APPENDICES

APPENDIX A

Valuation of tree with intermediate growth rate, long period of cutting cycle and High value of wood

Age(year)	Growth at breast height		Volume (m^3/tree)	Price by volume (bath/m^3)	Individual price (bath/tree)
	Diameter DBH (cm.)	Circumference GBH (cm.)			
1	2.80	8.80	0.02225	758.04	17
2	4.70	14.77	0.02819	1,342.37	38
3	6.30	19.80	0.03467	1,854.47	64
4	7.80	24.51	0.04190	2,324.65	97
5	9.20	28.91	0.05002	2,765.94	138
6	10.60	33.31	0.05916	3,185.49	188
7	11.90	37.40	0.06944	3,587.78	249
8	13.10	41.17	0.08099	3,975.87	322
9	14.40	45.26	0.09393	4,351.95	409
10	15.50	48.71	0.10841	4,717.68	511
11	16.70	52.49	0.12455	5,074.34	632
12	17.80	55.94	0.14251	5,422.95	773
13	18.90	59.40	0.16242	5,764.34	936
14	20.00	63.86	0.18422	6,099.21	1,125
15	21.10	66.31	0.20866	6,459.88	1,348
16	22.10	69.46	0.23527	6,814.65	1,603
17	23.10	72.60	0.26438	7,163.90	1,894
18	24.10	75.74	0.29609	7,508.03	2,223
19	25.10	78.89	0.33051	7,847.40	2,594
20	26.10	82.03	0.36770	8,182.32	3,009
21	27.10	85.17	0.40771	8,513.06	3,471
22	28.10	88.31	0.45056	8,839.89	3,983
23	29.00	91.14	0.49623	9,163.00	4,547
24	29.90	93.97	0.54468	9,482.61	5,165
25	30.90	97.11	0.59579	9,798.91	5,838
26	31.80	99.94	0.64945	11,876.15	7,713
27	32.70	102.77	0.70546	13,080.18	9,228
28	33.60	105.60	0.76371	14,273.09	10,899
29	34.50	108.43	0.82364	15,455.35	12,730
30	35.40	111.26	0.88525	16,205.49	14,346
31	36.30	114.09	0.94811	16,437.96	15,585
32	37.20	116.91	1.01188	16,668.55	16,867
33	38.00	119.43	1.07619	16,897.34	18,185
34	38.90	122.25	1.14067	17,124.41	19,533
35	39.70	124.77	1.20496	17,349.80	20,906
36	40.60	127.60	1.26868	17,573.59	22,295

Valuation of tree with intermediate growth rate, long period of cutting cycle and High value of wood (continued)

Age(year)	Growth at breast height		Volume (m^3/tree)	Price by volume (bath/m^3)	Individual price (bath/tree)
	Diameter DBH (cm.)	Circumference GBH (cm.)			
37	41.40	130.11	1.33150	17.607.91	23,445
38	42.30	132.94	1.39310	17,718.28	24,683
39	43.10	135.46	1.45318	17,827.92	25,907
40	43.90	137.97	1.51149	17,936.86	27,111
41	44.70	140.49	1.56781	18,045.11	28,291
42	45.60	143.31	1.62195	18,152.71	29,443
43	46.40	145.83	1.67379	18,259.67	30,563
44	47.20	148.34	1.72320	18.366.00	31,648
45	48.00	150.86	1.77013	18,471.73	32,697
46	48.80	153.37	1.81453	18,576.88	33,708
47	49.60	155.89	1.85640	18,681.45	34,680
48	50.30	158.09	1.89576	18,785.47	35,613
49	51.10	160.60	1.93266	18,888.94	36,506
50	51.90	163.11	1.96715	18,991.89	37,360

Source: Bank for Agriculture and Agricultural Cooperatives (2010)

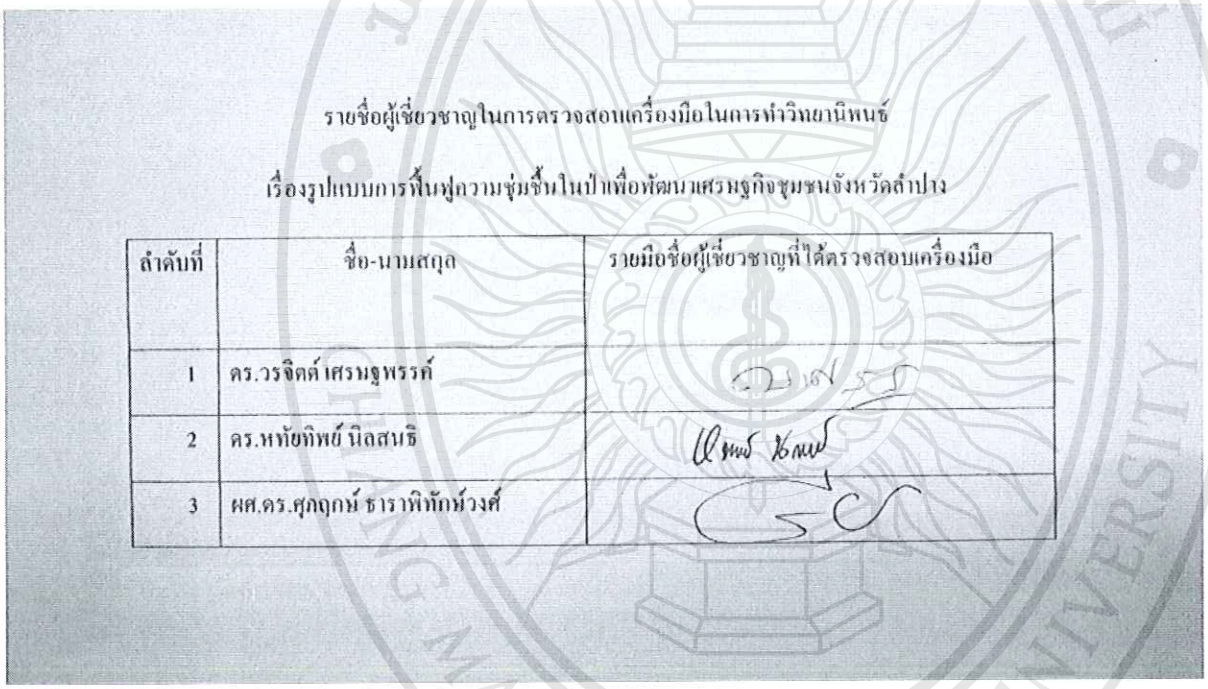
Appendix B

Lists of Expert for Verification of Questions

The observation and interview questions used in this research were verified by three experts as follows:

1. Dr. Worajit Setthapun
2. Dr. Hathaithip Ninsonti
3. Assistant Professor Dr.Suparerk Tarapitakwong

Figure B1: Verification form and Signature of Experts



รายชื่อผู้เชี่ยวชาญในการตรวจสอบเครื่องมือในการทำวิทยานิพนธ์

เรื่องรูปแบบการฟื้นฟูความชุ่มชื้นในป่าเพื่อพัฒนาเศรษฐกิจชุมชนจังหวัดลำปาง

ลำดับที่	ชื่อ-นามสกุล	รายมือชื่อผู้เชี่ยวชาญที่ได้ตรวจสอบเครื่องมือ
1	ดร.วรจิตต์ เศรษฐพรรค์	
2	ดร.หทัยทิพย์ นิลสนธิ	
3	ผศ.ดร.ศุภฤกษ์ ธาราพิทักษ์วงศ์	

Appendix C

Sheet No.....

