CHAPTER III

METHODOLOGY

3.1 SITE DESCRIPTION: NONG MEG-NONG HEE CULTURAL FOREST

This research was conducted at Nong Meg-Nong Hee cultural forest in Ban Suea Tao, Tambon Suea Tao, Amphoe Chiang Yuen, Maha Sarakham Province, Northeastern Thailand. The boundaries of this forest are as:

To the North: Ban Nong Rue, Tambon Suea Tao, Maha Sarakham Province;
To the South: Ban Kheng, Tambon Sue Tao, Maha Sarakham Province;
To the East: Communal land of Ban Suea Tao villager; and
To the West: Ban Khok Pae, Tmbon Khok Sri, Maha Sarakham Province.

Forest resources

Nong Meg-Nong Hee forest is one of the several cultural forests in Maha Sarakham Province. The forest is entirely surrounded by communal lands and covers public land area. It has been managed by local organization and the main purposes of this forest are focused on conservation use of non-timber forest products and for cultural practices. The cultural forest in Ban Suea Tao was classified as broad-leaf dry dipterocarp forest and consists of 2 different utilization types; Don Pu Ta forest (cemetery forest) and Tam Lae forest (public forest which named Nong Meg-Nong Hee). About 37 years ago, there was a small hill named Phu Kratae in the north of forest area but, in 1961, it was a concession of lateritic soil mine at Phu Kratae used for construction of Khon Kaen-Kalasin main road. The remaining of those activities is roughly hilly area with severe soil erosion. At present, Don Pu Ta area covers only 2 rai because some area had been donated to settle the Suea Tao's health care center. However, it is use for annual traditional ceremony. Tam Lae forest, covering 1169 rai (187 hectares), has been divided into 2 parts (Nong Meg-Nong Hee) with the main traveling road. All of them are served as the "natural market" for local people around there.

Five nearest villages, Ban Sua Taow, Ban Kheng, Ban Sua Taow Pattana, Ban Kheng Pattana, and Ban Kheng Mai Pattana, responsible for managing of Nong Meg forest-Nong Hee forest. According to regulation rules of local organization, fire suppression has been implemented since 1995 and forest has developed into more mature of successional stage. In 1999, the local community organization was one of the northeast local community that received the forest conservation flag with the highest honorable from Her Majesty Queen Sirikit at Phu Pan Royal Palace.

Soil resources

There were two soils types found in this forest, classified according to Soil Development Department as series No.17 and No. 35. Soil series No. 17 is characterized by sandy particulates mixed with clay. This soil type has a light brown to grey color with brown, yellow, or red spots throughout distributed, with a pH range of 4.4-5.5. Lateritic soil was found in some area especially at the northwest of forest areas. Soil series No. 35 is characterized by friable soil mixed with clay with brownish-grey, yellow, or red color. This type has high porosity and a pH range of 4.5-5.5 (Walai Rukhavej Botanical Research Institute, 1998).

Water Resources

There are many water resources (both man-made and nature) in the Ban Suea Tao area which are:

- Soak Sam Roi reservoir;
- Ta Aeung irrigation weir;
- Nong Naree reservoir;
- Nong E-ka reservoir;
- Nong Suea Taow irrigation weir;
- Nong Hee reservoir; and
- Huai Sai Bart stream.

3.2 THE CONCEPTUAL FOR SELECTION CRITERIA AND INDICATORS

3.2.1 Top-down and bottom-up approach

In this study, two approaches of selection and assessing/testing criteria and indicators, a top-down and a bottom-up approach, were combined and used to ensure that the appropriate conceptual information and field information were retained (Prabhu et al., 1996).

The top-down approach was always used, since starting until ending fieldwork, to generate the first set of ecological integrity's C&I. According to this approach, the existing standard generic templates of different management level available from several sources of C&I templates (e.g. ITTO, CIFOR, etc.) were considered as the template's framework. Moreover, the management goals and practices of local organization, and also harvesting pattern of local people nearby cultural forest were also considered to select C&I. Thus, this approach can be used initially to examine and to revise (mainly by rewording, rephrasing, rearranging, replacing, adapting, and modifying) the selected set of C&I.

The bottom-up approach was organized during the fieldwork with the participation of local team to filter the initial set of C&I in the direct involvement and participation of local organization. Along with this approach, the main objectives of C&I selection are also harmonious to the concept of ecological integrity with current pattern of forest utilization of local people.

3.2.2 Selection set of ecological integrity's criteria and indicators

This study can be divided into 2 mainly phases, Phase I "Selection and pre-field revised initial set of C&I" and Phase II "Filtering and testing initial set of C&I (Multi-Criteria Analysis)".

