table 9.2 Optimal use of household labor and hired labor  
by the equal weight method at the watershed level

Activities	Man-days
Household off-farm work	746,991
Hired labor	
January	816,915
February	830,722
March	845,425
April	310,115
May	391,265
June	677,014
July	418,111
August	202,731
September	276,955
October	631,505
November	621,147
December	845,425

- In March, there was full employment for household labor and hired labor in citrus pruning on the irrigated upland and irrigated lowland (36,509 hectares).
- In December, the citrus was ripe, so a lot of labor was needed for harvesting.
- The hired labor needed was at its lowest in August at 202,731 man-days. During this month, the main work was caring for crops with activities such as chemical spraying, fertilizer distribution, mowing and watering.

### 3. Loan and interest repayments

The watershed level had a total capital investment of 2,566 million baht but this was not sufficient. The model recommended having loans from the BAAC of 2,910 million baht. The BAAC had an interest rate of 7.5 percent per year with a total repayment figure of 3,128 million baht.

### 4. Net annual revenue from crop production

The optimal resource management gave the watershed level as having a total revenue after loans and interest repayments of 12,664 million baht minus the household consumption of 1,849 million baht (averaging 79,635 baht per household multiplied by the number of agricultural households in the watershed (23,215 households). This gave a net annual revenue from crop production of 10,815 million baht

## **9.1.2 Optimal resource management by the AHP method at the watershed level**

### 1. Optimal land use management

An analysis by the AHP method assessed optimal land use management for the watershed level. The results found that an optimal area for using forest resources was 25,123 hectares or 29.76 percent of the total area. The agricultural crops used 59,296 hectares or 70.24 percent of the total area. The agricultural area was divided into

permanent crops (57,725 hectares or 68.38 percent of the total area) and cash crops (1,570 hectares or 1.86 percent of the total area). The permanent crops were citrus, coffee, tea, longan and lychee. The details are as presented in Table 9.3.

Table 9.3 Optimal land use management by the AHP method at the watershed level

Land unit	Crop activities	Land use (hectare)
Irrigated upland	Longan	11,756
	Tea	2,451
	Sweet corn- sweet corn	1,570
	Forest	1,354
Rainfed upland	Lychee	13,526
	Coffee	10,614
	Forest	17,274
Irrigated lowland	Citrus	19,378
Rainfed lowland	Forest	6,494
Total area		84,418

- The irrigated upland was assessed as follows:
  - Longan production at 11,756 hectares; the harvest and subsequent pruning occurs during July and August.
  - Tea production at 2,451 hectares; there were two periods of harvesting and pruning; during June and July and between October and November.
  - Sweet corn followed by sweet corn at 1,570 hectares; there were two periods for planting and harvesting; May and July followed by August and October.
  - Forest area at 1,354 hectares.
  
- The rainfed upland was assessed as follows:
  - Lychee crop at 13,526 hectares; this was harvested and subsequently pruned during June and July.

- Coffee production at 10,614 hectares; this was harvested and pruned during October or early November.
- Forest area at 17,274 hectares.
  
- The irrigated lowland was assessed as being suitable for citrus at 19,378 hectares: the harvest starts in October and reaches a peak in December. Pruning takes place between February and March.
- The rainfed lowland was left as forest at 6,494 hectares.

## 2. Off-farm work and hired labor

The results found that the optimal household labor management for the watershed level was total off-farm work at 1,39 million man-days per year or 9.87 percent of the total household labor per year. This was primarily using household labor in the watershed for the crop activities. This was not sufficient for all the production activities especially during the planting and harvesting periods. In this study, the model recommended employing hired labor for 845,425 man-days per month during February, March, June, July, August, October, November and December. In each month, the hired labor was used as presented in Table 9.4.

Table 9.4 Optimal household labor and hired labor by the AHP method  
at the watershed level

Activities	Man-days
Household off-farm work	1,389,148
Hired labor	
January	792,501
February	845,425
March	845,425
April	693,731
May	617,743
June	845,425
July	845,425
August	845,425
September	773,868
October	845,425
November	796,780
December	845,425

- In February and March, there was full employment for the household labor and hired labor in citrus pruning on the irrigated lowland at 19,378 hectares.
- In June, July and August, the hired labor was used as follows:
  - In the irrigated upland, there was harvesting and pruning the tea crop at 2,451 hectares.
  - In the rainfed upland there was harvesting and pruning the lychee crop at 13,526 hectares.
  - In July and August, in the irrigated upland, there was harvesting and pruning the longan crop at 11,756 hectares.
- In October, the hired labor was used as follows:
  - In the irrigated upland, there was harvesting the second sweet corn crop at 1,570 hectares and starting to harvest the second tea crop at 2,451 hectares.