Observation Form: Characteristic and Composition of Community Forest

Name of Community forest .....

Date .....

1. Topography.....
2. Characteristics of primitive forest at an observation. .....
3. Characteristics of forest found at an observation .....
4. Elements of community forests. .....
   - 4.1 Water resources / water problems Flood / Drought / Surface / Groundwater .....
   - 4.2 Kind of wildlife .....
   - 4.3 Forest threats .....
   - 4.4 Forest fire situation .....
5. The amount of rainfall is obtained from..... volume..... mm./year
6. Size and number of plants

Community forest name ....Date.........

Forms of tree observation with PQC

Survey point no.	Coordinates UTM	Quarter	Species	Distance (m)	Size		Notes
					GBH (cm)	Height (m)	
		1st (0-90°)					
		2nd (90-180°)					
		3rd (180-270°)					
		4th (270-360°)					
		1st (0-90°)					
		2nd (90-180°)					
		3rd (180-270°)					
		4th (270-360°)					
		1st (0-90°)					
		2nd (90-180°)					
		3rd (180-270°)					
		4th (270-360°)					
		1st (0-90°)					
		2nd (90-180°)					
		3rd (180-270°)					
		4th (270-360°)					
		1st (0-90°)					
		2nd (90-180°)					
		3rd (180-270°)					
		4th (270-360°)					
		1st (0-90°)					
		2nd (90-180°)					
		3rd (180-270°)					
		4th (270-360°)					
		1st (0-90°)					
		2nd (90-180°)					
		3rd (180-270°)					
		4th (270-360°)					

7. Is there a small hydropower plant? ..... How much production capacity

8. Other observations ……..

APPENDIX D

List of Participants

No.	Name-surname	Position	Location	Type of Interview
C1	Pol.Sub.Lt.Chai Wongtrakul	Community Forest Committee	Baan Sam kha	Guru
C2	Mr.Jamnong Junjom	Community Forest Committee	Baan Sam Kha	Guru
C3	Mr.Tun Wansuwong	Community Forest Committee	Baan Sam Kha	Guru
C4	Mr.Indee Chaichana	Community Forest Committee	Baan Sam Kha	Guru
C5	Mr.Boontam Chaloemsook	Community Forest Committee	Baan Sam Kha	Guru
C6	Mr.Boonruan Taokam	Headman	Baan Sam Kha	Village Leader
C7	Mr.Sangwian Yaso	Assistant Headman	Baan Sam Kha	Village Leader
C8	Mr.Panom Jaisai	Assistant Headman	Baan Sam Kha	Village Leader
C9	Mr.Somwon Wongjina	Assistant Headman	Baan Sam Kha	Village Leader
C10	Mr.Panlop Auttiya	Members	Baan Sam Kha	Village Leader
C11	Mr.Somchai Ngamsom	Forest Preservation president	Baan Sa Sob Hok	Guru
C12	Mr.Sao Fungyen	President, Elderly Group	Baan Sa Sob Hok	Guru
C13	Mr.Sanan Intanun	Village water supply president	Baan Sa Sob Hok	Guru
C14	Mr.Pang Laemkla	President of Water Users Group	Baan Sa Sob Hok	Guru
C15	Mr.Jaroen Sema	Community Research Team Leader	Baan Sa Sob Hok	Guru

List of Participants (continued)

No.	Name-surname	Position	Location	Type of Interview
C16	Mr.Thongchai Ngamsom	Headman	Baan Sa Sob Hok	Village Leader
C17	Mr.Kamon Waisati	Assistan Headman	Baan Sa Sob Hok	Village Leader
C18	Mr.Kasem Ngamsom	Assistan Headman	Baan Sa Sob Hok	Village Leader
C19	Mr.Au-thai Sema	Members	Baan Sa Sob Hok	Village Leader
C20	Mr.Boonpan Paopit	Members	Baan Sa Sob Hok	Village Leader
C21	Mr.Boonlun Ratchaiya	Volunteer Village	Baan Rai Sila Thong	Guru
C22	Mr.Payom Techasub	Volunteer Village	Baan Rai Sila Thong	Guru
C23	Mr.San Kumfu	Volunteer Village	Baan Rai Sila Thong	Guru
C24	Mr.Wician Kankla	Volunteer Village	Baan Rai Sila Thong	Guru
C25	Mr.Thanom Jaingam	Volunteer Village	Baan Rai Sila Thong	Guru
C26	Mr.Jaroon Wannarat	Former Village Headman	Baan Rai Sila Thong	Village Leader
C27	Mr.Soem Techasub	Headman	Baan Rai Sila Thong	Village Leader
C28	Mr.Sanong Wannarat	Assistant Headman	Baan Rai Sila Thong	Village Leader
C29	Mr.Tong-in Yamonkaew	Assistant Headman	Baan Rai Sila Thong	Village Leader
C30	Mr.Tongsook Pintatib	Members	Baan Rai Sila Thong	Village Leader
C31	Mr.Auan Poomipak	Chairman of the community forest	Baan Ton Tong	Guru

List of Participants (continued)

No.	Name-surname	Position	Location	Type of Interview
C32	Mr.Nikorn Duangkumfu	Community Forest Committee	Baan Ton Tong	Guru
C33	Mrs.Yupin Duangkumfu	Community Forest Committee	Baan Ton Tong	Guru
C34	Mr.Niyom Kumpunboot	Community Forest Committee	Baan Ton Tong	Guru
C35	Mr.Um-nuai Yasutti	Community Forest Committee	Baan Ton Tong	Guru
C36	Mr.Manit Unkrua	President of Tambon Administration Organization	Baan Ton Tong	Village Leader
C37	Mr.Somporn Satinae	Permanent of Tambon Administration Organization	Baan Ton Tong	Village Leader
C38	Mr.Krid Inkumchua	Head of forestry office	Baan Ton Tong	Village Leader
C39	Mr.Rattanachai Puangkaew	Security guard	Baan Ton Tong	Village Leader
C40	Mr.Somchay Lakumpiang	Chauffeur	Baan Ton Tong	Village Leader

Appendix E

Interview Form for collecting the problems of community forest restoration

Name of interviewee.....

Name of community forest..... Date of interview.....