Phase I. Selection and pre-field revised initial set of criteria and indicators

During this phase, theoretical of ecological integrity concept and the existing standard generic templates of C&I, aiming only at ecological category, were reviewed and used as the framework database for selecting initial set of C&I (Noss, 1990; FSC, 1994; Koop et al. 1995; Stork et al., 1997; ITTO, 1998; Colfer et al. 1999; Oliver, 2002). Preliminary survey, review of site information and desk exercise were essential to carry out the appropriately initial set of ecological integrity C&I. Regarding with local participation, a three-person team[1] was selected from the local organization which is playing a major role in forest management (*i.e.* policy making and rules regulation). The first member is the chairman; the second and the last one are the first and second assistant of local forest organization, respectively. This team was involved in the filtering processes throughout of both phases. The initial set of C&I which consisted of 3 principles, 8 criteria, and 40 indicators was generated in a hierarchical framework as show in Table 3.1. Thus, after the end of this phase the revision set of ecological integrity C&I will be generated.

[1] Team members have already mentioned in Chapter 3 in Phase I description. There were Mr. Boonkwan Suwanpakdee (chairperson of local forest organization), Mr. Niyom Khokpae (the first assistant), and Mr. Prajak Chomthong (the second assistant).

Table 3.1 Initial set of C&I for forest ecological integrity

Principle 1: Structure and composition of forest ecosystem are maintained
Criterion 1.1: To maintain landscape heterogeneity
Indicator 1.1.1: Areal extent of each patch/vegetation type to total forest area
Indicator 1.1.2: Number of patches/vegetation type per unit area
Indicator 1.1.3: Largest patch size/vegetation type
Indicator 1.1.4: Number of gap
Indicator 1.1.5: Largest gap size
Indicator 1.1.6: Patch distribution pattern
Indicator 1.1.7: Similarity of patch/vegetation type
Indicator 1.1.8: Average, minimum, and maximum distance between patches of the same cover type
Indicator 1.1.9: Area-weight patch/vegetation size
Criterion 1.2: To improve and maintain habitat heterogeneity
Indicator 1.2.1: Vertical stratification
Indicator 1.2.2: Canopy cover
Indicator 1.2.3: Frequency distribution of leaf size and shape
Criterion 1.3: To improve and maintain richness/diversity
Indicator 1.3.1: Species diversity
Indicator 1.3.2: Abundance of key stone species
Indicator 1.3.3: Abundance of nest of social bee
Indicator 1.3.4: Abundance of bird species
Indicator 1.3.5: Abundance of butterfly species
Principle 2: Forest ecosystem function is maintained
Criterion 1.4:To monitor population sizes and demographic structures of selected group
Indicator 1.4.1: Density and size class of tree
Indicator 1.4.2: Height class of sapling
Indicator 1.4.3: Relative abundance of seedling and sapling
Criterion 2.1: To conserve soil and water
Indicator 2.1.1: Frequency occurrence of detritivorous soil fauna of selected group
Indicator 2.1.3: Decomposition rate determines from leaf bag
Indicator 2.1.2: Soil pH and conductivity
Indicator 2.1.4: Quantity of leaf litters and small woody debris (under 10-cm diameter)
Indicator 2.1.5: Abundance of epiphytic species
Indicator 2.1.6: Abundance of epiphytic mosses
Indicator 2.1.7: Abundance of herbaceous bole climbers
Indicator 2.1.8: Abundance of amphibian species
Indicator 2.1.9: % ground cover
Indicator 2.1.10: Soil nutrient contents
Indicator 2.1.11: Frequency occurrence of soil erosion
Criterion 2.2: To improve and maintain yield and forest products
Indicator 2.2.1: Basal area
Indicator 2.2.2: Above ground biomass
Indicator 2.2.3: Number of species removed from the forest (for sale/subsistence use)
Indicator 2.2.4: Quantity of certain species harvested from the forest
Principle 3: Disturbance sign should be under control
Criterion 3.1: To limit human disturbances
Indicator 3.1.1: Number of stumps
Indicator 3.1.2: Frequency occurrence of charcoals/burned logs
Indicator 3.1.3: Frequency occurrence of fire
Indicator 3.1.4: Frequency occurrence of garbage/wastes
Indicator 3.1.5: Number of walkways/trails

Phase II. Filtering and testing initial set of criteria and indicators (Multi-Criteria Analysis: MCA)

This phase was conducted at forest site during and after field working. Consensus with disclosing procedure could be applied for this phase. The initial set of C&I were used for filtering by the local three-member team with their field practical knowledge and their consensus (Figure 3.1). Phase II divided into 2 steps: step I and step II.

