MAKING BIODIVERSITY CONSERVATION ECONOMICALLY ATTRACTIVE:

OPPORTUNITIES AND CHALLENGES OF PES

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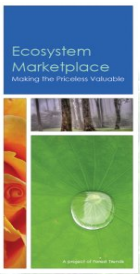
WORKSHOP ON BIODIVERSITY CONSERVATION AND IMPROVEMENT OF RURAL LIVELIHOODS,
1 TO 14 DECEMBER, KUNMING, CHINA

BACKGROUND

- **Biodiversity conservation has become a major thrust of forest management.**
- **Large extent of forests has been set aside as protected areas and many countries have imposed logging bans to enhance the flow of environmental services.**
- **Keeping forests largely for the provision of ecological services imposes costs on society and the issue is who will bear the direct and indirect costs of conservation.**
- **It is in this context that Payments for Ecological Services have been mooted and there has been a proliferation of efforts to develop systems for payment for environmental services.**
- **Payment for environmental services an appealing "two birds in one shot" proposition addressing the social and environmental dimensions:**
  - **Enhancing resource availability for sustainable forest management**
  - **Poverty alleviation.**
- **This presentation provides an overview of PES and the pros and cons in the use of PES for biodiversity conservation especially as regards livelihood improvement of rural communities.**

CRITICAL STEPS

- **Valuation of ecosystem services including biodiversity.**
- **Translating the value that society attributes to biodiversity to actual payments .**
- **Fair distribution of income to enhance the livelihoods of people who actually conserve biodiversity.**



VALUING ECOSYSTEM SERVICES

- **Much of the thrust of forest management has been on production of products that are directly or indirectly used by people, generating value in use. These include products like timber, woodfuel, non-wood forest products, etc.**
- **In addition forests also provide other ecological services that are not transacted through markets. These include watershed protection, carbon sequestration, biodiversity conservation, scenic values, etc.**
- **Many of these are considered as "God-given" and although valued highly by society, no price tag is attached to them.**
- **In the absence of any price tag, a money-driven economy tends to assign a low priority to environmental considerations.**

VALUE OF BIODIVERSITY

BIODIVERSITY CONTRIBUTES TO THE FOLLOWING

- **Productivity: More diverse plant systems tend to be more productive.**
- **Resilience: Diversity promotes stability as they are more resilient to external disturbances**
- **Insurance: Diversity provides insurance against catastrophic events**
- **Knowledge: Biodiversity can be used as a source of knowledge to develop new products in the biotechnology industry or pharmaceuticals.**

VALUATION OF ECOSYSTEM SERVICES

Use Values		Non-use values		
Direct use values	Indirect use values	Option value	Bequest values	Existence values
Timber	Watershed protection	Future direct and indirect values (especially stemming from conservation)	Future direct and indirect values (especially stemming from conservation)	Biodiversity, culture and heritage (satisfaction that stakeholders may derive from knowing about their existence without actually using them)
Woodfuel	Carbon sequestration			
Non-wood forest products	Arresting land degradation and desertification			
Recreational and cultural use	Control of air pollution			
Human habitat	Improved microclimate			

Biodiversity conservation generates direct use and non-use values for the present and future generations.

OPTIONS FOR PROVISION OF ENVIRONMENTAL SERVICES

- Invariably the emphasis as regards provision of ecological services has been through public interventions. This stems from the fact most of the environmental services are public goods.
  - Example: Publically funded protected areas
- Difficulties in public provisioning of environmental services has led to market approaches – for example PES.

KEY AREAS OF PES DEVELOPMENT

- Watershed management
- Carbon sequestration
- Amenity vales
- Biodiversity conservation

A review of PES literature suggests that most PES initiatives have been in the area of watershed management and carbon sequestration as these have a long history and they are less complicated as providers and users of the services can be more easily identifiable.

WHY PES FOR BIODIVERSITY CONSERVATION IS CHALLENGING

- Biodiversity generates two types of values
  - Values for the present generation by way of various products
  - Values for future generations
- Notwithstanding various difficulties, values accruing to present generations are amenable to assessment.
- This is however not the case with the value accruing to future generations, which remain extremely challenging.
- Considerable difficulties exist in identifying beneficiaries among future generations and the precise nature of benefits they derive.

PES FOR BIODIVERSITY

Bio-prospecting for new products and services.

Rewarding traditional knowledge.

Payment for conserving biodiversity rich areas.

BIO-PROSPECTING

- Bio-prospecting for new products and services.

  Bio-prospecting or biodiversity prospecting is the exploration, extraction and screening of biological diversity and indigenous knowledge for commercially valuable genetic and biochemical resources.
- Tropical forests are a major respository of plant and animal species with an enormous potential for new products, especially pharmaceuticals. Almost 25% of the prescription drugs in allopathic system are plant based and if we include medicines in the various indigenous systems the proportion could be very high.
- The existence of this potential is often put forth as the justification for biodiversity conservation.
- A series of steps are involved in the production of commercially important products and at each stage there are multiple risks.
- Both those undertaking bio-prospecting and those allowing bio-prospecting

BIO-PROSPECTING: COSTS AND RISKS

- A series of steps are involved in the production of commercially important products and at each stage there are multiple risks.
- Both those undertaking bio-prospecting and those allowing bio-prospecting face considerable uncertainties.

Source: Evans-Illidge & Murphy https://www.cbd.int/financial/benefitsharing/australia-marine.pdf

BIO-PROSPECTING AND INDIGENOUS KNOWLEDGE

- Considering the high costs and risks involved, random bio-prospecting is seldom undertaken. Agreements for such bioprospecting have considerable uncertainties.
- It is in this context that traditional knowledge comes in handy, which could significantly reduce the costs and risks, especially when drug development is narrowed to a small number of species.
- This however raises several questions relating to intellectual property rights and how to ensure a just system of access and benefit sharing, a key concern of CBD.

BIO-PROSPECTING AND LOCAL LIVELIHOOD – THE "JEEVANI" CASE STUDY

Probably the first time when access and benefit sharing arrangement was developed

- The species: Trichopus zeylanicus travancoricus
- Local community involved: The Kani tribe in Southern Kerala
- Institutions: CSIR Regional Research Laboratory, Jammu
  Tropical Botanic Garden and Research Institute
  Arya Vaidya Pharmacy, Coimbatore




THE "JEEVANI" CASE STUDY : THE CHRONOLOGY

- Botanical expedition in 1987 by the scientists and collection of information from the local guides from the Kani community.
- Product development – Jeevani - by the Tropical Botanic Garden and Research Institute and filing of patent 1996
- Agreement with local pharmaceutical company in 1996.
- Establishment of a Trust for the Kani community 1997
- Funds (part of the license fees and royalty) transferred to the Trust.
- Agreement with Pharmaceutical company comes to an end in 2004 and renegotiation.
- No takers for new arrangements after the agreement with the Pharmaceutical Company came to an end in 2008.
- The Kani Community Trust becomes dysfunctional

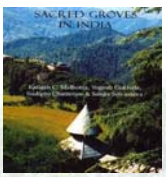
THE "JEEVANI" CASE STUDY : HOW IT FAILED?

The Kani –TBGRI- Pharmaceutical company initiative on Jeevani was one of the earliest efforts of Access and Benefit Sharing arrangement, even before the emergence of ABS under CBD. It received the UN's Equator Prize in 2002. Yet in a few years time it became a failed initiative on account of several factors.

- Ownership disputes over the medicinal plant – Between Forest Department and the local communities.
- Institutional problems within the Kani tribe trust and conflicts as regards ownership of knowledge.
- Absence of broad based participation
- Failure to obtain product patent resulting in widespread copying of the product.
- Illegal collection of raw material.
- Conflicting views of different institutions and inability to build a consensus

BIODIVERSITY CONSERVATION: THE CASE OF SACRED GROVES

- Many communities protect natural vegetation in the agricultural landscapes based on religious and cultural beliefs. This is a widespread practice in several countries.
- In many cases these sacred groves harbour relic vegetation and help to conserve biodiversity.
- Largely these are protected based on various religious beliefs
- However in the context of changing values and beliefs and increasing population pressure, these sacred groves are under threat.
- There are instances where governments are providing financial support to local communities to protect these sacred groves.



BIODIVERSITY CONSERVATION: THE CASE OF CAMPFIRE IN ZIMBABWE

- CAMPFIRE (Communal Areas Management Programme for Indigenous Resources) was initiated in 1986 to encourage local community management of wildlife, especially to reduce conflicts in resource use and enhancing income to local communities.
- Ensuring that income from trophy hunting, photography, game viewing, etc. accrue to local communities.
- By 2002 CAMPFIRE Association covered 35 rural districts, 777000 households and 244,000 km2 of communal lands, with actual wildlife production covered 85400 households over an area of 34,000 km2.
- Revenue sharing agreement between the various stakeholders.
- Very low income on a per household basis; but for the ward and district institutions the revenue appeared to be quite critical.
- Elite manipulation of income.

CAMPFIRE's approach is to make wildlife more valuable alive than dead.

MEXICO'S PES FOR HYDROLOGICAL SERVICES

- Mexico's federal payments for hydrological services program began in 2003. Although this is focused on hydrological services, its focus stopping deforestation addresses biodiversity conservation also.
- Pays land owners to maintain forest cover under a 5 year contract, compensating land owners for the environmental services provided by their forests.
- Between 2003 – 2011 3979 providers of ecological services were included covering an area of 2.664 million ha. Mexican National Forestry Commission allocated US$ 450 million for compensation during the period.

MEXICO'S PES FOR HYDROLOGICAL SERVICES

- Land owners will have to maintain forest cover in the enrolled parcel.
- Average rate of payment: US$ 27/ ha/ year for normal forest and US$ 36 for cloud forests
- Average income per year for those who occupy common property: US$ 130/ year
- Average income to private land owners: US$ 3050/ year (This accounts for almost 12% of the household income.

LESSONS FROM CASE STUDIES

- Among the various ecological services, biodiversity conservation is the most challenging as regards the development of PES. This stems from the multiplicity of products and the uncertainties involved as regards the future use of biodiversity.
- All the more difficult is to ensure that income actually accrues to local communities.
- There is a need to clearly identify the trade-offs between conservation and livelihood improvement as there could be situations when they could diverge.
- Building strong institutions enabling local community participation is very critical.
- Substantial research inputs are required especially to translate traditional knowledge into marketable products and services. This would require strong institutional capacity.
- Bundling of a number of ecological services – for example carbon sequestration, watershed protection, biodiversity conservation, amenity and scenic values may be an option. While there is a lot of convergences between these objectives, it is important to identify circumstances under which these objectives may diverge,

LESSONS FROM CASE STUDIES

- Most of the destruction of biodiversity is stemming from large developmental projects supported by governments, largely focused on enhancing immediate income.
- Biodiversity destruction by local communities is comparatively much less.
- Unless major changes are made as regards development policies, destruction of biodiversity on account of large projects will continue. Development of PES is unlikely to slow down the trend.
- Market mechanisms – PES – have very serious limitations in the conservation of biodiversity. Largely this stems from the fact that a significant proportion of the potential users of benefits from biodiversity conservation are from the future generations and it is extremely difficult to figure out what the "future's market" will be in the long term.
- Successful bio-prospecting is not sufficient to improve investment in biodiversity conservation. Increase in value has often led to over exploitation of resources.

CHALLENGES IN THE DEVELOPMENT OF PES

- Development of ecosystem services markets are related to the overall social and economic development.
- Even in economically well developed societies PES markets remain undeveloped.
- So can we expect the development of PES in developing countries, enhancing resources for SFM and alleviating poverty?
- Challenges in the development of PES:
  - Policy, legal and institutional issues
  - Technical problems
  - Economic issues – Will PES generate income commensurate with the transaction costs.
  - Potential for aggravating poverty, when environmental services are brought under the purview of markets.
  - Potential of PES to accentuate forest related conflicts.

SOME CONCLUSIONS FROM THE COSTA RICA INTERNATIONAL CONFERENCE ON PES

- Overall, PES schemes are not having the desired impacts in the vast majority of tropical forests that are vulnerable to deforestation and degradation, and they are benefiting only a few of the many millions of forest peoples and other owners and managers.
- Currently there are more sellers than buyers of the environmental services provided by tropical forests. There is a need to increase demand, develop formal markets with the engagement of the private sector, and increase the availability of secure, sustainable financing by creating an enabling environment.
- Indigenous peoples, local communities and private forest owners should be able to participate in schemes to pay for tropical forest environmental services as entrepreneurs rather than simply as passive receivers of compensation.
- To be successful and sustainable, PES schemes should use inclusive processes and sustainable practices, be transparent and accountable, and have robust and transparent institutional frameworks and enabling policies, and their benefits should be accounted for.

