# CHAPTER IV

# MATERIALS AND METHODS

The research work was divided into *miang* grower interview and field study. The field study was conducted to determine canopy structure and root architecture.

## 4.1 Farmer Interview

### 4.1.1 Location

The farmer interview was carried out during July 1997 at Ban Phadeng, Pa Pae sub-district, Mae Taeng district, Chiang Mai province. It is approximately 67 km northwest from Chiang Mai city. The main agricultural practice was traditional *miang*. Ban Phadeng is an old settlement for over 100 years. The number of household of Ban Phadeng was 115, settled along 1.5 km of the Chiang Mai province to Pai district road (AAN, 1995).

Geographically Ban Phadeng is located at 98° 44′ north latitude and 19° 06′ east longitude. In Universal Transverse Mercater (UTM) system, it is located at 472,000 mE and 2,113,000 mN of zone 47.

### 4.1.2 Methods

The structured interview with questionnaire was used to interview 19 *miang* growers and pickers. They were interviewed on past and present land use practices in which the indigenous *miang* system was incorporated. The attitude of growing *miang* and perspective of future land use were also asked.

## 4.2 Field Study

### 4.2.1 The Experimental Site

Canopy structure, root architecture, canopy gap analysis, productivity and income of *miang*-based agroforestry system were conducted from December 1995 to December 1996 at one farmer's field, Ban Phadeng, Pa Pae sub-district, Mae Taeng district, Chiang Mai province. The total area of the field covers 6.4 ha. The area was forest land with 35-40% slope and altitude 800-900 m above mean sea level.

**Table 4.1** Meteorological data in 1996 of Nong Hoi meteorological station, Mae Rim district, Chiang Mai province.

| Month | Min. Temp. (°C) | Max. Temp. (°C) | Rainfall (mm) | Actual Solar Radiation (mm $d^{-1}$) | E-pan (mm $d^{-1}$) |
|---|---|---|---|---|---|
| January | 9.1 | 30.2 | 0 | 6.4 | 3.2 |
| February | 11.3 | 31.1 | 23.6 | 6.5 | 3.9 |
| March | 16.9 | 36.3 | 7.0 | 8.3 | 4.9 |
| April | 18.2 | 37.5 | 107.0 | 7.8 | 4.6 |
| May | 18.6 | 35.6 | 75.6 | 7.5 | 3.9 |
| June | 18.6 | 33.6 | 210.0 | 6.7 | 3.0 |
| July | 19.1 | 32.1 | 134.1 | 6.2 | 2.5 |
| August | 18.0 | 27.7 | 242.0 | 5.9 | 2.9 |
| September | 18.8 | 26.9 | 210.8 | 6.1 | 2.4 |
| October | 18.1 | 25.7 | 141.4 | 5.9 | 3.2 |
| November | 15.5 | 24.7 | 123.0 | 5.4 | 2.2 |
| December | 12.0 | 23.1 | 0 | 5.0 | 2.1 |
| Total | | | 1,274.5 | | |
| Mean | 16.2 | 30.4 | | 6.5 | 3.2 |

Source: Department Soil Science and Conservation, Faculty of Agriculture, Chiang Mai University, Thailand.

The climate where the experimental site was carried out characterised by hot summer and cold winter. Table 4.1 shows meteorological data of Nong Hoi sub-district which is located at the same elevation with Papae sub-district, 22 km from the experiment site. The torrential rainfall started in April until November and had little rainfall in January, February, March and December. The mean monthly temperature ranged from 16.8 °C in December to 26.5 °C in April. The highest pan evaporation (4.9 mm $d^{-1}$) was in March and the lowest was in December (2.1 mm $d^{-1}$). The actual solar radiation was 8.3 mm $d^{-1}$ in March and the lowest was 5.0 mm $d^{-1}$ in December.

### 4.2.2 Materials

The *miang*-based agroforestry system comprised of natural trees, planted trees, fruit trees and tea. The natural trees occupied top storey such as *Dipterocarpus alatus*, *Gemelina arborea*, and *Schima wallichii*

The planted tree, *Zanthoxylum rhetsa* (rhetsa), was the second storey under the natural trees. The underneath canopy was *Camellia sinensis* (tea or *miang*). The fruit trees as the third storey were *Artocarpus heterophyllus* (jack fruit), *Citrus grandis* (pomelo), *Litchi chinensis* (litchi), *Mangifera indica* (mango), *Prunus mume* (Japanese apricot), *P. persica* (peach), *Psidium guajava* (guava) and *Sandoricum indicum* (santol).