Step I. General filter

There are 2 simple techniques that Multi-criteria analysis (MCA) uses to identify and select relevant C&I are ranking and rating (Mendoza et al., 1999; Mendoza and Prabhu, 2000a, 2000b). In this study, ranking is preferable. Indicators were ranked according to their ordinal importance[2]. Every member of the team was asked to contribute their opinions and suggestion in the numeric scale.

Scoring method

For the preliminary evaluation of all initial set of C&I to determine the most appropriate for assessing ecological integrity of forest, based on management team judgment, scoring method was used in this step. With this condition team will be given the score by their overall agreement by discussion or consensus between team members. The result of this method will be used for further suggestion in eliminating those deficient C&I which are not accepted for further evaluation. The scoring system is suggested as

0	Not an applicable indicator;
1	Extremely weak performance; strongly unfavorable;
2	Poor performance; unfavorable;
3	Acceptable;
4	Very favorable; and
5	Clearly outstanding.

[2] The order of importance of the list of elements involved. For example, which one comes first, second, etc.

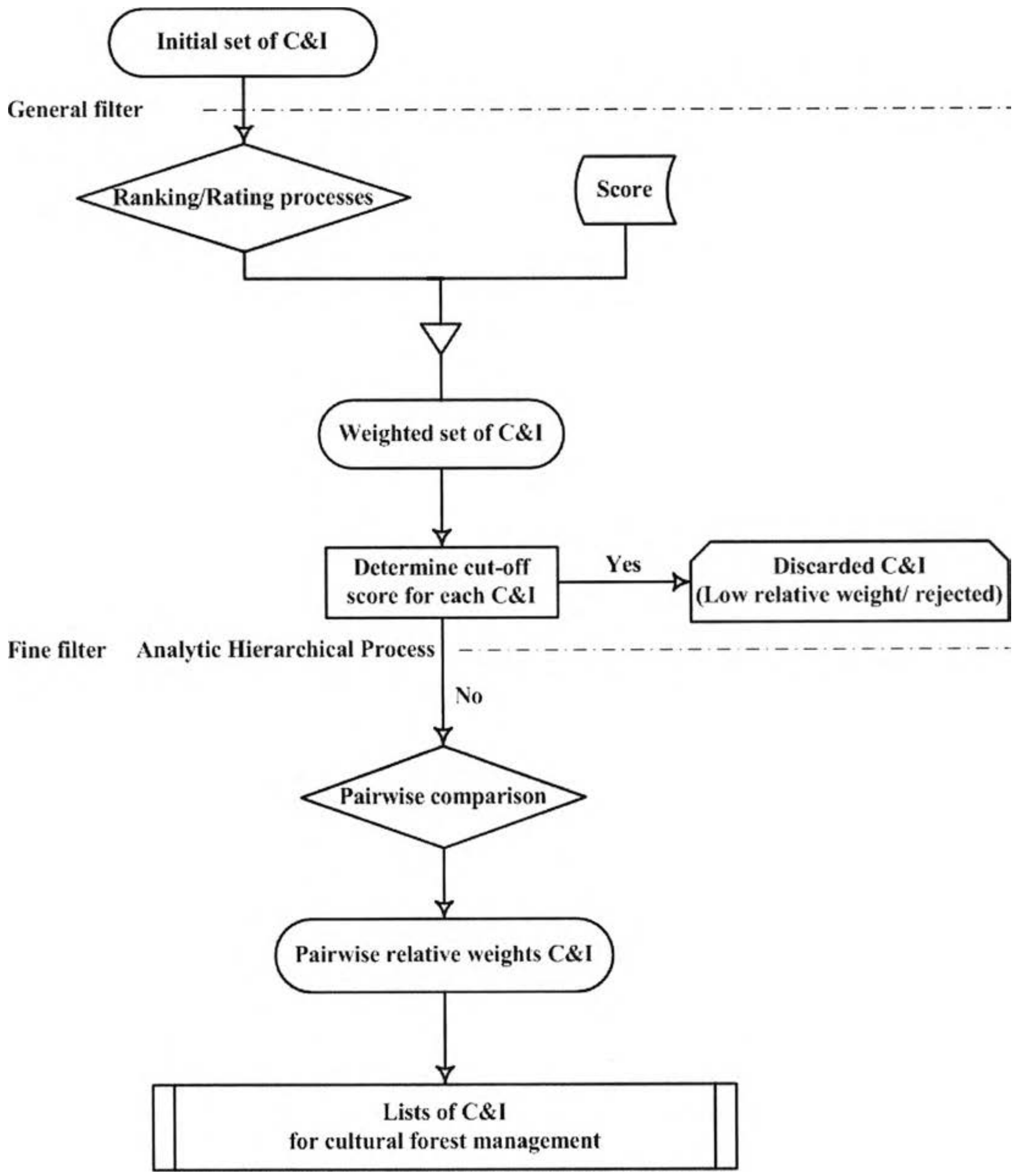

Figure 3.1 Processes of general and fine filter

The following conditions are to focus on important attributes of C&I and to enable the elimination of those deficient C&I.