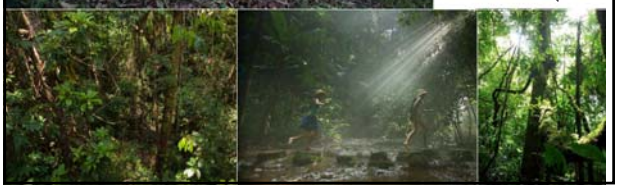

THANK YOU
WORKSHOP ON DEGRADED FOREST REHABILITATION AND
SUSTAINBLE FOREST MANAGEMENT 1 TO 12 JULY 2014

TianZi

A model project of Protection of Biodiversity and Rainforestation Farming system

Xishuangbanna once has possesses a very unique landscape, as well as great biological and cultural diversity.

however



The planting of a single crop such as rubber, banana,hemp,sugar caneand and tea has formed an industrialized system , in which the farming lunar calendar used by local farmers for quite a long time has completely become useless.

What are the disadvantages of reforestation?

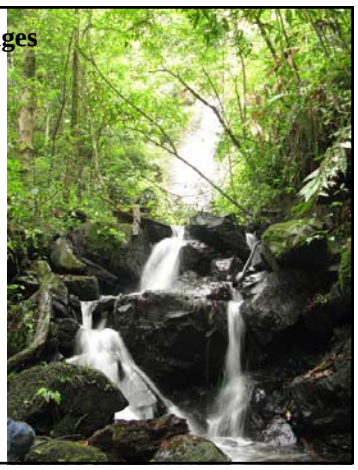
More seriously,the environmental consequences are catastrphic (endangering biodiversity, application of pesticides, concentration of heavy metals etc.) .

As a system of ecological environment and cognition, the real tropic rainforest was disappearing in Xiashuangbanna.

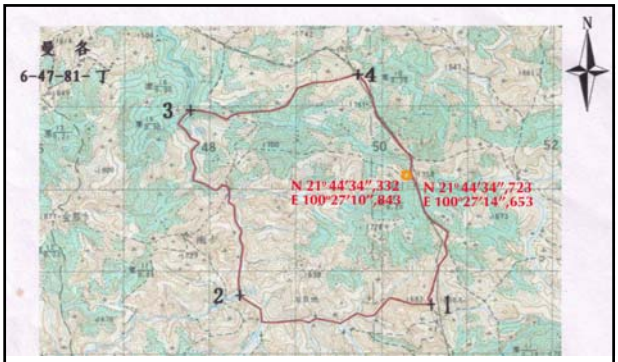
If deforestation leads to desertification, reforestation, by contrast, is favourable to increase vegetation.

What are the advantages of reforestation?

- *- It helps to combat soil erosion.*
- *It purifies the atmosphere from dust and numerous chemical composites.*
- *- It cleans the soil of heavy metals and destroys certain chemical composites (phyto-re-processing).*
- *- It cleanses water from numerous chemicals such as nitrates .*



Location of the TianZi* biodiverstity *planting base: Southern Yunnan,China.



Markers 1 to 4 represent the 4 corners of the Tian Zi Biodiversity Center reservation of about 600 ha.

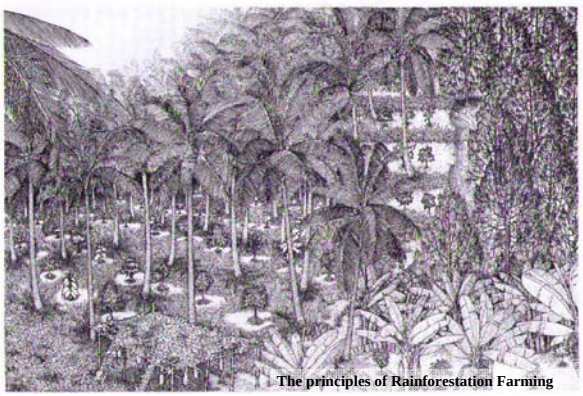
The lot dedicated to TianZi planting base is located near the entrance of the reservation.

A stereo ecoagricultural system-"Rainforestation Farming "

-The new technique of "Rainforestation" has been developed by Dr. Josef Margraf.

-Josef has experimented with this novel farming system in the Philippines, then he brought it to Yunnan.

-He believes that the agriculture of reconstruction could have been developed in Xishuangbanna due to its unique natural endowment.



The principles of Rainforestation Farming

It comprises a system of inter-cropping tubers, champignons, shadow-loving fruit trees,epiphytes, and trees of 40 to 60 meters height.

Which are the principles of the Rainforestation Farming ?

•The rainforestation farming makes it possible to develop all the stages of the vegetation, from the grounds to the summit of the trees.

•This new forest system gives a strong productivity as well as a highly diversified durable production.

•The rainforestation farming restores a whole ecosystem for the greatest benefit of the local populations while protecting the biodiversity.

•The rainforestation farming reduces the existing bad ecological impacts arising from the large-scale industrial agriculture inappropriate in the tropical zone.

•It is a question of combining production and conservation skilfully.

How can the system achieved?

The primary forest has been destroyed about 50 years ago and it was converted into graslands. The process of reforestation has already started.

Description of the Project

Before starting the work,TianZi signed long-term land use agreements with the villagers since the beginning of 2007. with the possibility to extend this area in the coming years.

Technical aspects

- *The most important principle in planting techniques consists of allowing the natural growth of the vegatation during the initial period. Pioneering species like the trees and bushes of Betulaceae Family (Alnus nepalensis, Betula alnoides) or of the Lauraceae (Cinnamomum austro-yunnanensis) or else the Theaceae (Schima wallichii and Anneslea fragrans) will eventually form a coverage with shadow that will eliminate grassy plants.*

Technical aspects

At the beginning of the rainy season the saplings grown in the TianZi nursery, are planted by way of inter-cropping, using the shadow of the tall pillar trees.

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Technical aspects

The young saplings are planted in groups of 9, and in a circular. These trees and bushes will form the "skeleton" of our future Rainforest. The new eco-system will be ready to to receive a number of epiphytes, such as orchids and numerous creeper

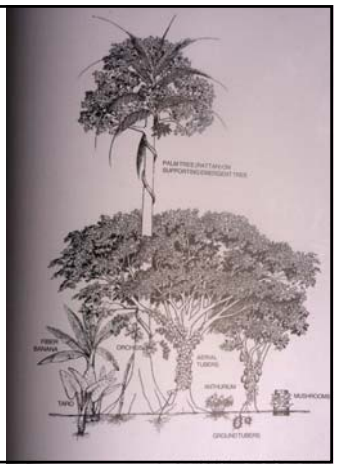
Protect the endangered species

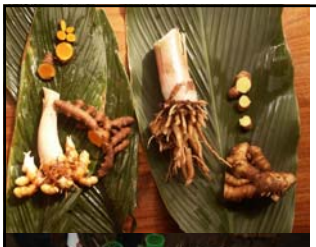
Protecting biodiversity

A minimum of one hundred different species of trees and bushes will be planted in the plot assigned
such as:
-Dipterocarpus turbinatus,
-Thea sinensis,
-Mesua ferea,
-Toona sinensis
-Musa xishuangbannensis,
-Michelia heydiosperma

Protecting biodiversity

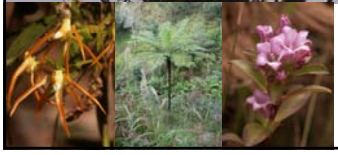
It is essential to note that in sub-tropical areas virutally all products (with the exception of rice and sugar cane) are harvested from shadow-loving plants.





Protection biodiverstity

These shadow-loving plants may provide basic food of the highest priority (taro, champignons), spices (ginger, cardamom), medicinal plants (Gynostemma pentaphylla), plants useful for the production of cosmetics (Thea oleifera), fruits (Mango sylvatica) or ornamental plant s (orchids, Vanda coerulea).



Protection biodiverstity

Certain species, such as this creeping plant by the name of Hodgsonia macrocarpa, which belongs to the family of the Cucurbitaceae, demand very special attention; its seeds are of a very high nutritional value, including a high percentage of non-sturated fatty acids.

Protection biodiverstity

Hodgsonia macrocarpa présente également l'intérêt d'attirer une fourmis très agressive qui débarrasse son arbre hôte de tous les parasites et insectes indésirables.

Protecting biodiversity

The Dendrobium chrysotoxum is used locally to enhance the flavour of the best Yunnan Teas, and it was re-introduced in grand scale within the reservation area.

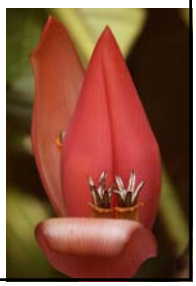
Protecting biodiversity

Within the lot allocated to Jardin Express, the TianZi Reservation has re-introduced two species under threat of extinction: these are a very small banana plant, Masa rubinea, and an orchid named Cymbidium bicolor.

These endangered species were taken form the botanical garden of Josef in Jinghong to be re-introduced into the 600 ha reservation of the Bulang Mountains.

Protecting biodiversity

Masa rubinea *is a small banana plant that is resistant to certain types of small noxious jellies in Yunnan; it has practically disappeared from ist natural habitat; the beautif of ist flower is unforgettable, and ist ornamental value will ensure ist survival.*

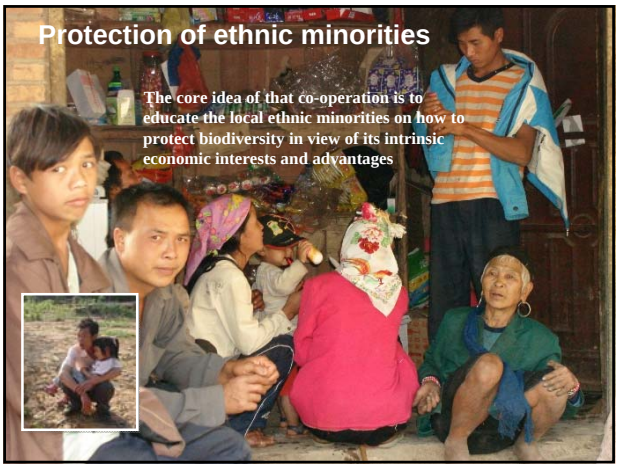


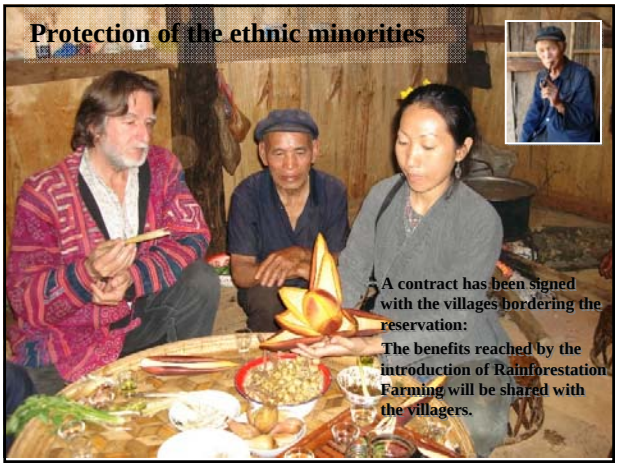
Protecting biodiversity

The Cymbidium bicolor is a epiphyte orchid one can also find by way of a production of hybrids in all of Asia. However, it has practically disappeared in its wild form as it is utilized as a cure-all and therfore as an enrichment to Tradional Chinese Medicine.

Protecting biodiversity

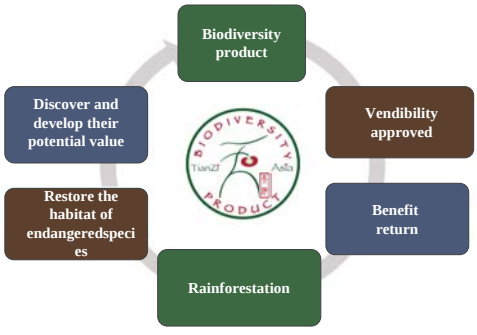
In order to complete the re-introduction, in vitro germination will be started in order to be able to replant, two years from now, the young offspring throughout the reservation.





To improve livelihood of ethnic communities.