- In the irrigated lowland, there was the start of the citrus crop harvest at 19,378 hectares.
- In November, in the irrigated upland, there was the tea harvest. In the irrigated lowland, there was the citrus harvest.
- In December, the citrus harvest was at its peak so a lot of labor was needed.
- The quantity of hired labor needed was at its lowest in May at 617,743 man-days. During this month, there was taking care of the crops with activities such as chemical spraying, fertilizer distribution, mowing and watering.

### 3. Loan and interest repayments

The results found that the model recommended having total loans from the BAAC of 2,449 million baht. The BAAC had an interest rate of 7.5 percent per year with total repayments 2,633 million baht.

### 4. Net annual revenue from crop production

When the stakeholder increased the environmental weighting and the model was optimized in favor of the forest area, it resulted in a loss of agricultural land from 84,418 hectares to 59,296 hectares. The optimal resource management gave the watershed level a revenue after loan and interest repayments of 7,444 million baht. When the household consumption of 1,849 million baht was subtracted, this gave a net annual revenue from crop production of 5,595 million baht.

#### **9.1.3 Goal achievement rates by the equal weight and AHP methods at the watershed level**

The results from the equal weight and the AHP methods show different goal achievement rates. The equal weight method achieved the highest score at 93.56 percent of the target goal for the annual equivalent value followed by employment at 86.86

percent. The lowest goal achievement rate was in the revenue variance at 4.66 percent. The AHP method achieved the highest score at 68.85 percent in soil erosion and revenue from non-timber forest products. The other goals achieved rates between 45.59 to 59.92 percent of the target goals (Figure 9.1). The results show that the AHP method gave a goal achievement rate where the results were within a narrow spread of each other. The highest results were for the environmental objectives such as revenue from non-timber forest products, nitrogen use and soil erosion. However, the results recommended reducing the economic objective (annual equivalent value) but this could be compensated for by an increase in revenue from non-timber forest products.

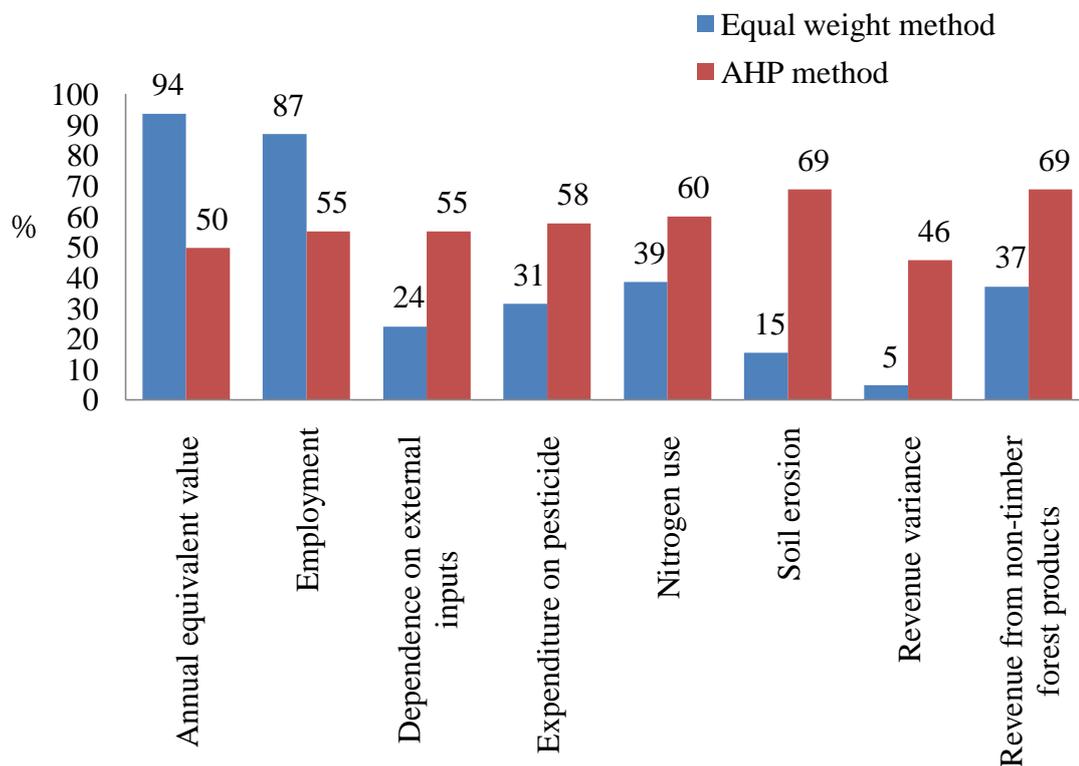


Figure 9.1 Objective goals achieved using the equal weight and the AHP methods at the watershed level