Type of interviewee

☐ 1. Guru (Those who know the history of the forest as a place for more than 30 years.)

☐ 2. Village leader (Those who have been or are responsible for carrying out community forest restoration on location.)

1. What was the primitive nature of community forests?.....
2. What were the species of trees used to exist in community forest?.....
3. Why was the forest destroyed? .....
4. What was the condition of forest after the destruction?.....
5. Do you have any water problems after forest destruction?.....
6. Community responsibilities of forest restoration at an initial stage of the forest restoration scheme, in regarding to 4W and 1H (Who, What, When Why, and How)?.....
7. What were the problems of forest restoration at initial stage and the solution?... .....
8. What activities did the community take to restore the forest? .....

9. What were the species of trees used in forest restoration/age of seedling/and how many?.....

10. How much money did community spend on forest restoration?.....

11. What is the current condition of community forests?.....

12. What benefits do villagers get from current community forests? .....

13. Does the community still have water problems after the forests have been restored? .....

14. Are there any problems and obstacles to forest restoration? .....

15. Are there any small hydropower plants installed in community forests? .....

16. Other suggestions.....

APPENDIX F

List of experts in reforestation with Water – drawing trees' roots model

No.	Name – Surname	Position
E1	Mr.Panutap Wongwan	Former director of the conservation management office at 13 branches of Lampang
E2	Mr.Sumai Maimun	Chairman of Lampang Community Forest Network
E3	Mr.Chan Auttiya	Community Member of Ban Samkha Community Forest, Mae Tha District, Lampang

APPENDIX G

List of representative for Water-drawing trees' roots model verification

No.	Name-Surname	Position	Village community name	Sample
D1	Pol.Sub.Lt.Chai Wongtrakul	Community Forest Committee	Baan Sam Kha	Guru
D2	Mr.Boonruan Taokam	Headman	Baan Sam Kha	Village
D3	Mr.Somchai Ngamsom	Forest preservation president	Baan Sa Sob Hok	Guru
D4	Mr.Thongchai Ngamsom	Headman	Baan Sa Sob Hok	Village
D5	Mr.Boonlun Ratchaiya	Volunteer Village	Baan Rai Sila Thong	Guru
D6	Mr.Soem Techasub	Headman	Baan Rai Sila Thong	Village
D7	Mr.Auan Poomipak	Chairman of the community forest	Baan Ton Tong	Guru
D8	Mr.Manit Unkrua	President of Tambon Administration Organization	Baan Ton Tong	Village

List of representative for Water-drawing trees' roots model verification(continued)

No.	Name-Surname	Position	Village community name	Sample
D9	Miss Pantong Makaew	Head of Arboretum	Hangchat	Expert
D10	Miss Duangporn Kiatdamrong	Head of Arboretum	Doiprabat	Expert
D11	Dr.Sawai Wanghongsa	Ecological expert	Of the conservation management office at 13 branches of Lampang	Expert

Appendix H

Interview Form of water – drawing tree's roots Model

Interviewee.....

Type of interviewee

☐ 1. Experts from state agencies ☐ 2. NGOs, relevant to community forest

☐ 3. Guru

Date.....

Notify

This interview was designed to find out the process three planting in Lampang community forests. The researcher found that there are 4 evergreen trees, including, Tao Rang, Ma Muang Pa, Waa and Yang Na that are suitable to be planted to accelerate the restoration of community forests.

.....

Explanation

The Water – drawing tree's roots model is a form of accelerating moisture restoration in community forests. The model was formulated by bringing local knowledge in forest restoration and the facts appear in four community forest areas of Lampang Province, theory and experiment. It was found that 4 evergreen species were suitable for community forest area in Lampang province. They were Tao Rang, Ma Muang Pa, Waa, and Yang Na. This interview consists of two parts.

Part 1. The ecology and importance of wood to be planted.

Part 2. The number of trees used to replant forests.

Part 1. Ecological characteristics and importance of trees

The four evergreen species derived from the Water – drawing tree's roots Model as follows:

1. Tao Rang or Ma Mue in Lanna language (*Caryotamitis*Lour.) is a single-stem species in the Palmae family. It is a large tree and has no thorn. With heights ranging from 3-12 meters, Tao Rang trees like to grow in areas with high humidity. The trunk of a Tao Rang tree has a number of joined spathes or bracts enveloping around it. The trunk's diameter is about 10 cm. It has alternate bipinnately compound foliage. A leaflet has a triangular shape with a concave notch. Each leaflet is about 13 cm wide and 20-30 cm long. The leaf's tip is sharp like a fish's tail, while the base has a wedge shape. The leaf's top is green and smooth. The leaf sheath is about 0.5-2 meters long, with its base being covered with brownish, reddish, grayish, or blackish hair and appendages. Its wood is suitable for construction and making agricultural tools. Tao rang is also grown as an ornamental tree. The flower spike can be sliced off to obtain nectar for producing sugar. The leaves can be used for making roof and rope. The young twigs' tops can be boiled and eaten. Regarding medicinal properties, Tao Rang's roots and heads can be boiled for drinking. The drink has a sweet bitter and cool taste, which is helpful for curing internal bruises, a ruined liver, a handicapped spleen, a handicapped heart, black marks on a lung, and a poisoned lung. Gum of Tao Rang can cause itching and red rashes on skin. If it touches an eye, the gum can cause blindness. The seeds can be food of several animals including squirrels, flying squirrels, civets, and palm civets. The trunk's base has cobalt, which is essential for some herbivores like deer and barking deer.

2. Ma Muang Pa or wild mango (*Mangiferacaloneura* Kurz.) is a medium-sized to big-sized tree, with a height of 20-30 meters. It does not shed leaves or may shed leaves for only a short period of time. It is found in evergreen forests and dry evergreen forests where the terrain is flat or plateau with elevation not exceeding 400 meters above the sea level. The trunk is clean and straight. The bark is brownish or blackish brown. It has dense leaves. The canopy has a round shape. Its wood usually has no heartwood. The wood color is yellowish gray, grayish, or somehow brownish mixed with some dark lines. If the wood has heartwood, the sapwood will be grayish mixed with some yellow parts, while the heartwood will be reddish mixed with dark

brown or almost black, which is highly distinguishable from the sapwood. The wood texture is rather fine and has a few splinters. The wood is not so enduring when using under sunlight and rain or when being exposed to damp soil. It is suitable for making furniture or handles of some tools. Its edible fruits ripen during April-May. Young fruits have vitamin C, while ripe fruits have antioxidants that can prevent cancer and ageing. Young leaves can be a fresh vegetable that contains carbohydrate, fiber, protein, calcium, phosphorus, iron, vitamin A, vitamin B1, vitamin B2, niacin, and vitamin C. In addition, its ripe fruits also contain a large quantity of beta-carotene. The flesh inside a seed and the bark has tannin, which has medicinal properties in curing diarrhea, dysentery, and vomit. Its ripe fruits are favorite food of several kinds of birds, squirrels, flying squirrels, small gongs, and plant-eating bats (Yanasumpanno, 2014).