How does our project works and output ?



TianZi Native Products Co.

To develop rainforest industries of medicine, spices, organic foods, display of high-end life, ecotourism, study of natural science etc..

TianZi Biodiversity Products

TianZi Biodiversity product-Fragrance

设计思路：立体的香韵和香阶设计

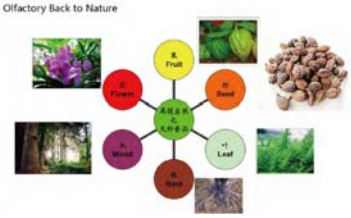
Ideas of Design : Stereo Aroma Note & Tone Scale

Stereoscopic and Multi-level Olfactory Perception System

TianZi Biodiversity product-Fragrance

原料的选择:嗅觉感知系统之自然的再现

Selected Incense : Olfactory Back to Nature



TianZi Biodiversity product-Golden Orchid

天籽金蘭

TianZi Biodiversity product-Pu'er tea

TianZi Pu'er tea |ancient tea tree

TianZi Biodiversity product - Daily cosmetics

Pure-plant essential oil repellent spray

Pure-plant skin care gel

TianZi Biodiversity product-Golden Orchid mix with Pu'er tea

TianZi Golden Orchid Pu'er tea was selected into the list which "FOOD THAT CHANGE THE WORLD"

THANKS

"It's the world's most advanced rainforest restoration projects"

The project – which was launched about five years ago by the German biologist Josef Margraf, now deceased, and his wife Minguo – pioneers a "rainforest farming" technique that creates a rich habitat for multiple species, from which a modest income for people can be cultivated from orchids, tea, honey and other products.
Hopes were high that the project could offer an economically viable alternative to the monocultures that are gobbling up forests across vast swaths of south China and south-east Asia. "

—— The Guardian（2011 10.25 EST）
writer: Johnathan Watts

Location of Yunnan Province

-- A remote mountainous province situated in southwest China
-- Sharing borders with Burma, Laos PDR and Vietnam
-- More than 44 million people with 25 ethnic groups
-- With the total land area of 394,000 Km^2, 94% of which is mountainous areas.

Basic Information

- Definition of forest resources
- Administrative system of Forestry
- Land tenure and ownership of forest resources
- Collective forestland tenure reform in rural community

Definition of forest resources

According to Chinese Forest Law in 1998:

- forest resources consist of *timber, bamboo, forestry land and other wild plants and animals* living in the forests.
- forest resources belong to *state* except those parts belonging to *collectives entities (communities/collectives).*

Administrative system of Forestry

Central Government (State Council)

- Provincial Governments
  - Prefecture/City Governments
    - County/City/District Governments
      - Township Governments
        - Administrative Villager's Committees
          - Villages Groups

- State Forestry Administration
  - Forestry Departments
    - Forestry Bureaus
      - Forestry Bureaus
        - Forestry Stations
          - Forestry Guiders

Forest Resources (owned by State and Community)

Land tenure and ownership

- In general, both arable and forestland was defined as State owned and Collective or Community owned officially after 1949 in China.
- The forests tenure in China involves ownerships of forestland as well as trees or forest resources above the land.

1. **State owned forestland (42% of total forestland)**

Such as Commercial forests, Nature Reserves, National Park, and Protection Forests (ecological benefits, water conservation, shelter belt etc.) and Forests Contracted to individuals.

2. **Collective/community owned forestland (58% of total)**

- Collective forests (including holy hills, sacred forests),
- Contracted forests for self use, as well as responsible forests. (before ongoing reform of rural collective forests tenure).

3. CF-Background in China

- The hilly areas account for 69% of the total land area and are home to 56% of the total population in China.
- Large portions of hilly areas have been classified as "forestry land" or land areas for forestry development, even though many hilly areas are not forested or barren.
- Currently, rural community/collectives own 2.5 billion mu (15 mu =1 ha) of forestry land, which accounts for 58% of the total forestland in China.

4. The main historical changes on forestland tenure system

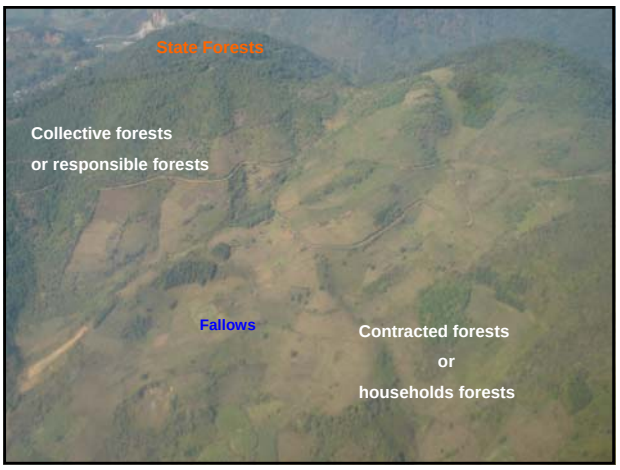
- Before the establishment of People's Republic of China in 1949, the privately owned system was the dominated system both for land resources and forests resource.
- After that, the policy changes of land tenure and forest ownership could be divided into four phases since 1950's up to now.

I. *1st rural land reform "* : Both land and Forests allocated to individual households in the early 1950s until 1958.

II. *"Collective period* : Highly centralized system from 1958 to early 1980s.

III. *"liangshandaohu"* started in 1982 to 2008 (next to land contracted responsibility system in 1979/2nd "rural land reform").

IV. Current ongoing reform of rural collective forest tenure system (formally started from 2008- until 2014).



5. Collective forestland tenure reform in rural community

- A nationwide program for rural collective forestland tenure reform launched in July 2008, it proposed to be completed by 2014.
- Seventy years as the contracted period for forestland allocation, and it will be renewed once the term of seventy years was finished.
- With the issued tenure certificate, individual households will be allowed to transfer the forests tenure to others freely by the ways of sub-contract, rent/sale, auction, mortgage and joint venture within the contracted period.

5.1 Initiatives

- The forest tenure system has been changed several times since the early 1950's, but the rights to own, use and benefit from collective/community forests was still not clarified by those ambiguity tenure systems between individual farmer households.
- Individual households lack a real ownership on rights to allocated forests, and also lack necessary laws to protect benefits from forest resources under their management.
- The ambiguity of forest tenure system has been a main problem for rural community forest management and interfered with sustainable development of community forestry.

5.2 Objectives

- The reform aims to increase the confidence, initiative, and ability of local communities to participate in the sustainable community forestry management than before.
- To improve the previous forest management mechanism by clarifying and transferring of forestland tenure and ownership of forests from collectives to individual households with the fixed duration of seventy years by issued tenure certificate based on the contract of forest allocation.

5.3 Targets

- The reform targets all collective commercial forest and waste hills/fallow suitable for forestation. The collective forests recognized as nature reserves, and forests under the national forest protection program are excluded from the reform.
- An emphasis is focused on the equal allocation of forestland among individual households based on the number of family member. The allocation of ownership over a fixed number of the family size will not increase as the growth of population.

5.4 Tasks

- The current reform ensures individual farmer's "four rights" as following:
  - the information right regarding forest ownership and use arrangements;
  - the right to independently manage forest resources;
  - the right to transfer ownership of forest resources use rights;
  - and the right to benefit economically from ownership of those forest resources.

5.5 Procedures of reform

Field inventory /investigation of forestland

Boundary mapping and delimiting

Field re-checking and confirmation with individual farmer

Intermediation of forestland disputes

Creating documental files and preparing for issuing certificates

Public ceremony for delivering official certificates

Distribution of certificate to individual farmer

5.5 Progress of the reform

- Presently, the reform for rural collective forest tenure system has fully implemented throughout the whole country based on the experiences from the previous eight pilot provinces where the reform is nearly completed.
- There are 290.16 million mu of community forestland in Yunnan. In which, 96.7% of total community forestland was allocated to the individual farmer households with the certificate issued officially by government up to date.

- The reform has popularly accepted by individual households because farmer not only receive the actual use right of forestland for seventy years, but also gain the ownership of forest resources on the contracted forestland, such as trees, timber and NTFPs and so on.

Traditional upland shifting cultivation, especially the slash and burn almost disappeared now.

Conversion of uplad farming system

(Upland rice+Chinese fir)

Land use changes after the reform of community forestland tenure system

Landscape before reform in 2009

Landscape after reform in 2012

Thank you !!!

Forest Biodiversity Conservation and improvement of rural livelihoods In Cambodia

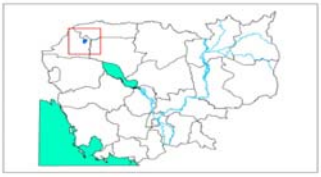
1-14 Nov 2014, Kunming, China

Outline

1. Background
2. Objective
3. Institutional and Legislation
4. Issues and challenges
5. Approaches
6. Lesion Learned
7. Opportunity
8. Conclusion

Background

- ATT is located in the north west of Cambodia.
- It's man made reservoir (20,000 people died from building dam).
- People collected plant and do other activities from the reservoir for their daily livelihood.
- Important feeding ground for Sarus Crane *(Eleocharis dulcis)*



Objectives :

- To protect Sarus Crane and other wildlife species for future generation
- To protect the natural resources for sustainable use of local people.

Institutional and legislative framework

- Established Royal degree on ATT Sarus Crane reserve Conservation and Management Area for Biodiversity Conservation and to improve local people 's livelihoods.
- Established Community Management Committee for implementation and management the work.
- Established role ,regulation and agreement which is recognized by local authority .
- All the work are monitor and evaluation from the Forestry Administration staffs.

Outline

1. Background
2. Objective
3. Institutional and Legislation
4. Issues and challenges
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6. Lesion Learned
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8. Conclusion

Issues and challenges

- Hunting for food and for sell
- Hunting at night time using home made gun

- Poison water bird for food and selling
- Crane Chick selling in the Cambodia -Thai border and Trapping .

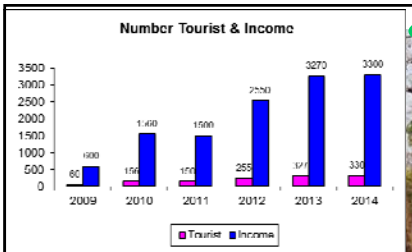
- Canal construction
- Land grabbing and encroachment
- Weak collaboration
- Financing
- The enforcement of these legislations are not strong enough
- There are overlapping responsibilities and involvement of inter agencies.

Approach

- **Community Forestry (CF) and Community Protected Areas Development**
- **Participatory Land Used Planning**
- **Capacity building**
- **Demarcation**
- **Law enforcement and governance**
- **Planting and rehabilitation**
- **Capacity building and education**
- **Involve with all stakeholders on decision makers**

Approach (continue)

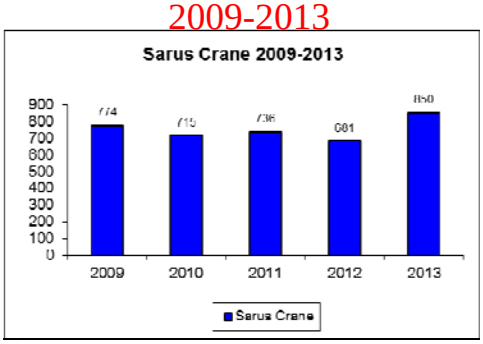
- **Ecotourism**
- **Wildlife Friendly Rice**
- **Rice bank**



Tourists – number & income

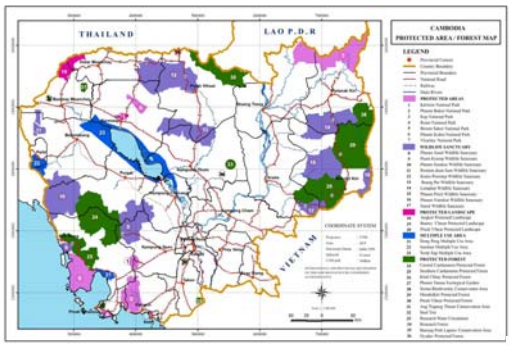
Ecotourism con..

Sarus Crane Count in Cambodia 2009-2013



- Count Crane from the early morning and the late afternoon
- Count Crane in the same time in different places in Cambodia

Protected area system in Cambodia



Lessons learned

- Sustainable forest and biodiversity management with participation from local community proves to be effective.
- Designation of the Conservation Area and protected forest provides an excellent opportunity for sustainable biodiversity and forest management.
- Collaboration and coordination among involved stakeholders ranging from decision makers to local community donors and NGOs are a powerful tools in sustainable biodiversity and forest management
- Divided the core zone and buffer zone and participatory land use planning.