### 4.2.3 Management of Experiment

The three different components and arrangement stages from the existing *miang*-based agroforestry pattern were identified. Each stages covering an area of 1-1.5 ha had different combinations of rhetsa fruits trees and *miang*. The characteristics of each representative stages are as follows:

(1) Mature stage: Rhetsa and fruit tree were mature. *Miang* was grown at randomly in wide spacing and short row. After the natural trees, rhetsa was the second storey followed by fruit trees and *miang*. The dominated species for fruit trees were mango, pomelo and peach. The size of the studied plot was 3,200 $m^2$ with the dimension of 40*80 m.

(2) Middle stage: Rhetsa and fruit tree were younger than the mature stage, however they produced yield. Rhetsa was the most top storey. *Miang* was under storey grown at alternate rows with fruit trees which mango was middle storey. Rhetsa was grown randomly. The size of studied plot was 2,800 $m^2$ with dimension of 40*70 m.

(3) Early stage: Rhetsa was the newly established about one year, therefore, it was under storey and no yield. While *miang* was middle storey and mango as the second storey after the natural trees. *Miang* was grown at alternate row with row of fruit trees and rhetsa. Since, rhetsa was grown alternately plant with mango in the same row. The dominated fruit tree species were mango and litchi. However, litchi was in juvenile stage. There were many ages of mango such as 2, 4 and 8 years old. The size of the studied plot was 2,400 $m^2$ with the dimension of 30*80 m.

The characteristics of each stage are shown in Table 4.2. Middle stage plot was different from the other patterns in conservation practice, viz., terracing practice in middle stage plot. *Miang* was grown in row in middle stage and early stage plots. The direction of *miang*'s rows were the north-south. However, it was grown in short row and randomly in mature stage plot. The fruit trees in mature stage plot were grown with spacing of 4*4 m and 8*4 m in middle stage and early stage plots, the row direction was north-south as well. Rhetsa was not planted in alignment in mature stage and middle stage plot, but it was grown in row in early stage plot.

**Table 4.2** Characteristics of three stage plots in *miang*-based system.

| | Mature stage plot | Middle stage plot | Early stage plot |
|---|---|---|---|
| Plot size ($m^2$) | 3,200 | 2,800 | 2,400 |
| Slope (%) | 38 | 40 | 35 |
| Aspect | west facing | west facing | west facing |
| Conservation practices | grass cover | grass cover<br>*miang* hedgerow<br>terracing | grass cover<br>*miang* hedgerow |
| Arrangement of *miang* | randomly and short row with spacing 4*1 m | row with spacing 4*1 m | row with spacing 4*1 m |
| Arrangement of rhetsa | randomly | randomly | row |
| Arrangement of fruit trees | rectangular row with spacing 4*4 m | triangular row with spacing 4*8 m | triangular row with spacing 4*8 m |

### 4.2.4 Above-ground Measurements

The co-ordinate of existing trees and *miang*s in the sampling patterns were recorded in Cartesian co-ordinate. Each studied plot was divided into grid of 10 m times 30-40 m with rope. The smallest scale on the rope was 1 m. The Cartesian co-ordinate was recorded and imprinted every tree and *miang* position on graph paper. The positions of each tree and *miang* were redrawn again in the tracing paper.

4.2.4.1 Stem Measurement

Tree's height (H), diameter at breast height (DBH) and basal diameter (BD) were measured to estimate above-ground biomass.

To estimate the woody volume accumulation, Hakkila (1989) recommended to use form factor (F), which depends upon the percentage of branch. Form factor is the function of basal cross sectional area ($CSA_{BD}$), height (H) and above-ground woody volume (V) (Suprichakorn, 1982). The formula are as follows:

$$F = \frac{V}{CSA_{BD} * H}$$

Then,

$$V = F * CSA_{BD} * H$$

4.2.4.2 Canopy Measurement

Canopy measurement was carried out on every tree and every *miang* plant. It was included tree height, crown edge height, crown depth, crown width and crown shape. Crown edge height was measured the height from the ground level to the imaginary canopy flat (Hinchaem, 1986). Crown height was measured from the lowest crown to the highest crown. Crown width was measured as a radius in four direction, i.e., north, south, east and west. Crown shape was qualitative data, i.e., use the sight evaluation, for instance round shape, conical shape, bell shape, etc. Since, the crown shape can be converted to quantitative data in term of form factor approximately. Crown width and crown shape were also used for drawing the canopy map. Crown of each tree species such as rhetsa, mango and *miang*, was drawn in tracing paper to show the canopy cover.

4.2.4.3 Phenological Characteristics Record

Phenological characteristics included litter fall, emergence of new leaf, and self-pruning branching characteristics were studied in order to classify the tree as ever green or deciduous species.