3. Waa or Java plum *(Syzygium cumini* (L.) Skeels) is an evergreen tree that may shed leaves for only a short period of time. Its height is around 10-35 meters. It is found commonly in tropical rain forests and deciduous forests being in areas slightly higher than the sea level up to about 1,100 meters above the sea level. The brown bark is quite smooth. It has opposite egg-shaped or oval-shaped single leaves. Each leaf is about 3-7 cm wide and 8-14 cm long. The leaf's edge has some oily spots. It yields flowers and fruits around December - June. The fruits are edible. The trunk's bark can be boiled with water to drink for curing dysentery. The bark can be kept in the mouth to cure oral diseases. The wood is good for indoor construction. Immature fruits can cure diarrhea. Ripe fruits are edible and can be made as wine or fruit juice with purple color and a sour-astringent taste. The drinks from Waa fruits are also helpful for curing diarrhea and dysentery. The seed has a substance that can reduce blood sugar, cure diarrhea, and remove poison from the seed of Sa Laeng Jai tree (*Strychnosnux-vomica* L.). The bark can also be used for cloth dyeing to provide purple color. It ripe fruits are food of several bird species, squirrels, flying squirrels, small gongs, and herbivorous bats (MedThai, 2013).

4. Yang Na (*Dipterocarpusalatus*Roxb. Ex) is an large-sized evergreen tree species that may shed leaves for a short period of time. Its stem can reach as high as 50 meters. The canopy has a dense round shape. Its trunk's base usually has lobes. The trunk is clean and straight. The bark is smooth with a soft tone of gray, and may

slough off as round pieces. The reddish-brown wood has a rough texture with straight splinters. The parts along young branches and twigs are hairy. The leaves have some apparent scars. Yang Na can be bred via a seed growing technique. This technique involves removing the seed's wing prior to being planted. The seed will germinate within 12 days. Within the next 7 months, the seedling will be about 30-35 cm tall, and will be ready for transplanting. Yang Na is a shade-intolerant species that grows well on almost all kinds of soil. However, it prefers soil with rich nutrients and moderate humidity. After 1 year old, the tree should be exposed to sunlight all day long. Yang Na grows naturally in evergreen forests, mixed deciduous forests, dry evergreen forests, tropical rain forests, and in lowland areas (50-400 meters above the sea level) near rivers, water sources, and valleys in all regions throughout the country. According to a Thai traditional recipe, its bark can be boiled to drink as a tonic that is beneficial for cleaning and nourishing blood and curing liver inflammation. The warm bark can also be used for massaging to relieve pain at a joint. Its gum can be mixed with seeds of GuiChaii (*Allium tuberosum*Rottler ex Spreng.), roasted until being quite burnt, grinded to obtain fine powder, and then used as a teeth filling to cure a decayed tooth. Its seeds and leaves have a hot astringent taste. They can be boiled together with some salt and then kept in the mouth to relieve toothache and healing a shaking tooth. Oil from its raw gum has a hot bitter dizzy taste. It has a laxative property that can wither heads of anal hemorrhoids. In addition, it can cure wounds and stop pus. It is an effective medicine for applying on the skin with rotten wounds, pussy wounds, and wounds from leprosy. It can also cure gonorrhea and expel phlegm (Med Thai, 2015).

Part 2.The number of trees used to replant forests.

From the documentation of the reforestation, it was found that the number of suitable trees grown in one area depending on the nature of the area and the purpose of planting is as follows:

1. The reforestation project for watershed ecosystem rehabilitation at a density of 25 trees per/rai.
2. Upstream forest rehabilitation project planted trees at a density of 200 trees/rai.

3. The "Growing 3 Types of Forests and Gaining 4 Types of Benefits" according to His Majesty the King's initiative planted fruit trees at a density of 40 trees per/rai.
4. Planting for recovery at mining. It is recommended to grow 250 trees per/rai.

Based on the information provided. Please answer the following questions:

1. Where should the following 4 species of tree be planted on the slop started from the plains along the creeks upwards to mountain ridge?

1.1 Tao Rang.....

1.2 Ma Muang Pa.....

1.3 Waa.....

1.4Yang Na.....

2. What are the numbers of suitable trees should be planted in community forest?

2.1 Tao Rang.....

2.2 Ma Muang Pa.....

2.3 Waa.....

2.4Yang Na.....

Appendix I

Interview Form for verifying Water – Drawing tree's Roots Model

Interviewee.....

Community Forest.....

Type of interviewee

☐ 1. Guru ☐ 2.Community leader

☐ 3. Expert

Date.....

Explanation

This interview is designed to review, certify and verify Water – Drawing Tree's Root Model to speed up development of forests for sustainable uses. Water – drawing tree's roots Model is a form of accelerating moisture restoration in community forests. The research took local knowledge in forest restoration and the facts appeared in four community forest areas of Lampang Province to analyze with theory, and experiment based on a concept of Solar Energy Maximizing, or SEM. Itconsists of 4 parts:

1. Part 1: Community Forest Restoration: local wisdom and participation
2. Part 2: Current community forest condition
3. Part 3: Model to accelerate community forest development
4. Part 4: Planting sequence and number of trees planted

Part 1: Community Forest Restoration: local wisdom and participation

This is a field survey, interview, search, and collect knowledge information that four communities used to develop community forests from unhealthy forest areas (Figure 1 and Figure 2) that could not provide sustainable benefits the communities after being managed in the last 6 to 14 years. It shows that, the community's restoration processes has a similar beginning. People had problems of living from an

environment that was not able to support their basic needs. They gathered together and try to solve problems by their own. They started with growing conscience to lover and cherish the forest, protecting forests, preventing and fighting forest fire and burning, building check dams, and planting trees. It shows the forests have been recovered to the stage that was able to provide some benefits based on adopting their wisdom, experience, learning to the context of the community. They received honor in the conservation and management of forests with people participation.

Part 2: Current community forest condition

Field survey of community forests with a scientific procedures found that the characteristics and composition of the forest, especially trees in the 5 attributes. They are basal areas, wood volume, tree's age, GBH and proportion of evergreen trees. They are compared with that of the natural forest that provides sustainable benefits to the community. It appeared that the community forests were 23.71 – 46.94 % of natural forest (Figure 1). This affect its potential in withstand external threats especial forest fire. The community forests could not absorb, retain and release water to community throughout the year as in Mae Mon natural forest in which trees on average were 30 years of age. They can stand against the threats and providing benefits the community sustainably. Communities still need to devote resources to protecting their own forest communities to resist the threat, especially drought and wildfires.