Opportunities

- More Painted and Milky Storks may come to nest in the ATT Sarus Crane reserve Conservation and Management Area and other large water birds, possibly Black necked Stork, Spot-billed Pelican, Black headed Ibis , Lesser and Greater Adjutant, and Sarus Cranes will follow suit.
- Local community benefits - conservation
- Ecotourism is getting much income for local people because the population of bird increase
- Even more roosting places for water birds
- Ecotourism and Wildlife friendly rice is best chance for improving of local people standards .

Conclusion

- To improve on Forest biodiversity Conservation and improvement of Rural livelihoods in Cambodia are:
- Education program and awareness of Forestry and wildlife law
- To give local people incentive through ecotourism &Wildlife friendly rice.
- To establish of Protected Forest and Conservation Area
- The Cambodia government should provide enough support for capacity building and financial for community Management committee to implement the work.

FIJI COUNTRY REPORT

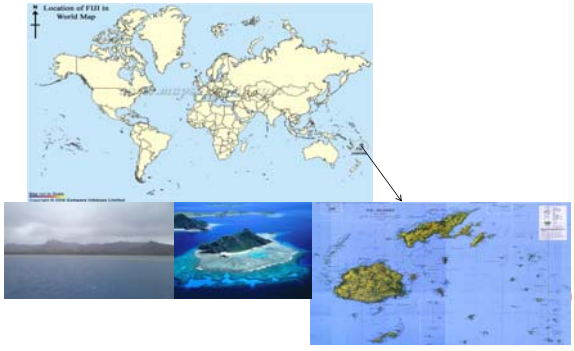
FOREST BIODIVERSITY CONSERVATION AND IMPROVEMENT OF RURAL LIVELIHOODS

Fiji Forestry Department
P. O. Box 2218
Government Building
Suva
Fiji Islands

GEOGRAPHICAL LOCATION

- Fiji is an island nation in Melanesia in the South Pacific Ocean.
- Its closet neighbors are Vanuatu to the west, France's New Caledonia to the southwest, New Zealand to the southeast, Tonga to the east, the Samoa's, France's Wallis and Futuna to the northeast, and Tuvalu to the north.
- The majority of Fiji's islands were formed through volcanic activity starting around 150 million years ago.

GEOGRAPHICAL LOCATION



LAND AREA

The country comprises of more than 332 islands

- 110 are permanently inhabited
- and more than 500 islets,
- amounting to a total land area of 18,300 square kilometers (7,100 sq mi).

POPULATION

- The estimated population of the country is 849,000
- Indigenous Fijians is counted at 511,838,
- while there are 290,129 Indians and 56,071 Others (January 2012). Most Fijians live on Viti Levu's

GOVERMENT

- **Fiji Government** was formed in 1970, when the country gained independence from Britain.
- It was interrupted when a military regime was established in 1987 followed by two coups.
- In 1992 again an elected government came to power.
- The President is the head of state while the Prime Minister is head of **Fiji Government**
- Currently the Government had already release the 2013 draft constitution. As from today the Government is looking forward to the 2014 election.

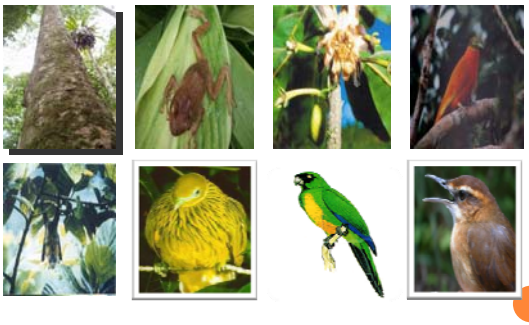
CLIMATE

- Fiji enjoys a tropical maritime climate without great extremes of heat or cold
- **coolest months** (July and August) and **warmest months** (January to February).
- the average temperatures rangers from 18 - 32° C
- Rainfall is usually abundant during the wet season (November-April)
- Annual rainfall in the dry zones averages around 2000mm, whereas in the wet zones, it ranges from 3000mm around the coast

FLORA AND FAUNA

- Fijis Flora and fauna are relatively few in number but high proportion of endemic species
- 10% of the 476 indigenous Fijian plant species identified are endemic
- 2,600 flora and fauna been confirmed to be existed nationwide
- 1600 types of plants and trees are classified to be endemic.
- 1000 types of plants and trees are classified to be exotic
- 310 types of ferns, where at least 30% are endemic.30 types of Palm, where at least 99% are endemic.200 types of plants and tree are native.

FIJI'S RAREST FLORA AND FAUNA



LAND USE

- open grazing 2,700 km² including 950 km² of roadsides
- 280 km² grazing under coconut or forest trees
- 380 km² of crop or fallow under coconuts
- 1,950 km² ha of arable and tree crops other than coconuts
- 1,000 km² of plantation Mahogany and Caribbean Pine

FOREST COVER

- Fiji's Forest cover is approximately 1011,505 hectares in relation to total land mass of 18,376km² which includes;
- Indigenous forest-857,533 ha
- Pine Plantation-93.524ha
- Hardwood Plantations-60.448ha

FOREST TYPE

- Forest is also classified according to their designation and management as follows:
- Multiple Use Forests-498.999ha
- Protection Forest-304.200ha
- Preserved forest-88.800ha
- Production forest-132.278ha

VEGETATION

- Vegetation cover is classified as follows:
- Closed Forest-556.385ha
- Open Forest-342.845ha

LAND TENURE SYSTEM

- Land in the Fiji Islands is managed through three complementary systems- Native Land, freehold land and Crown Land
- Freehold land can be bought and sold. Native Land and Crown Land cannot be bought and sold but is available only on a leasehold basis
- Leasehold land can be developed as much of it is available on a long-term lease basis (often 99 years)
- 83% of the country is native land, 10% is freehold and 7% is crown land

ECONOMY

- Fiji is one of the most developed countries of the Pacific island economies though still with a large subsistence sector endowed with forest, mineral, and fish resources
- Sugar exports, remittances and a tourism with 400,000 to 500,000 tourists visit the country annually

NATIONAL FORESTRY ACTION PLAN

- Fiji is currently reviewing its Forest Policy in the hope of streamlining its strategies
- to adequately address the ecological, economical and social dimension
- A key principal is the implementation of land use planning at the national, provincial, district and even landscape level
- government will classify land according to their potential use
- higher-value timber production, Afforestation, rehabilitation
- protection and conversion to other land uses

CONTRIBUTION OF FOREST SECTOR TO THE NATIONAL ECONOMY

- Forestry Department's policies and strategies are driven towards the sustainable management of forest resources for the benefit of the rural community in particular the land owners.
- Foreign earnings from the export of timber and other wood based products averaged $42 million a year in the decade.
- Each year the Government allocates an average of $1.3 million to undertake community forest development, landowner's awareness and training on sustainable forest management
- to improve the monitoring and surveillance of logging operations, portable sawmills for resource owners and forest certification to promote and assist landowner participation in the forestry sector.

IMPORTANCE OF FOREST AND TREES TO THE COUNTRY'S ENVIRONMENT

- Fiji islands are rich in biodiversity. Natural forests host unique communities of plants and animals of which many species are endemic
- biodiversity is critically threatened by over exploitation of resources, and the fragmentation of ecosystem and habitat destructions as a result of human activities and the impact of invasive species.
- Sustainable management of forest resources is an important element of sound land use
- it is in the interest of all Fijians to maintain a natural forest cover that is in a position to provide the full range of economic, ecological and social functions for present and future generation

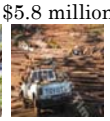
CONT'

- Fiji has exisisting forest estates that are known as forest reserves and protected sites. These sites are under state
- non-governmental organization sees a significant contribution to the long term conservation and biodiversity in collaboration with the custodial communities.
- Nature reserves and protected areas are rich in fauna and flora, wildlife, diversity and have immeasurable benefits

BENEFITS OF FOREST HAVE PROVIDE MEALS FOR THE LOCAL COMMUNITIES

TIMBER PRODUCTION

- Logs are mainly processed into sawn timber, veneer, plywood, block board, molding, poles and posts, and woodchips with total export volumes averaging 266,000 cubic metres each year.
- Total earnings derived from the exports for 2010 was $77.2 million,81% increased, compare to 2009 ($42.6 million).
- The total import for 2010amount to $5.9 million compare to $5.8 million(2% increases)

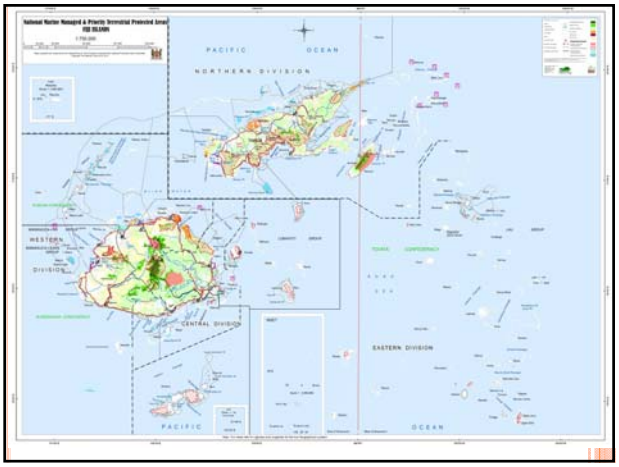


CONT'

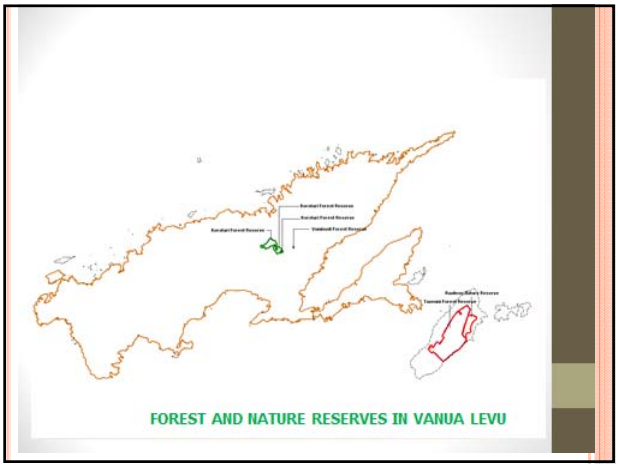
- Most of the wood products are sold to Australia and New Zealand, whilst wood chips are sold exclusively to Japan.
- The American market absorbs approximately 40 percent of all veneer products

TYPES OF CONSERVATION

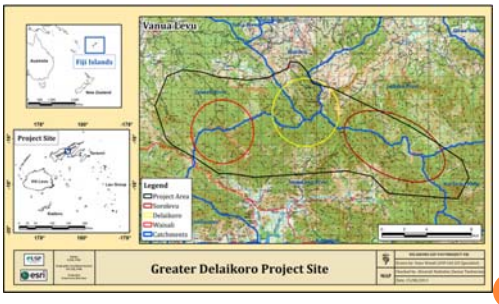
Nature Reserves
Protected Forests
Forest Reserves
Important Birds Area
Heritage sites
REDD +
Marine Protected Areas