- Relate to goal

  Directly, obviously, and logically relate to local management goal.

- Understandable/practical

  Easy to understand for local management team and can practice in local team perspectives.

- Precision

  Get the closeness of measurement when reapplied the same procedure to the same condition.

- Cost-effective

  Applying indicators is worth to expense in term of data gather and goal relevant.

- Important/priority

  The overall evaluate considering of the previous four conditions. In this condition, only 0 and 1 should be filled either

  0 denotes not accepted for further evaluation

  1 denotes accepted for further evaluation

Ranking method

This method involves in the analysis of perceive importance of indicators. Each indicator is assigned the rank which is depended on its perceived importance. Participants are encouraged to express their opinion and discuss their votes in terms of preferences reflected in their response form. Ranks are assigned following a numeric nine-point scale as

1	Weakly importance;
3	Less importance;
5	Moderately importance;
7	More importance;
9	Extremely importance; and
2, 4, 6 and 8	Intermediate assessments.

Consider a criterion j with m indicators as below:

$$C_j \in \{I_{j1}, I_{j2}, I_{j3}, \ldots, I_{jm}\}$$

Expert k gave the following ranking to the respective indicators of criterion j as r_{jk1}, r_{jk2}, ..., r_{jkm}. The average weight of indicator i (a_{ji}) and relative importance/weight of indicator i (w_{ji}) (i= 1, 2, ..., m) can be calculated based on the rank assigned to each indicator.

$$a_{ji} = \sum_k r_{jki} \qquad \text{(Equation 3.1)}$$

$$\sum a_{ji} = \sum_i \sum_k r_{jki} \qquad \text{(Equation 3.2)}$$

$$w_{ji} = \frac{a_{ji}}{\sum a_{ji}} \qquad \text{(Equation 3.3)}$$

Step II. Fine filter

In step II, the filtered set of C&I were next evaluated in this step under the process named Analytic Hierarchical Process (AHP).

Analytic Hierarchy Process

The AHP approach makes a decision by arranging the important component into hierarchical structure. It reduces complex elements of decision hierarchy into a series of simple comparisons named pairwise comparisons (Mendoza and Prabhu, 2000b; Mendoza, 1997a, 1997b; Saaty, 1995; Golden, Harker, and Wasil, 1989; Vargas and Zahedi, 1993 and Kangas, 1993). AHP can be summarized into the procedure as first, set up the decision hierarchy by streamline the problem into the relevant hierarchy; second, generate input data consisting of comparative judgment of decision indicators use the pairewise comparison and numeric nine-point scale; third, analyze those judgments and calculate relative weights between all indicators; and fourth determine the aggregate relative weights of decision indicators to get the final weight of team decision making (Mendoza and Prabhu, 2000a, 2000b).

Pairwise comparisons[3]

This method is the most significantly involved in evaluation of C&I. It arranges the complex components into a series of one-on-one judgment regarding to the significance of each indicator relative to its criterion. Each indicator under the same criterion is compared with every each other indicator to examine its relative importance/weight. Pairwise comparisons offer the mean to more precisely differentiate the C&I elements in term of their relative important/weight. Moreover, pairwise comparisons techniques can be analyzed for (In)Consistency index (C.I.) (Mendoza and Prabhu, 2000a). The numeric nine-point scale was used for one-on-one comparative judgment as

1	Equal importance;
3	Moderately more importance;
5	Strongly more importance;
7	Very strongly more importance;
9	Extremely more importance; and
2, 4, 6 and 8	Intermediate assessments.

(In)Consistency index (C.I.)[4]

This index provide information of each criterion about how consistent the judgment of the team participants following the pairwise comparisons. In general, a higher of consistency implies a better judgment and result more reliable of relative importance/weights. The higher of Consistency index, the more inconsistence of relative importance/weights.

$$C.I. = \frac{\sum_{i}\left[(\sum_{i} w_{jiC}) \times w_{jiF}\right] - N_i}{(N_i - 1)} \qquad \text{(Equation 3.4)}$$

Where w_{jiC} = column summation of first relative weight of indicators from pairwise matrix table

w_{jiF} = final relative weight of indicator from pairwise matrix table

N_i = number of indicators compared

[3] Calculating for pairwise comparison was showed in B1, Appendix B.
[4] Calculating for C.I. was showed in B1, Appendix B.