Part 3: Model to accelerate community forest development

Although participation in community forest restoration proves that the forest can be improved benefits to the community. However, it cannot be confirmed and certified that forests can stand to develop themselves naturally. It may take another 100 years. It is precarious to return to the fall of the jungle. Community has to help restore because of long period of times, situation may be changed. There are transfers the management to new generation in some areas. Accelerating the development of forests as natural forests is the heart of community forest management.

Water – drawing tree's roots took a characteristics and composition of natural forests as a model for community forest development. It was integrated with

the idea of using Solar Energy Maximizing (SEM) to accelerate the development of community forests to complete faster than natural mechanisms. The model introduced to plant perennial trees with green leaves throughout the year in the community forest areas (Figure 3 and Figure 4). These trees would help to distribute the water from the depression along the creek that the community build check dams for a sediment trap and collect moisture. A network of tree's roots search for water for photosynthesis. These green leave trees help blocking sunlight to reach the forest floor. This helps to reduce moisture loss from the evaporation of water under the forest. The forest does not halt growth during the dry season. This study proposed that four species of trees be planted in community forest areas on altitudinal slope. Started from stream upwards, fishtail palms are planted followed by wild mango, and Javan fruits and Yang Na. There is enough potential to help keep the sunlight on the forest floor, protect the forest with green foliage among the forest floor and to increase the utilization of sunlight by photosynthesis. In addition, all four plants are also food crops that are beneficial to wild animals. The water-drawing trees' root model can shorten forest development from 100 years to merely 30 years.

Part 4: Planting sequence and number of trees planted

In the model of recovering humidity in community forests with 4 tree species, the trees are proposed to be planted in the forest according to slope, which can be explained as follows:

4.1 Planting sequence

4.1.1 In flat areas near rivers, which are areas with the highest humidity in the forest, the soil surface should be protected by planting Tao Rang trees, which can help maintain the humidity. Tao Rang has a large canopy that is green for all year long. Its roots spread widely. Thus it can provide shade and protect the soil very well. The loss of soil humidity will be reduced. Moreover, humidity from the nearby river will be drawn by its roots to spread widely throughout the lowland foothill area. Tao Rang can help protect the plant and animal societies around the river banks. It is bred through seed germination that requires an animal to act as a dispersers. Therefore, planting Tao Rang also help increase food for animals and allows animals to have a

larger area for feeding. Thus Tao Rang is more efficient in attracting wildlife and enriching the forest than other tree species that shed their leaves during a dry season and are planted popularly these days.

4.1.2 The inclining foothill area with some slope is categorized into two parts as follows:

4.1.2.1 A lower foothill area refers to the area next to the river bank area. This area should be protected from sunlight to reduce moisture loss by growing Ma Muang Pa trees, which have a wide dome-shaped or hemisphere-shaped canopy with thick green leaves. Ma Muang Pa trees will be very helpful in preventing excessive sunlight during a dry season when other trees in the forest shed their leaves to reduce water loss. Trees of this species can also draw humidity from the area near rivers to expand even more. They help transfer the soil humidity to the upper foothill area. Fruits of Ma Muang Pa are food of both human beings and animals. Since the fruit has quite a large seed, it can stimulate medium-sized and large-sized animals, especially those in the group of civets, to inhabit in the area.

4.1.2.2 An upper foothill area should be protected by Waa trees. The trunk's base of a Waa tree is slightly lobed, making it suitable for trapping sediments and protecting the soil surface from erosion. The tree can transfer humidity to underground. This humidity will be supplemented by the humidity sent upward from the lower uphill area by the root system of Ma Muang Pa. The coordinated functions of these trees will make the upper foothill area more humid. Branches of Waa expand laterally, thus its canopy has a thick round or oval shape being suitable for providing shade. Waa is a food plant for animals with its small-sized fruits. The small fruits help attract birds and some small mammals like squirrels and flying squirrels to the forest and inhibit in these trees:

4.1.3 A hilltop or a mountain ridge area is located higher and receive stronger wind than other areas. Yang Na, which is a large-sized tree species with a tall trunk and a thick round canopy can protect the soil surface in this area by reducing force of wind and rain. Its roots spread so widely and deeply that allow it to take over the humidity from the upper hilltop area. A Yang Na tree breeds by releasing its winged seeds that are normally blown by the wind to spread further. Therefore, it is suitable for such this windy area. Although its seeds are not food for wild animals, its shade

under the thick evergreen canopy makes it a perfect habitat for certain animals, particularly birds.

4.2 Numbers of trees planting for moisture restoration

Based on reviewing articles related to numbers of trees existing in some areas or trees that are grown for specific purposes? It can be concluded that the appropriate numbers of trees in certain areas are as follows:

4.2.1 The reforestation project for watershed ecosystem rehabilitation at a density of 25 trees per/rai.

4.2.2 The "Growing 3 Types of Forests and Gaining 4 Types of Benefits" according to His Majesty the King's initiative planted fruit trees at a density of 40 trees per/rai

4.2.3 In a natural dry evergreen forest in Khao Ang Rue Nai Wildlife Sanctuary in Chachoengsao Province, the proportion of animal-food trees in the area was found to be at1.82:1. The density of standing trees in this forest was 121.95 trees/rai. Therefore, in an area of 1rai, the number of trees that can be food for animals is 67.00 trees.

4.2.4 Planting for recovery at mining. It is recommended to grow 250 trees per/rai.

According to the criteria above, the numbers of trees grown additionally in a 1-rai area may range from 25-67 trees. The data on forest plantation for rehabilitating watershed forests of Department of National Parks, Wildlife, and Plant Conservation show that the average survival rate of the planted trees is at 80%. Therefore, When compiled with expert advice the model of recovering forest humidity for developing the economy of communities in Lampang Province proposes to plant 4 tree species (Tao Rang, Ma Muang Pa, Wa, and Yang Na) for 50 trees each. Thus 200 trees per rai will be planted in total. Based on the survival rate mentioned above, there will be 160 trees/rai remain in the forest to perform duties of providing shades and protecting ecosystems for 4 community forests as shown in Figure 5.