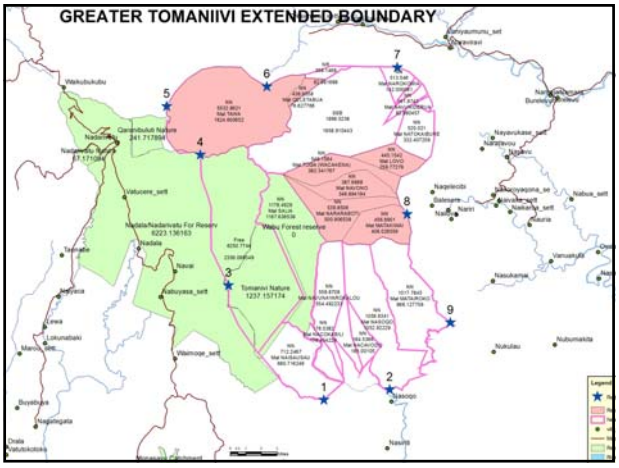


NAME	Type of Protection	Area (ha)	Area SQ_KM
Taveuni	Forest Reserve	11089	110.89
Yunimoli	Nature Reserve	20	0.20
Draunibota Nature	Nature Reserve	41	0.41
Labiko Nature	Nature Reserve	2	0.02
Vuo Nature	Nature Reserve	3	0.03
Ravilevu	Nature Reserve	3939	39.39
Vadua Taba	Crested Iguana Sanctuary	71	0.71
Waisali Forest	Forest Reserve	306	3.06
Garrick Memorial park	Memorial Park	434	4.34
Vaturu Catchment	Water Catchment	218	2.18
Monasavu Catchment	Water Catchment	706	7.06
Sovi basin	Conservation Reserve	20377	203.77
Colo-i-suva	Forest Reserve	497	4.97
Sigatoka Sand dunes	National Park	177	1.77
Namenalala island	Conservation Reserve	43	0.43
Wabu	Forest Reserve	1062	10.62
Tomaniivi	Nature Reserve	1104	11.04
Nagaranibuluti	Nature Reserve	241	2.41
Nadarivatu	Nature Reserve	67	0.67
Nadarivatu/Nadala	Forest Reserve	6246	62.46
Koroyanitu Heritage Park	Koroyanitu Heritage Park	2434	24.34
Rivers Fiji (Upper Navua)	Eco Tourism	859	8.59
Savura Forest Reserve	Savura Forest Reserve	188	1.88
Bouma_Lavena	Community cons areas	3769	37.69
Kago	Forest Reserve	365.00	3.65
Qoya	Forest Reserve	29.00	0.29
Yarawa	Forest Reserve	394.00	3.94
Naboro	Forest Reserve	47.00	0.47
Buretolu	Forest Reserve	2960.00	29.60
Lololo	Forest Reserve	8.00	0.08
Saru Creek	Forest Reserve	1235.00	12.35
Koroutari	Forest Reserve	4186.00	41.86
Total		63117	631.17



NEW CONSERVATION SITE





RATIONALE

Issue 1: Level of CBD is LOW

Issue 2: Poor forestry & agriculture practices result in low productivity and degradation

Conservation Focus:

Biological Diversity Conservation is **"WEAK"**, due to the following **BARRIERS:**

- **Resistance to change** in Local Communities;
- **Poor Coordination**
- **Lack of Capacity** (including resources);
- **Lack of experience** with community-based approaches to conservation;
- **Inadequate/Out-dated** Policy & Legal Framework

AIM: to assist in removing these "BARRIERS"

WAY FORWARD

- Establish Laws and Policy Framework for Protected Area;
- Establish and Ensure Proper Management of Demonstration Sites;
- Build Capacity and Create Awareness;
- Establish Sustainable Financing Mechanism;

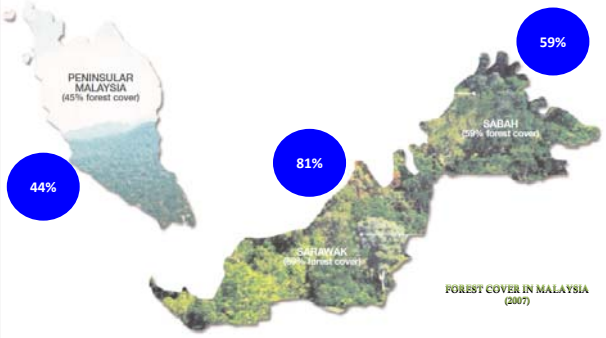
VINAKA ! (THANK YOU)

FOREST BIODIVERSITY CONSERVATION IN PENINSULAR MALAYSIA

Mohd Syahrir Azrin bin Salleh
Forestry Department Peninsular Malaysia Headquarters,
Jalan Sultan Salahuddin, 50660 Kuala Lumpur, MALAYSIA

Largest *Neobalanacarpus heimii*, Pasir Raja FR, Terengganu.

FOREST COVER IN MALAYSIA (2013)



AN OVERVIEW OF FOREST BIODIVERSITY IN MALAYSIA

Flora

- 15,000 flowering plant species
- 2,650 tree species
- 1,100 species of fern and fern-allies

Fauna

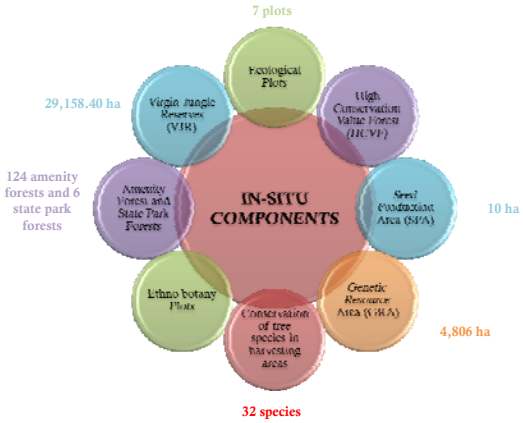
- 300 species of mammals
- 700 – 750 species of birds
- 165 species of amphibians
- 350 species of reptiles
- 300 species of fresh water fish
- 1,200 species of butterflies
- 12,000 species of moths

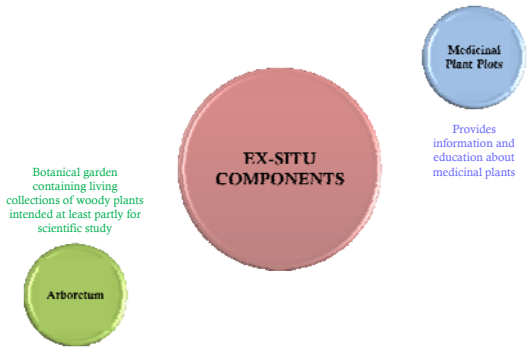
FOREST BIODIVERSITY CONSERVATION INITIATIVES

FDPM's initiatives in conserving forest biodiversity involves two main components:

i. In-Situ:
On-site conservation or the conservation of genetic resources in natural populations

ii.Ex-Situ:
The conservation and maintenance of samples of living organisms outside their natural habitat





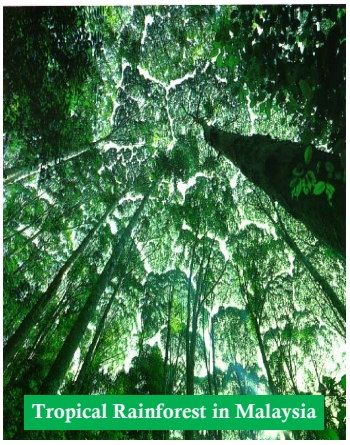
Other initiatives:

i. Forest Biodiversity Scientific Expedition and Seminar; and

ii. Public Awareness and Publication.

CONCLUSION

Conservation of forest biological diversity is essential for sustaining the productive values of forests, for maintaining the health and vitality of forest ecosystems and, thereby, for maintaining their protective and environmental roles. The greatest threat to forests and the diversity is the conversion of forests into other land uses. While it is inevitable that land use changes will occur in the future, such changes should be planned to help ensure that complementary goals are achieved. This can be done by including concerns for conservation as a major component in land use planning and management strategies.


Tropical Rainforest in Malaysia

THANK YOU

http:// www.forestry.gov.my

Workshop Forest Biodiversity Conservation and Improvement of Rural Livelihoods

Mexican Case Payment for Environmental Services (PES)

November, 2014

Reference framework
Extent of forest

Rank	Country	Forest cover 1,000 ha
1	Russian Federation	809,090
2	Brazil	519,522
3	Canada	310,134
4	United States of America	304,022
5	China	206,861
6	Democratic Republic of the Congo	154,135
7	Australia	149,300
8	Indonesia	94,432
9	Sudan	69,949
10	India	68,434
11	Peru	67,992
12	MEXICO	64,802
-	World	4,033,060

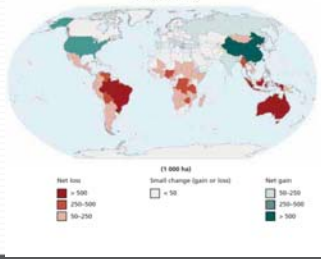
Forest area as a percentage of total land area by country, 2010

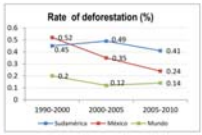
Source: Global Forest Resources Assessment 2010, Food and Agriculture Organization of the United Nations (FAO)

Annual change rate

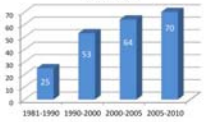
Average deforestation of 155,000 hectares per year

Annual change in forest area by country, 2005–2010





Mexico´s position according to rate of deforestation



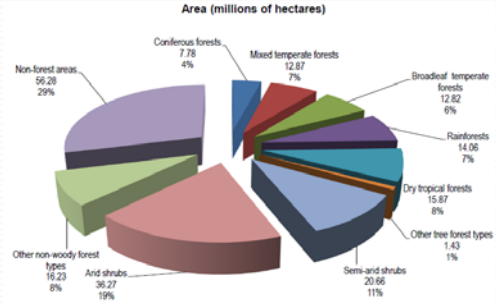
Source: Global Forest Resources Assessment 2010, Food and Agriculture Organization of the United Nations (FAO)

Land use and vegetation types

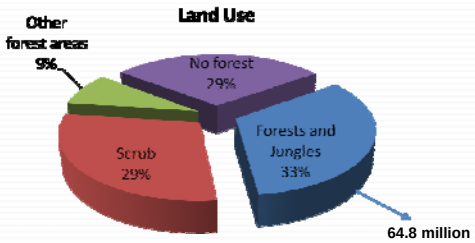
- Total area of Mexico is **195.9 million** hectares
- **138 million** hectares of natural vegetation (**71%**)
- **64.8 million** hectares of tree forests types (**33%**)

Land use and vegetation types

Area (millions of hectares)

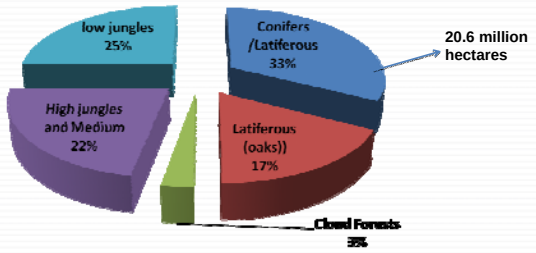


Land Use



64.8 million hectares

Forests and Jungles



Diagnosis of forest sector

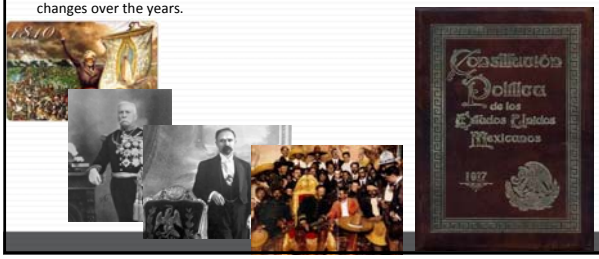
- **7.5 million ha of forest management (utilization).**
- Timber production meets **20%** of domestic consumption.
- The forest products trade deficit of almost **6 billion dollars**
- INEGI estimated that inhabit forest areas **11 million people**.
- The annual net deforestation of **155,000 hectares per year.**

Diagnosis of forest sector

- Approximately 18% of farmers with harvesting rights "sub reports" volumes.
- Replacing imported domestic product by product.
- Reduced capacity of industrialization.
- Contraction of the productivity of links of primary production (farming, mining).
- Low vertical and horizontal integration Forest Enterprises.
- Lack of market information (demand and supply) of alternative vertical and horizontal integration and even features and uses of the products.

The management of forest resources in Mexico

To understand forest management policies on forestry and actions implemented with the community forestry development approach in Mexico, it must be observed which is primarily governed by its constitution of 1917, with a history of independence of 1810, result of the movement of revolution of 1910, and some changes over the years.



It is in this political constitution which set out the basis for the organization of the state, meaning the system composed of a territory, a society and establishing rules for healthy living socialized. In his chapter contended considered a human rights and guarantees, where one can find the **"Article 2. The Mexican nation is one and indivisible "**, recognizing the multicultural composition based on its indigenous peoples descended from populations that originally inhabited the present territory of Mexico and at the beginning of colonization retained their own social, economic, cultural and political, or part them.

The constitution also recognizes and guarantees the right of indigenous peoples and communities.