4.2.4.4 Canopy Structure

Canopy gap of upper storey was studied in term of crown closure, and index of gap size which imitates from index size of clearing (ISC)

$$\text{Crown closure} = \frac{\text{Area of crown cover}}{\text{Total area}}$$

Since the ISC is the ratio of radius of canopy gap (D) and average height of tree around the area (H), therefore,

$$\text{ISC} = \frac{D}{H}$$

### 4.2.5 Root Measurement

Proximal root geometry and fractal branching model were used to estimate root parameters. Only the dominant species in the patterns were selected to study the root, i.e., 40 trees for mango, 16 plants for *miang*, 8 trees for pomelo, and 6 trees for rhetsa. The basal part of the roots at the stem base was excavated with care, in half sphere of 0.5-1.0 m radius.

Root diameter and angle from the horizontal plane were measured for all proximal roots, i.e., roots originated from the stem base or lateral from the top part of the tap root ($D_o$). Root diameter before ($D_{before}$) and after branching point ($D_{after}$), length of internode ($L_l$), and diameter of root tip ($D_m$) were measured.

The number of root branch per branch event ($N_k$) were recorded. The roots were classified to horizontal ($D_{hor}$) and vertical ($D_{vert}$) root that angle less than 45° and more than 45° from horizontal plane respectively. The root samples were taken for measuring the specific root density in laboratory.

These measurements were used to calculate the parameters, i.e., total root length, root dry weight, root volume, specific root length, length of longest branch root and horizontal root spread or index of shallow rootedness.

4.2.5.1 Test of Fractal Model

However, before calculating the parameters, the fractal model of root has to be tested. The regression analysis was a tool to test the independence of root diameter to link length, α and q. The null hypothesis of no relation was tested with 5% probability level (Van Noordwijk and Purnomosidhi, 1995). The α and q were calculated from the following formulas:

$$\alpha = \frac{(\text{Diameter before branching})^2}{\sum(\text{Diameter after branching})^2}$$

$$q = \frac{\max.\, D_{after}^2}{\sum D_{after}^2}$$

4.2.5.2 Specific root density (δ)

The roots were cut into 10 cm long. The samples were taken from 4 trees in each species. Roots were cut at beginning part, middle part, and end part of root. Root volume was measured by water substitution in graduate cylinder. Root dry weight was measured after placing it into hot air oven with temperature of 75 °C for 48 hours (Ryser and Lambers, 1995). Specific root density was calculated from the following formula:

$$\delta = \frac{\text{Root dry matter}}{\text{Root volume}}$$

4.2.5.3 Root isoline or Altitude ($N_p$)

$$N_p = \frac{2\log(D_o/D_m)}{\log(\alpha N_k)}$$

4.2.5.4 Total root length ($L_t$)

$$L_t = \frac{(N_k^{N_p+1} - 1)}{(N_k - 1)} L_1$$

4.2.5.5 Root dry weight ($W_t$)

$$W_t = \frac{\delta \pi D_o^2 L_1}{4}(N_p + 1)$$

4.2.5.6 Specific root length ($L_{rw}$)

$$L_{rw} = \frac{L_t}{W_t}$$

4.2.5.7 Length of main axis ($N_{max}$)

$$N_{max} = N_p * L_l$$

4.2.5.8 Index of shallow rootedness (SR)

$$SR = \frac{\sum D_{hor}^2}{BD^2}$$

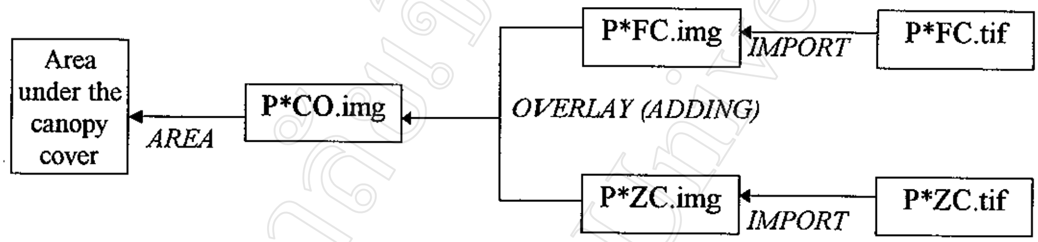
### 4.2.6 Spatial Analysis in *Miang*-based Agroforestry Systems

The spatial information system was used to estimate the canopy gap and in the studied pattern. The maps of canopy and of rhetsa, fruit trees and *miang* were drawn separately and then digitised by raster scanning using an optical scanner. The DeskScan II software was a tool for scanning and stored in TIF extension file. Filling the colour of polygon and editing the drawing errors by using Aldus PhotoStyler 2.0 software.