3.3 TESTING CRITERIA AND INDICATORS IN EXPERIMENT PLOTS

The final filtering set of C&I will be assessed in experimental plots during 2002-2003 as describe in the following topics.

3.3.1 Forest inventory

Establishing line transect

- Delineated the approximate boundaries of this forest on a sketch map which, if possible, is based on a topographical map and/or aerial photo. If map is not available, delineated the boundaries of the area using any available natural or permanent human made features such as streams, roads or trails. Running the line transect through and cover the forest area.
- Along the line transect, number of bird species in the sighting range will be identified using binocular and bird guide of Thailand and recorded the name.

Establishing permanent plots

- Twenty five rectangular sampling plots of 10x40 m were established along left and right side of the line. Map, compass, and tape will be used to determine location and distance. In this plots, the ecological parameters will be measured and recorded such as tree (dbh $\geq$ 10 cm) local name, number, girth size, number of butterfly species, and occurrence of soil erosion. Butterfly will be collected with the spoon-net, identified and record the name. Percentage of canopy cover will be measured using line intercept method (Müller-Dombois and Ellenberg, 1974),
- Within each 10x40 m sampling plot, half of plot size (10x20 m) were marked as subplot. One of 10x20 m plot will be selected for record human disturbance signs (e.g., number of stumps, number of digging hole, occurrence of fire, and occurrence of

garbage), and other ecological indicators (e.g., abundance of epiphytic species, abundance of epiphytic moss, and abundance of herbaceous bole climber species). At the middle of all 25 plots, one leaf bag contain 1 kg of leaf litter was buried to examine decomposition rate.

- Within each 10×40 m plot, 2 rectangular subplots (5×10 m) are set up to examine regeneration (seedling (h <1.3 m), and sapling (dbh < 10 cm, h > 1.3 m)).
- With in each 5×10 m subplot, 2 square quadrats (1×1 m) are set up to examine percentage of ground cover (all species which are 20-50 cm height) (Daubenmire, 1959), litter weight, and detritivorous macro-soil fauna.

3.3.2 Questionnaire

Some of variables or indicators that can not directly assess at the experimental plots will be gathered by questionnaires and secondary data which are available from previous study. The questionnaire was showed in B2, Appendix B.

3.4 DATA COLLECTION

Vegetations

The census was conducted in 25 of 10×40 m plots for tree ≥ 10 cm dbh, local name, girth and height was recorded. In 50 of 5×10 m subplots, tree < 10 cm dbh with ≥ 1.3 m height, name and height were recorded, and plants < 1.3 m in height were counted and recorded the local name. The scientific names of vegetations were checked at Walai Rukhavej Botanical Research Institute, Mahasarakham University.

Soil samples and analytical methods

At the middle of 10×40 m plots, 50 of soil samples were collected in the middle of each 10×40 m plot, 1 kg of top soil at 0-30 cm depth and 1 kg of subsoil at 30-60 cm depth. The samples were air-dried and prepared to analyze for texture, pH,

% organic matter, % organic carbon, % nitrogen, available phosphorus, exchangeable cation (Ca, Mg, and K), Cation Exchange Capacity (CEC), and Electric Conductivity. Soil analysis was conducted at Soil Science Laboratory, Department of Agricultural Technology, King Mongkut Institute of Technology Ladkrabang, Bangkok based on Soil Survey Staff (1975).

3.5 DATA ANALYSIS

The ecological parameters of 2 data sets from all sampling plots in annual cycle (2002-2003) have been computerized and will be compared.

Vegetation data were analyzed for quantitative ecological parameters such equations as follows:

Basal area of each tree following equation

$$BA = (0.00007854)dbh^2 \qquad \text{(Equation 3.5)}$$

Richness index of following equation of Magalef (1969)

$$R = \left(\frac{(S-1)}{\ln N} \right) \qquad \text{(Equation 3.6)}$$

Where S = Total number of total species present in plot

N = Total number of total individuals present in plot

Binary similarity coefficients (Kreb, 1989)

Coefficient of Sorensen

$$S_s = \frac{2c}{2c + a + b} \qquad \text{(Equation 3.7)}$$

Where a = Number of species in sample A

b = Number of species in sample B,

c = Number of species in both sample A and sample B

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