Mixtecos

Rarámuris

Huicholes

There in Mexico about 65 Ethnic Groups

Amuzgos, Chatinos, Chontales, Lacandones, Mayos, Mazatecos, Mazahua, Mixes, Otomís, Purépechas, Zoques, ...

http://www.cdi.gob.mx/index.php

VI. *Give access, with respect to the forms and property modalities and land tenure established in the Constitution and the regulation of matter as well as the rights acquired by third parties or members of the community, the preferential use of the natural resources of the places they inhabit and occupy communities except those which correspond to strategic areas.*

It's in the previous section VI, where is based on access mode, form and modalities of land ownership throughout the territory the country.

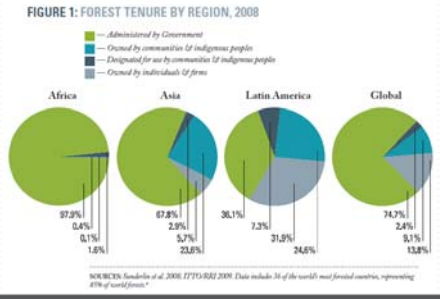
32 States 2,456 Municipalities

Article 27. - The ownership of the lands national territory is vested originally in right to transmit title thereof to privat property.

*.....**The Nation shall have at all times** such that the public interest dictates, as natural elements of ownership, in orde public wealth, care for their conservatio country and improvement of the livi population. In consequence, necessar settlements and establish adequate pr*

*er to execute public works and planning and preservation, improvement and growth of and restore the ecological balance for the o provide, in the terms of the regulatory law, oitation **of ejidos and communities, for the ock, forestry and other economic activities in ruction of the elements and property damage society**.*

Mexico ranks second worldwide, with ownership or control ejido or community forest area, the first place is Papua New Guinea and China third.

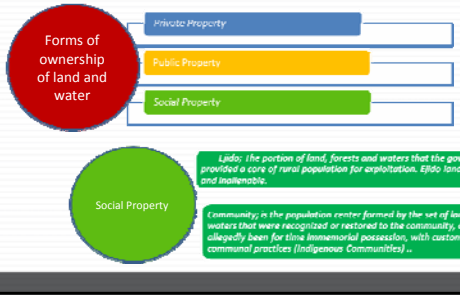


Legal Status of Forest Tenure.

31,518 Ejidos y Communities (105,949,096.97 Ha.)

Community forestry is conceived as a strategy to achieve sustainable forest management, in about 80% of the forest land of Mexico that are owned by the social figures called ejidos and communities (CONAFOR, 2013), in Mexico there around 15,584 communities and ejidos considered as potential forest with 62,62 millions of Ha. (IICA, 2012).

The legal framework renovated in 1992 (Article 27 of the Constitution and respective Agrarian Law) recognizes three forms of ownership of land and water:



Authorities

The Land Act provides authorities or bodies as the agrarian communities to the Assembly, the ejido commissioner or communal land and the Supervisory Board.

Bodies agrarian groups

- **General Assembly** — The supreme body of the agrarian and it all ejidatarios or comuneros participate.
- **Ejidal Commissariat or Communal Properties** — Body responsible for the implementation of the resolutions of the Assembly, as well as the representation and administration. It consists of a president, a secretary and a treasurer.
- **Supervisory Board** — Monitoring body that acts Commissariat conform to the legal aspects, the provisions of the rules and decisions of the Assembly; also reviews the accounts and operations of the Commissariat. It consists of a president and two secretaries, or a president, a secretary and a treasurer.

Community forestry enterprises

The ejidos and communities, enterprises may establish for the use of their natural resources or other opinionas well as service delivery.

They may participate ejidatarios, organized groups of rural women, children of ejidatarios, comuneros, domiciled and small producers.

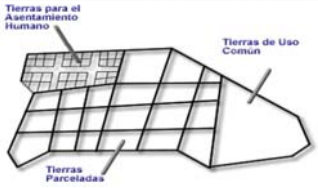
Companies referred to the two preceding paragraphs may take any of the forms of association as provided by law.

Article 108 Agrarian Law 1992

The structure of the ejidos and communities is composed of one or more polygons, they can be in the same state and municipality or several

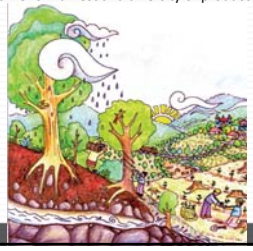
Fate of the land

The land can be used for three types of use in accordance with the determination of the General Assembly:



- ***Parcels of land.***
- **Land for Human Settlements**.
- **Common Land Use.** constitute the economic livelihood of the community life of the agrarian and are comprised of those lands that have not been reserved by the Assembly for the establishment of the center town, nor are parcels of land.

Community forestry or (Latin silva, jungle or forest, and culture, cultivation) in Mexico is conceived as the science for the training and cultivation of forests by ejidos and communities. It is part of its scope, the ability to create or preserve a forest, the theory and practice of regulating the establishment of tree mass, composition and development, not outside its sister science of agriculture, differing from it in the waiting time for harvest and diversity of production.



The production of timber is the source of forest income more important of these communities, but in most cases, also carry various uses of nc forest products, showing that forests are not only central to their iden and customs, but also are important economic assets and their managem primary option to advance their economic welfare.

Potential for timber production (15 mill ha):
- Sustainable forest management
- Supply chains
- 8-10 mill has are under authorized management

Non-timber production (49 mill ha):
- Non timber forest products
- Provision of environmental services 2.38 million ha
- 25.38 million ha under Protected Area status

The historical process in Mexico returning to ejidos and communities ownership of the land and making decisions about their management, shows that this aspect of social dimensions are linked with other elements (economic, technical, legal and agricultural) and a concessions administrative problem that left very little benefit to communities, the Mexican government considered that the claims of communities seeking alternatives to exploit its natural resources were sufficiently reasonable and economically and politically viable, thereby culminating mid of eighty forest concessions policy of this country.

Indigenous peoples and communities | Forest Concessions 80's | Ejidos and Communities

Deriving in the modifications to Article 27 of the Constitution and regulated by the Land Law (1992) and the update of the Forestry Law (1986, 1992, 1997) and vest in the General Law for Sustainable Forest Development (2003).

Based on the above and that the Mexican government has laws and regulations, specifically for forestry, **in 2003 issued the General Law for Sustainable Forest Development (LGDFS)**, which regulates Article 27 of the CPEUM, with the purpose of promote sustainable forest development, its objective expressed in article 2 mentions:

Article 2. The general objectives of this Law:
I.Contribute to the social, economic, ecological and environmental development of Mexico through integrated sustainable management of forest resources and watershed and hydrological-forest ecosystems, subject to the provisions of other laws;
II.Promote forestry and use of forest resources, to contribute to goods and services which will improve the standard of living of Mexicans, especially the owners and forest dwellers;
III.Develop environmental goods and services and to protect, maintain and enhance biodiversity that provide forest resources;
IV.Promote the organization, operational capacity, integrity and professionalism of the public institutions of the Federation, States, Federal District and Municipalities, sustainable forest development, and
V.Respect the right to preferential use of forest resources in the places they occupy and inhabit the indigenous communities.

And it is the job of the National Forestry Commission (CONAFOR), decentralized public body of the Federal Public Administration, created in 2001 with legal personality and its own, where sectoral coordination falls to the Ministry of Environment and Natural Resources (SEMARNAT) in accordance with the applicable legal provisions, as established in Article 17 LGDFS:

Article 17. .... The object of the CONAFOR **will develop, encourage and promote productive activities, protection, conservation and restoration in forestry**, which under this Law are declared as a priority area of development as well as participate in the formulation of plans and programs and the implementation of sustainable forest development policy and its instruments.

Based on the Strategic Forestry Program for 2000-2025 (PEF 2025).

Then, with the above terms and with the purpose of strengthen community forest development and the National Forestry Commission and created in 2001, the operation of the Commission is based on two key elements:

1) Strategic Forestry Program 2025 (2001), and
2) General Law for Sustainable Forest Development (2003).

This vision of sectorial development among its priorities strengthen community forestry, encouraging the use of strategies and guidelines to consolidate communities and establish sustainable management practices that contribute to improving their quality of life based on the use of natural resources . The strategy considers the Community Forest Enterprise (EFC by its Spanish acronym), as an essential tool for community ownership of forest resource management and means to strengthen social capital, strengthening social organization for forest farming, and promote timber harvesting, non-timber and environmental services directly by local communities.

This policy includes as a key element of this development process fostering a permanent social participation to make more efficient and effective interventions.

In this way the National Forestry Commission implements specific actions to promote community forestry, through the Community Forestry Development Program, PROCYMAF, considering that the strategies included in this permit to the Commission:

1) Identify new approaches to health sector;
2) Support specific population groups, such as indigenous and
3) Being the spearhead for institutional synergies sectoral development.

The goal of the **Community Forestry Development Program** is to strengthen and consolidate local development processes ejidos and indigenous forest communities and preferably, promoting the organization and strengthening community institutions, inducing an improvement of traditional management of forest resources on forest development schemes Community.

Particularly encourages the strengthening of social capital, referring to the connections between individuals, social networks and norms of reciprocity and trustworthiness that arise from them, makes the common life, strengthens identity within a group, creating solidarity among its members and at the same time, builds bridges with groups and people outside our own circle, making it easier to deal with common problems, circulate information and promote understanding.

In addition to strengthening human capital, defined as the knowledge and the attitude that each individual possesses.

Particularly Program is characterized by implementing a "**Model of Attention**" to its target population, the model aims to build and integrate a regional forestry development to improve the quality and standard of living in the forest communities and ejidos so self-advocate, considering the characteristics of natural resources, forms of agrarian production, social organization, cultural values and beliefs.

This model, based on the fact that the conditions, characteristics and situation that keep the country's agrarian, remains the collective ownership of forests, based on high-priority social participation in planning and decision making regarding the use and management of forest resources.

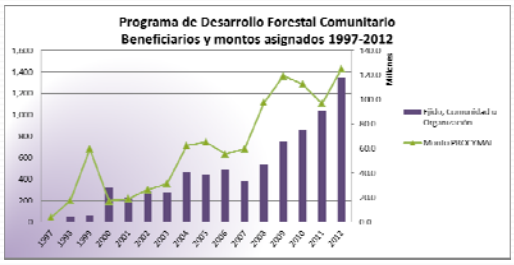
To this end, it focuses on the identification and integration of spaces for social participation and consultation (regional forums or regional natural resource committees), which have allowed to spread, plan, evaluate and monitor the construction process and strengthening community development capital.
For the formulation of this strategy of care and strengthen community forestry in the country, is considered the implementation of three key components:

- **Establishment of regional spaces PERMANENT social consultation and participation.**
- **Permanent and personalized care in general assemblies**.
- **Presence CONAFOR staff (promoters).**

The Program with the purpose of promote self-advocate discipline in the ejidos and communities, in addition to the above, implemented in subsidy scheme, the implementation of a classification or typology is well known producer, who lives in, differentiate granting certain amount of subsidy depending on the degree of organization present, this classification has four levels:

- **Type I. Potential Producers** (Subsidizes 90% of its projects).
- **Type II. Producers who sell standing** (Subsidizes 85% of its projects).
- **Type III. Forest raw material producers** (Subsidizes 80% of its projects).
- **Type IV. Producers with a capacity of processing and marketing** (Subsidizes 75% of its projects).

Social Representative in the technical evaluation committee



Graphic 1. Beneficiaries vs economic resources allocated from Community Forestry Development Program 1997-2012.

From 2007-2013 the Community Forestry Development Program has allocated an amount almost of 47.7 million of dollars, benefiting 3,013 ejidos, communities or unions. The map shows in green all those ejidos and communities that have gained access to community forest development scheme.

On the map that appears, you can watch the ejidos and communities that have incorporated its surface the Territorial Community Managment, basic tool for planning and regulating the use of natural resources.