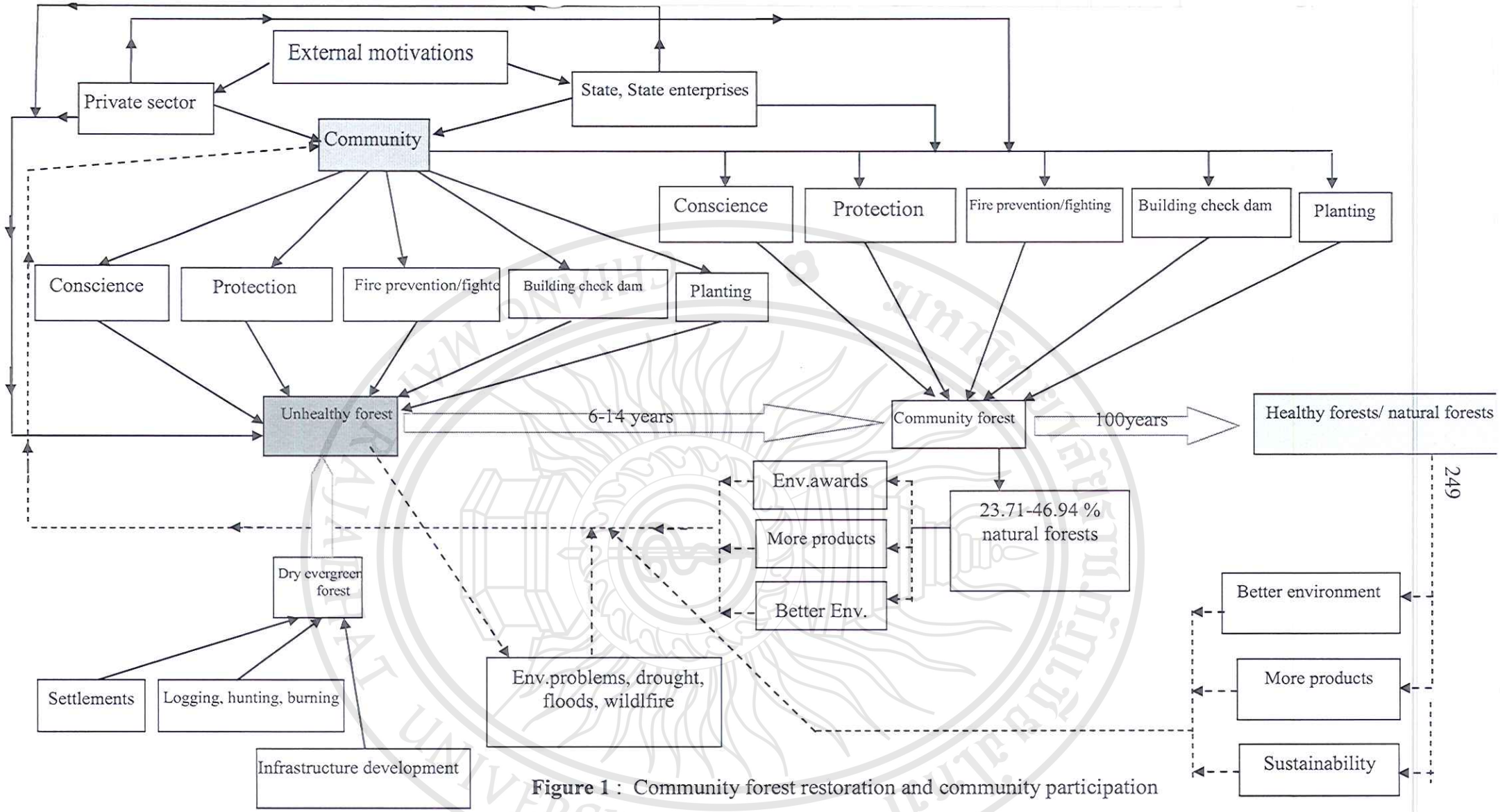


Figure 1 : Community forest restoration and community participation

Show the nature of the forest at each moment.

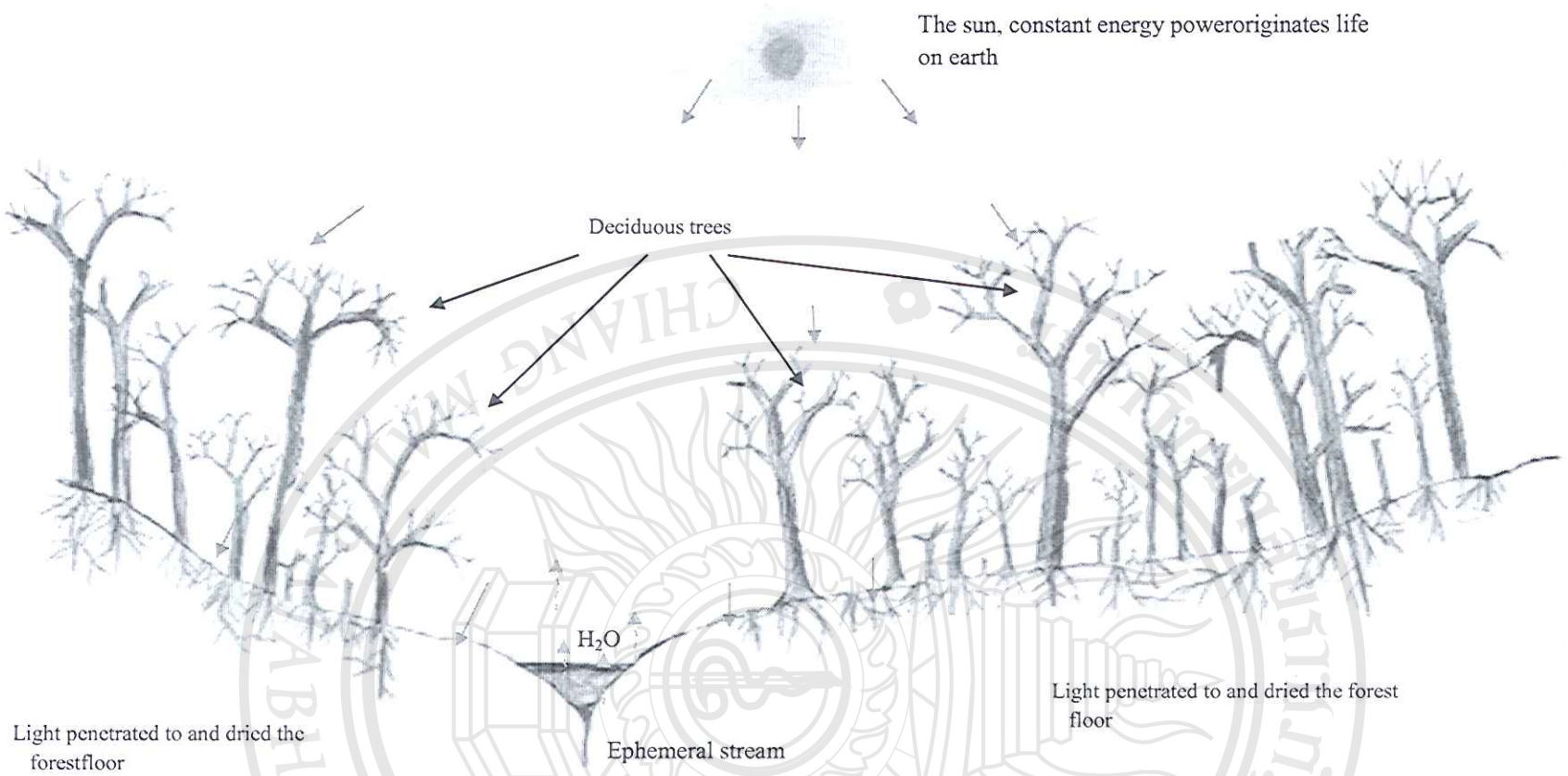


Figure 2. A sketch depicted problematic forests from reforestation done by the four communities

Figure 2. shows that sunlight was able to penetrate the deciduous trees whose leaves were shed in dry season into forest's floors. Losses of moisture from surface soils were unavoidable, making litter-falls and dried leaves prone to intensified burning. Although check dams were built to trap sediments and retain water, water was not able to permeate upwards to forest's floor as no roots of evergreen trees draw water from the adjacent check dams. Retained water at check dams eventually evaporated.