The map analysis under IDRISI software (Eastman, 1995) was used to combine and analyse among canopy maps to produce the thematic map of availability space. However, before analysis with IDRISI software, the image in the form of TIF-images had to be converted to IMG-images which could be used for analysis in IDRISI. The cartographic model of analysis are shown in Figure 4.1, Figure 4.2 and Figure 4.3.

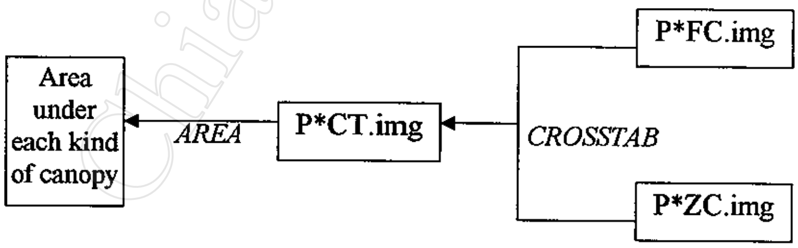
Canopy maps of rhetsa (P*ZC.img) and fruit trees (O*FC.img) were overlaid by using '*OVERLAY (ADDING)*' (Figure 4.1). Then the output of map was P*CO.img showed the overlay and single canopy as well as open space.

Figure 4.2 shows the analysis similar to Figure 4.1, but the output map and area analysis showed the detail of interactions (P*CT.img) by using '*CROSSTAB*'. The out put map (P*CT.img) was calculated the area under the kind canopied cover and open space by using '*AREA*'.




P* - Mature stage or middle stage or early stage
P*FC - Canopy of fruit trees
P*ZC - Canopy of rhetsa
P*CO - Canopy of fruit trees *OVERLAY* with canopy of rhetsa

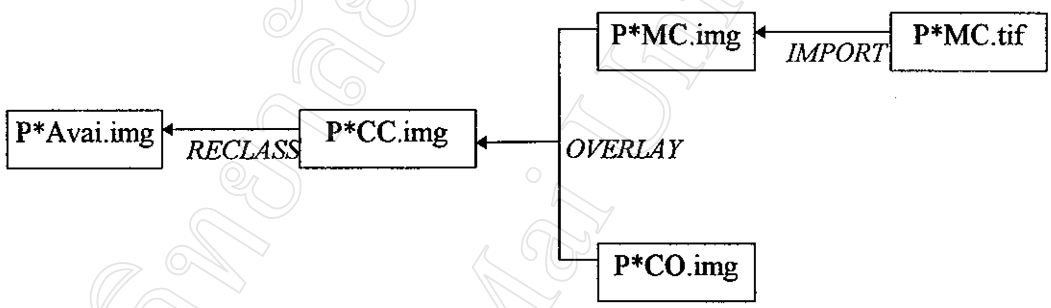
**Figure 4.1** A cartographic model for determines the area under canopy cover of rhetsa and fruit trees.




P* - Mature stage or middle stage or early stage plots
P*FC - Canopy of fruit trees
P*ZC - Canopy of rhetsa
P*CT - Canopy of fruit trees *CROSSTAB* with canopy of rhetsa

**Figure 4.2** A cartographic model for classifying the canopy

The process of analysis to come up with output map of availability area are shown in Figure 4.3. Map of canopy of *miang* (P*MC.img) was generated by the module '*OVERLAY*' with the output map to show interaction of canopy of rhetsa and fruit trees. The P*CC.img map showed the canopy cover from rhetsa, fruit trees and *miang*. The output map (P*Avai.img) came from using '*RECLASS*' the P*CC.img, indicated the area where the new plants can be established.




P* - Early stage or middle stage or mature stage
P*MC - Canopy of *miang*
P*CO - Canopy cover of fruit trees and rhetsa (*OVERLAY*)
P*CC - Canopy cover of rhetsa, fruit tree and *miang*
P*Avai - Availability space map

**Figure 4.3** A cartographic model for classifying the availability space for adding new plants.

### 4.2.7 Financial Assessment

Benefit-cost ratio was used to evaluate the three patterns of *miang*-based agroforestry system. The cost at any month in a year such as material inputs and labour were recorded. Benefit was calculated from sales of the products at any month in a year with the actual market price. Benefit and cost in terms of net present value, and benefit-cost ratios of the different patterns were analysed. The benefit-cost ratio was calculated from the formula:

$$\text{B.C ratio} = \frac{\sum_{t=1}^{n} B_t \Big/ (1+i)^t}{\sum_{t=1}^{n} C_t \Big/ (1+i)^t}$$

where,

$B_t$ - benefit at t-month

$C_t$ - cost at t-month

t - month

i - monthly discount rate

The discount rate here was the average of opportunity cost of capital (OOC) which suggested by Arayarangsarit (1985) for the developing country. The OOC is varying between 8-15% per year, with average of 12% per year, i.e, 1% per month.