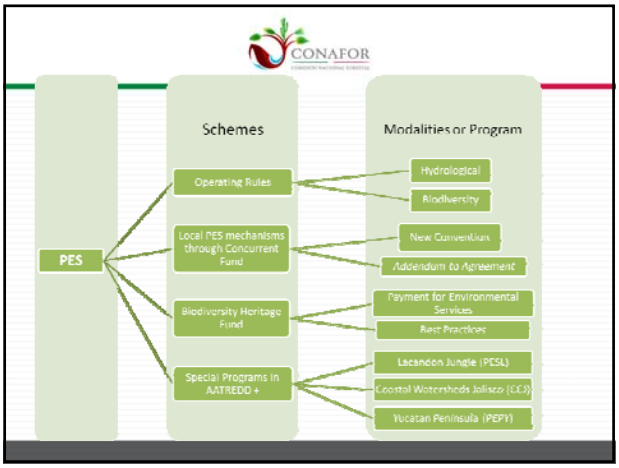
8.2 million hectares

Payment for Environmental Services (**PES**)

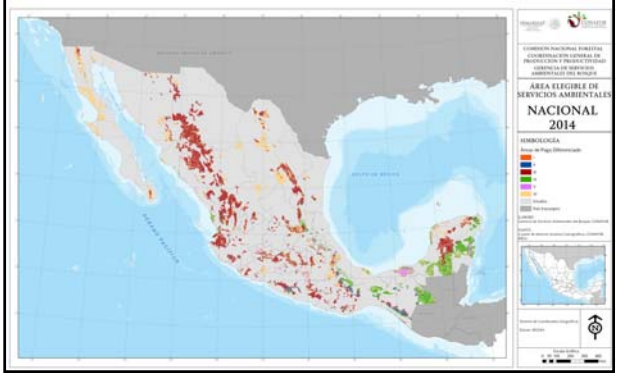
PSA

Objective

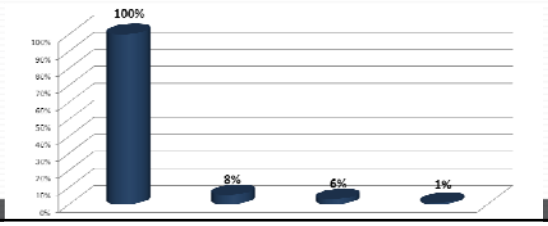
•Provide support to owners of forest land, in order to incorporate best management practices to promote conservation, sustainable management of ecosystems, and promote long-term provision of environmental services (water harvesting, biodiversity conservation the carbon capture and storage).



Eligible Areas
PES 2014



Category	Area (ha)	Percentage
Eligible area	33,916,341	100%
Area requested	2,890,514	8.2%
Feasible area	2,187,728	6.2%
Incorporated area	471,387.84	1.3%



Pay scheme

Signing of Contract

Annual payment
for 5 years

- Forest Management
- Protection
- reforestation
- Maintaining forest cover

Paid Distribution of Resources

50% Reforestation
Gaps against fire
Forest Management

20% Roads

Vehicles

30% Distribution in the community

Differentiated Payments dollars / hectare / year

Arid Zones
21 dollars

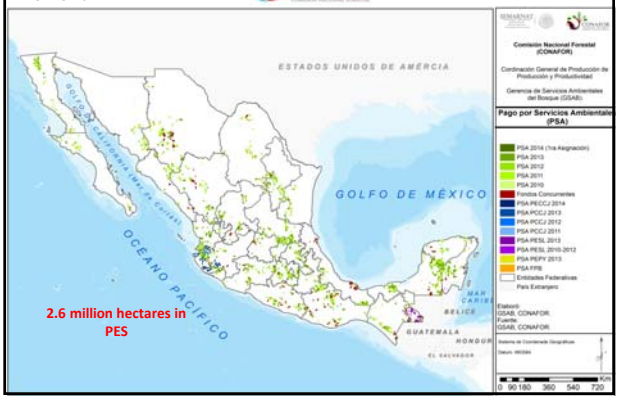
Coniferous forest
29 dollars

Differentiated Payments dollars / hectare / year

Evergreen Forest
42 dollars

Cloud Forest
84 dollars

Beneficiaries PES 2010 - 2014 (geographical distribution)



2.6 million hectares in PES

Current funding sources

CONAFOR COMISIÓN NACIONAL FORESTAL → **60%**

CONAGUA COMISIÓN NACIONAL DEL AGUA
Derechos por uso del agua → **30%**

FONDOS CONCURRENTES → **10%**

PES Through Concurrent Funds

248,000 hectares

Investment
67 million dollars

48%

52%
Local Governments, civil associations and private institutions

NATIONAL FORESTRY PROGRAM
GENERAL PURPOSE

To promote the sustainable use of forest resources in the country, revive the economy of the forest sector and improve the quality of life of the inhabitants of the forest areas, as well as, maintain and increase the provision of environmental goods and services to society and reduce carbon emissions from deforestation and forest degradation.

NATIONAL FORESTRY PROGRAM
EXPECTED RESULTS IN 2018

- Duplicate the area of **commercial forest plantations 242 thousand ha** in 2012 to 485,000 in 2018.
- Duplicate the **forest timber production** from 5.5 million m3 to 11 million in 2018.
- Tripling the forest area under sustainable management that has **sustainable management certification** from 826 thousand certified hectares in 2012 to 2.5 millions in 2018.
- Duplicate the **commercial forest plantations** area from 242 thousand hectares in 2012 to 485 thousand in 2018.

NATIONAL FORESTRY PROGRAM
EXPECTED RESULTS IN 2018

- Generate **25 thousand permanent jobs** in the forestry sector to 2018.
- Recovery of forest vocation surfaces through integrated **reforestation and restoration of micro-watersheds** of one million ha in 2018.
- Increase the **Payment for Environmental Services** from 2.8 million ha on 2012 to 3.1 millions in 2018.
- To have 32 State Inventories of Forest and Land.

FORESTS AND CLIMATE CHANGE

Objetive

To support rural communities in Mexico so they can manage their forests sustainably, develop social organization and generate additional revenue from forest products and services, including the reduction of emissions from deforestation and forest degradation (REDD +) .

Purposes

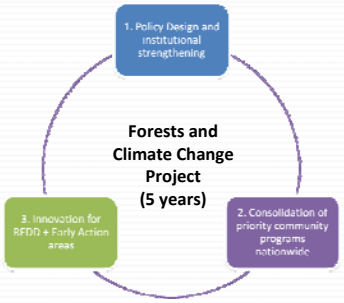
i) Contribute to modernize CONAFOR as a world-class institution that promotes the forestry sector;

ii) Strengthening the interagency collaboration at federal and local levels to serve the sector;

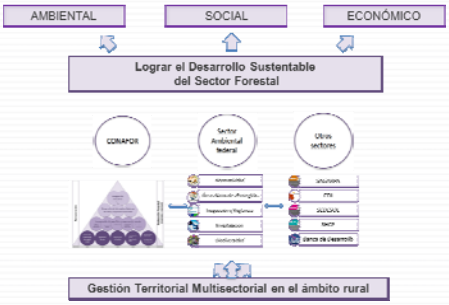
iii) Strengthen and improve CONAFOR´s incentives programs; and

iv) Promote the integration of public policies and innovative approaches to REDD + pilot projects in line with the national REDD + strategy.

Structure



Target Population: Ejidos and Communities

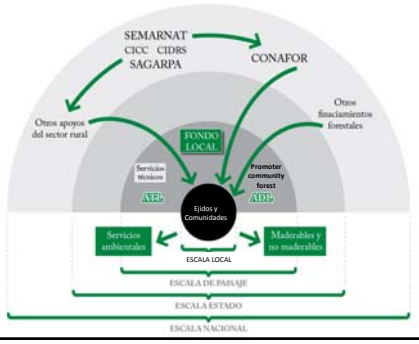


Territorial Management Multisectoral rural areas.

The basic design elements of the strategy, identifies variants in which some of them should be considered within the framework of restructuring and adjustments of CONAFOR and major adaptations to be made to the operational strategy.

Design elements of the strategy of forests and climate change.

ATTENTION MODEL



Case Study

The Lacandon Jungle

The Lacandon Jungle is located in the southeast of the Mexican Republic, on the eastern edge of the state of Chiapas. Ranked 0.16% of the country, covering approximately 1.8 million hectares.

It is one of the natural ecosystems of the country's most important humid tropics, due to its biodiversity and the ecosystem services it provides. On its surface, 20% of all species that live in the country is concentrated, including 31% of mammals, 48% of birds, 10% of higher plants, 44% of butterflies and 14% of freshwater fish.

Case Study

The Lacandon Jungle

The heart of this rainforest is located in the Montes Azules Biosphere Reserve in Chiapas near the border with Guatemala in the Montañas del Oriente region of the state.

Case Study

The Lacandon Jungle, people





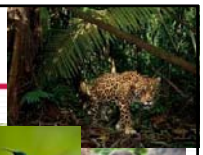

Case Study

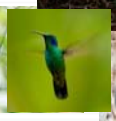
The Lacandon Jungle, Zapatista Army 1994



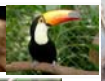

Case Study

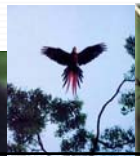
The Lacandon Jungle, biodiversity









Case Study

The Lacandon Jungle, natural resources



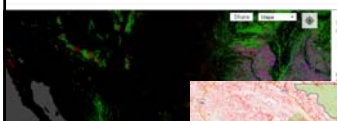


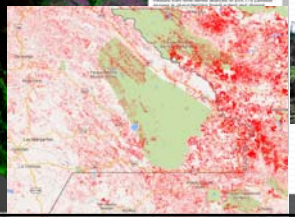




Case Study

The Lacandon Jungle, deforestation




Case Study

The Lacandon Jungle



Thank you


SEMARNAT
SECRETARÍA DE
MEDIO AMBIENTE
Y RECURSOS NATURALES
ESTADOS UNIDOS MEXICANOS

Status of Forest Biodiversity Conservation and its Role in Rural Livelihoods in Nepal

- Deepa Oli
Program Officer
Multi Stakeholder Forestry Programme
Ministry of Forests and Soil Conservation

Country Background

- Small and landlocked
- Altitudinal range: 70m to 8,848m
- Mountainous topography
- Diverse climatic condition
- Biodiversity of special significance

Introduction:
Habitat Diversity and Biodiversity Resources

- Nepal – small (147,141 sq.km. - 94th rank in the world) and landlocked country.
- 0.1% of global landmass, but has disproportionately high species diversity in wild habitat
  - Ranks 26th globally & 11th among countries of Asian continent
- Within short horizontal span of 193 km, has **five physiographic zones** and **six bioclimatic zones**
- 118 ecosystem types in total (Dobremez, 1970)
  - 112 forest ecosystems

Introduction:
Habitat Diversity and Biodiversity Resources

Physiographic and Bioclimatic Zones of Nepal

Physiographic zones	Coverage %	Elevation (m)	Bioclimatic regions
High Himal	23	Above 5,000	Nival
High Mountains	19	4,000 - 5,000 3,000 - 4,000	Alpine Sub Alpine
Middle Mountains	29	2,000 - 3,000 1,000 - 2,000	Montane Subtropical
Siwalik	15	500 - 1,000	Tropical
Terai	14	Below 500	Tropical

Source: Dobremez (1976)

Introduction:
Habitat Diversity and Biodiversity Resources

Ecosystems by Physiographic Regions

Physiographic region	Ecosystem		
	Total Number	Percentage	Number of Forest Ecosystems
High Himal and High Mountains	38	32.2	37
Middle Mountains	53	44.9	52
Siwalik	14	11.9	13
Tarai	12	10.2	10
Others	1	0.8	'Water bodies', found in all zones except the Siwalik
Total	118	100	

Source: Dobremez (1976), Biodiversity Profile Project (1995)

Introduction:
Habitat Diversity and Biodiversity Resources

Species Richness in Nepal

	Number of species found in Nepal	% of Global	Source
Mammals	208	5.2	Baral and Shah, 2008; Jnawali, *et al*., 2011
Birds	867	9.5	BCN and DNPWC, 2011
Reptiles	123	1.9	Schleich and Kastle, 2002
Amphibians	117	2.5	ICIMOD and MOEST, 2007
Angiosperms	6,973	3.2	UNEP-WCMC, 2004
Gymnosperms	26	5.1	Bista, 2006
Pteridophytes	534	5.1	DPR, 2006

Introduction:
Habitat Diversity and Biodiversity Resources

Endemic Species Richness in Nepal

Faunal Species	Number of endemic species	Floral Species	Number of endemic species
Mammals	1	Angiosperms	246
Birds	2	Pteridophytes	8
Amphibians and Reptiles	11	Bryophytes	30
Fishes	8	Algae	3
Butterflies and Moths	30	Fungi	16
Spiders	108	Lichens	39
Total	**160**	**Total**	**342**

Source: Compiled from various sources in Nepal Biodiversity Strategy, 2002

Introduction:
Habitat Diversity and Biodiversity Resources

- Mountain areas – high biodiversity
  - 34% of plant and animal diversity found in high mountains (above 3,000 m.) & 63% in middle mountains (1000-3000 m.)
  - Highest number of plants occurs from 1500-2500 m.
- Vascular plants even recorded above 6,000 m. in Nepal, e.g. *Christolae himalayayensis*
- Mosses and lichens –recorded upto 6,300 m.
- Mammals and birds even seen above 5,000 m.
- About 63% of endemic flowering plants – from high mountains and 38% from middle mountains
- Of 41 key NTFP species, 14 occur in alpine rangelands.