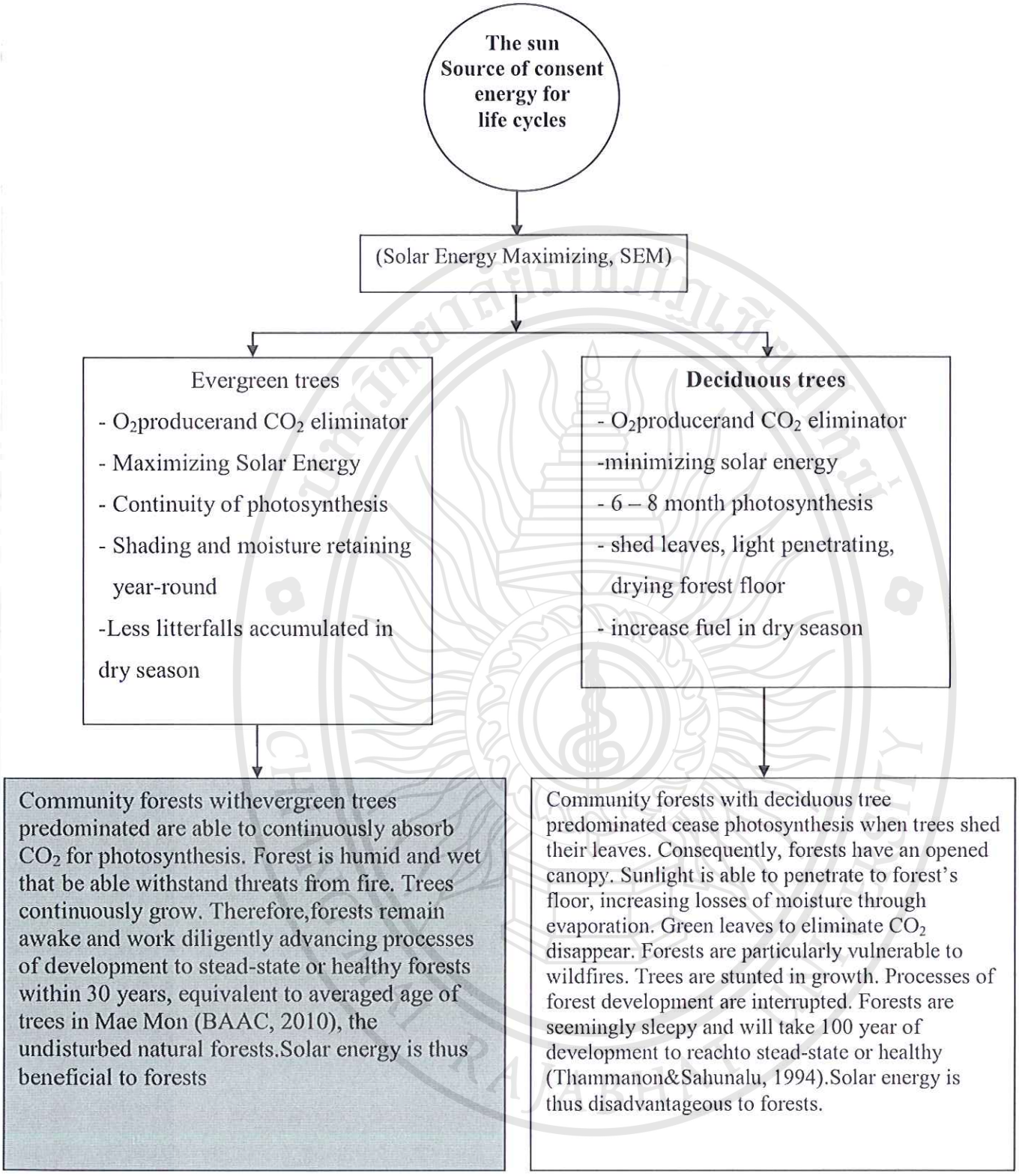


Figure 3 Concept of Solar Energy Maximizing (SEM).
Evergreen trees are predominated in order to increase capability of moisture retaining

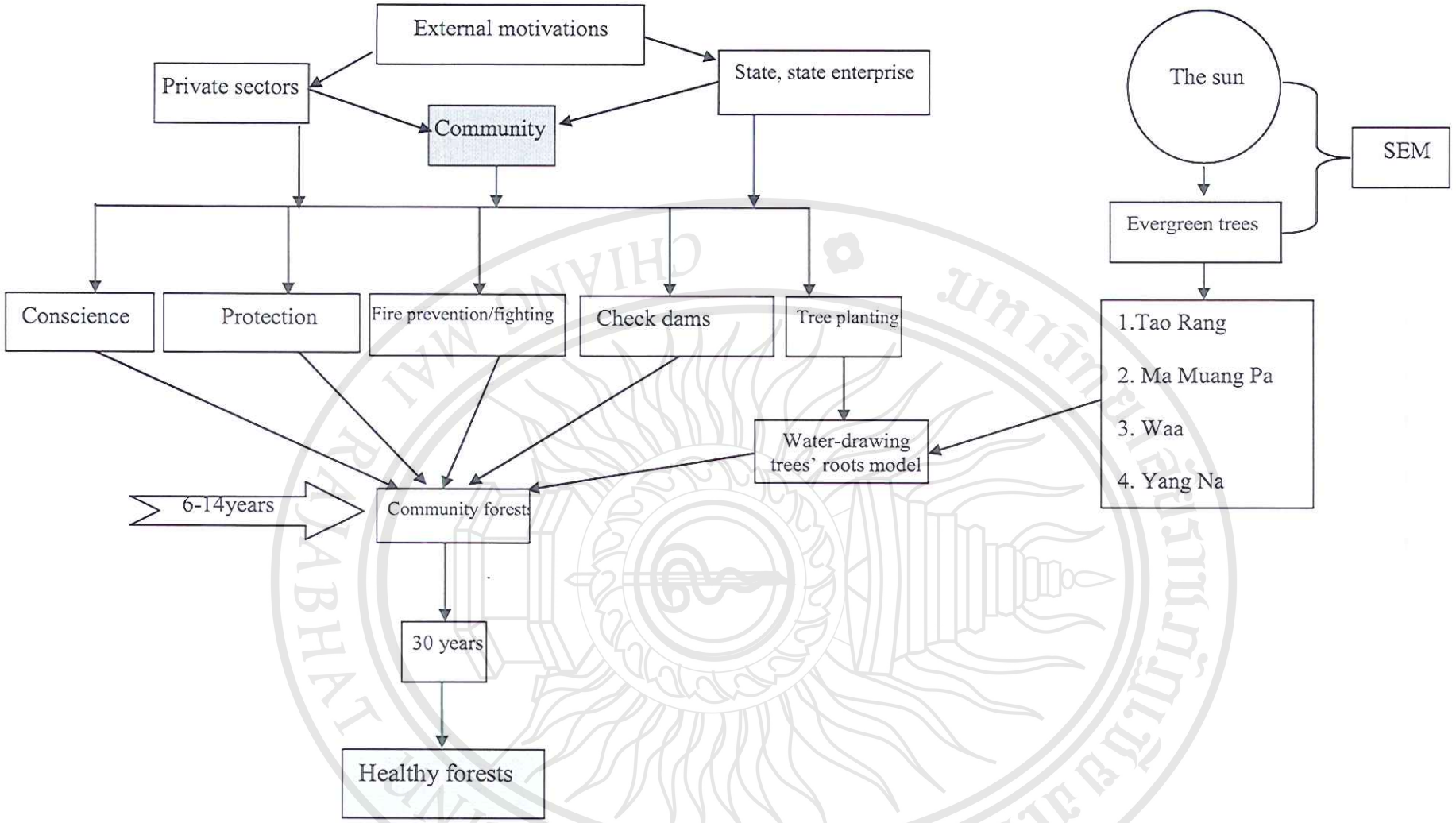


Figure 4 Forest restoration with the Water-drawing trees' roots model
SEM's concept and the four species of selected planted may shorten forest developing process from 100 years to 30 years

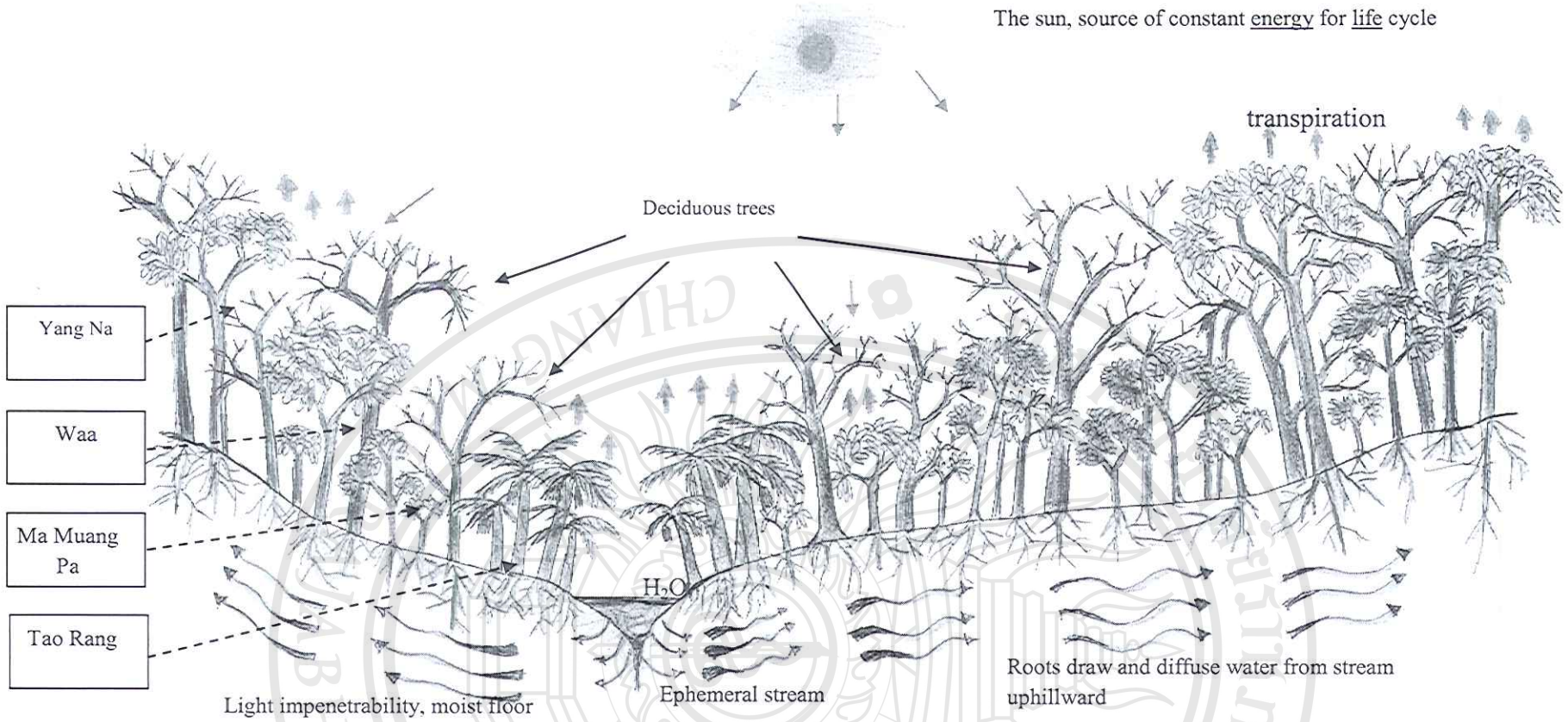


Figure 5.A sketch of reforestation with water-drawing trees' roots model

Figure 4.12 shows that sunlight is not able to penetrate to floors of forests restored with the water-draw roots' tree model. The floor is moist and wet, which is difficult to get burn. Photosynthesis and transpiration add more moisture under tree's canopy, attracting and flourishing organisms. Roots of tree continuously draw and diffuse water towards uphill as according to sequence planting of the four species, started from Tao Rang to Ma Muang Pa further to Waa and finally to Yang Na. This is called water-drawing trees' roots pattern.

Based on the information provided previously, please give your opinions based on the below questions:

Content	Opinions		Suggestions
	Agree	Disagree	
1. Appropriateness of forest rehabilitation approach with concept of SEM			
2. Applicability of forest restoration with the so-called Water-drawing trees' roots model			
3.The appropriateness of using the Water-drawing trees' roots model to solve the problem of forest restoration in all four communities.			
4. Your community would like to implement the Water-drawing trees' roots model to solve the problem of community forest restoration.			
5. Confidence that the Water-drawing trees' roots model can actually solve the problem of forest restoration of the four communities.			
6. You have other suggestions in order to make the Water-drawing trees' roots model more applicable.			

Overall opinion:

☐ Verified Water-drawing trees' roots model

☐ Unverified Water-drawing trees' roots model