Introduction:
Role of Forest Biodiversity

- Nepal – still a least developed country
  - 31% of population lives below the poverty line
- Forest biodiversity resources – closely linked to livelihood
- Agrarian society – 66% of population depends on agriculture based employment
- Forest is an integral part of agriculture and livelihood –
  - Agricultural productivity and sustainability, health and nutrition, water resources
- Well being of Nepal – closely linked to its natural resources – forest biodiversity is one of it

Introduction:
Role of Forest Biodiversity

- NTFPs (Non-Timber Forest Products) – 800 species of NTFPs used locally as food, medicine and other purposes (Subedi, 2000).
- Approx. 470,000 households are involved in commercial NTFPs collection and poor peoples involvement is even higher (Olsen 1998).
- Tourism – 45% of tourists visit Protected Areas
  - 30-50% of tourism revenue plough back to local community

Introduction:
Role of Forest Biodiversity

- Community forestry – focused on livelihood enhancement also
  - 35% of total income of community forests – expended for poor, women and disadvantaged groups
- Various projects and NGOs are promoting forest based micro-enterprises in Nepal
  - UNDP supported MEDEP (Micro-enterprise Development Program) – an increase in family per capita income by 56%

Introduction: *Challenges*

- Major factors posing threat to biodiversity, as identified by NBS (2014), are:
  - Loss of habitat (accelerated by encroachment, expansion of cultivation, development of infrastructure, planned conversion of forest land),
  - Degradation of habitat (accelerated by unsustainable overharvesting, uncontrolled forest fire, overgrazing in forests,)
  - Poaching and illegal wildlife trade,
  - Human-wildlife conflict,
  - Invasion by alien plant species, and
  - Stone, gravel and sand mining.
- Status of Encroachment in 2012– 82,934 hectares (66% higher as compared to 1994).
- World Bank (2008) estimated – 25% of Nepal's forest is heavily degraded
  - Loss of biodiversity, increased landslides and soil erosion

Conservation Efforts: *Institutional Arrangements*

- Various institutions at various levels

Parliament	Committee on Environment Protection
Ministry	Ministry of Forests and Soil Conservation (MoFSC) Ministry of Environment, Science and Technology
Departments & District Offices	Departments under MoFSC: • Depart of Forest • Department of National parks and Wildlife Conservation • Department of Soil Conservation and Watershed Management • Department of Plant Resources • Department of Forest Research and Survey District Offices for Field implementation

Conservation Efforts: *Institutional Arrangements*

State Planning	National Planning Commission
Sectoral Committees	High Level Sectoral Committees: • National Biodiversity Co-ordination Committee • National Tiger Conservation Committee • National Wildlife Crime Control Committee • Wildlife Crime Control Bureau • National Wetland Committee • Climate Change Council • REDD Forestry and Climate Change Cell
Elected Local Bodies	• District Development Committee (DDC) • Village Development Committees (VDCs) – grass root level institution
Autonomous Institution	National Trust for Nature Conservation: •Autonomous conservation institution founded by the Parliament – to complement government efforts

Conservation Efforts: *Community Institutions, Private Sector, INGOs, Donors*

- Government of Nepal recognizes the need of involvement of a wide range of sectors
  - Community institutions: Community Forest Users Groups – has become role model for rest of the developing world
  - Private sector: not significant involvement as yet. But new government policies/strategies give high emphasis to private sector involvement
  - NGOs: Federation of Community Forest Users Nepal (FECOFUN), Association of Collaborative Forest Users Nepal (ACOFUN) – key NGOs playing pivotal role in forestry sector
  - INGOs: IUCN, WWF – involved in forest biodiversity conservation and rural livelihood enhancement.

Conservation Efforts: *Bilateral donor agency funded projects*

Projects	Donor	Working policy
1. Forest Resource Assessment	Finland	Direct Funding
2. Participatory Watershed Management and Local Governance Project	Japan	Direct Funding
3. Improving Research Capacity of Forest Resource Information Technology	Finland	Direct Funding
4. Forest Preservation Program Nepal	Japan	Direct Funding
5. Multi Stakeholder Forestry Program	SDC, DFID and FINNISH	Indirect and Direct Funding

Source: MOFSC

Conservation Efforts: *Multilateral donor agency funded projects*

Projects	Donor	Working Policy
Technical Assistance for Leasehold Forest and Livestock Program in Nepal	Finland through FAO	Direct
Strengthening Regional Cooperation for Wildlife Conservation Project (IDA)	World Bank	Direct
Strengthening Institutional Capacity of DNPWC for the Effective Management of Mountain Pas	World Bank	Indirect
REDD Forestry and Climate Change	World Bank	Indirect
PPCR Component 1: Under negotiation	ADB	TBD
PPCR Component 5: Under negotiation	WB	TBD
Kailash Sacred Landscape	ICIMOD	Direct

Source: MOFSC

Conservation Efforts:
List of Development Partners

S.N.	Name
1	World Conservation Union (IUCN)
2	World Wildlife Fund (WWF) Kathmandu, Nepal
3	International Centre for Integrated Mountain Development (ICIMOD)
4	United Nation's Development Programme (UNDP)
5	Food and Agriculture Organizations (FAO)
6	CARE-Nepal
7	Asian Network for Small-scale Agriculture and Bioresources (ANSAB)
8	Action-Aid Nepal
9	Asia Pacific Forestry Commission
10	Convention on Biological Diversity (CBD)
11	International Network for Bamboo and Rattan (INBAR)

Source: MOFSC

Conservation Efforts:
Private Sector and User Groups

S.N.	Name
1	Dabur Nepal
2	Forest Product Development Board
3	The Timber Cooperation of Nepal(TCN)
4	Herbs Production and Processing company limited (HPPCL)
5	Federation of community Forest User's Group Nepal (FECOFUN)
6	Nepalese Federation of Forest Resources Users Group (NEFUG)
7	Nepal Forest products Entrepreneur's Association (NFPEA)

Source: MOFSC

Conservation Efforts:
Policy and Legislative Measures

- Around 4 dozens and legal and policy documents related to forest biodiversity conservation
- Key Legal/Strategy Documents:
  - Forest Act, 1993: provides legal foundation to involve local community in forest management
  - National Parks and Wildlife Conservation Act, 1973: has legal provisions to declared high biodiversity areas and Protected Area (national park and others). Legal provision to involve local community in buffer zone management.
  - Master Plan for Forestry Sector, 1989: Guided Nepalese forestry sector for past 25 years.
    - Expansion of community forests and network of protected areas.

Conservation Efforts:
Policy and Legislative Measures

- Other key policy and legislative measures include:
  - Leasehold Forest Policy – leasing forest to family living below poverty line
  - Forest Fire Management Strategy, 2010
  - Forest Encroachment Control Strategy, 2011
  - National Biodiversity Strategy, 2002/ 2014
  - Herbs and NTFP Development Policy, 2004
  - Rangeland Policy, 2012
  - National Wetlands Policy, 2012
  - Presidential Chure Conservation Program Implementation Directive, 2011
  - National Land Use Policy, 2012

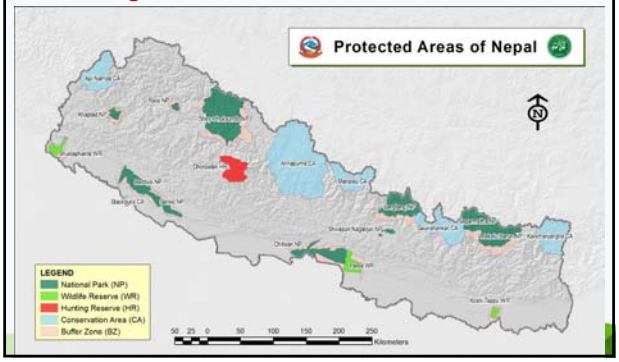
Conservation Efforts:
Management Practices and Initiatives

- Management of Forests of Nepal
  - Forest Act
  - National Parks and Wildlife Conservation Act
- Forest Act 1993 classifies forests as:
  - National Forest
  - Private Forest
- National Forests – Management Category
  - Government Managed Forest
  - Protected Forest
  - Community Forest
  - Leasehold Forest
  - Religious Forest

Conservation Efforts:
Management Practices and Initiatives

- Biodiversity Conservation – paradigm shifts
  - Informal protection based on traditional values and practices
  - Protective model
  - Participatory approach
  - Landscape level conservation approach
- Protected Area Network in Nepal – Cover 23.23% total area of the country
  - National Parks – 10
  - Wildlife Reserves – 3
  - Hunting Reserve – 1
  - Conservation Areas – 6
  - Buffer Zone - 12

Conservation Efforts: *Management Practices and Initiatives*



Conservation Efforts: *Management Practices and Initiatives*

- Protected Forests – Wildlife Corridors
  - Number – 8; Area – 133,754.8 hectare
- Chure Conservation Program
  - 26 *Siwalik* (highly fragile mountainous area) and *Terai* districts
- Afforestation, Reforestation, Reclamation of Encroached Forest Areas
- Medicinal & Aromatic Plants Development Program - 42 districts
- Public land agro-forestry, private forests and trees outside forests
- Initiatives to implement REDD+
- Central Zoo, Botanical gardens, elephant breeding center, vulture breeding center

Major Outputs in terms of Livelihood

- Recent review (2014) of Master Plan for the Forestry Sector concluded -
  - Community and private forestry program had significant impact – halting forest loss/degradation and livelihood enhancement of large number of rural people
- Significant change in coverage of community forestry and leasehold forestry has assured livelihood improvement of a large number of people (42.6% of total households of Nepal).

Categories	Community Forestry - 2013	Leasehold Forestry - 2013	Total
User Groups	18,133	7,413	25,546
Households	2,237,195	74,950	2,312,145
Forest Area (hectare)	1,700,048	42,773	1,742,821

Source: DoF, 2013

Major Outputs in terms of Livelihood

- Collaborative forest – 54,000 hectares
- Buffer zone (community management) – 560,270 hectares
- Income from protected area revenue in 2012/2013 – Approx. US$ 4,706,500
  - 30-50% plough back to local community for biodiversity conservation, livelihood enhancement and local development
- National Labor Force Survey showed 8.25% of HHs to be directly related with forestry sector (NLFS, 2008).
- Forestry sector contributes 9.23% of total national employment (91.30% in informal and 8.7% in formal sector) (LFP, 2011).




Lessons Learnt

- Biodiversity – can play tremendous role in livelihood enhancement and economic development of Nepal.
- Involvement of multiple stakeholders in conservation is needed to assure sustainability.
- Participatory approaches – highly effective for biodiversity conservation ensuring local commitment and sharing of benefits.
- Human interferences are the major challenges to the task to biodiversity conservation in developing countries like Nepal.

Way Forward

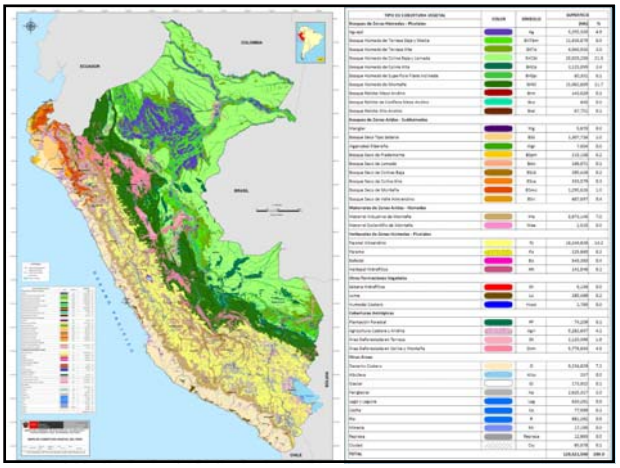
- Forest expansion – “Forest decade program”
  - Concept of “one house – one tree”, “one village – one forest”, “one town – many gardens”.
- Promote public land plantation and urban forestry
- Awareness campaigns
- Plantation in private land
- From subsistence to commercialization
  - Encourage private sector involvement in forestry sector – green enterprises
- Encourage co-operative based NTFPs farming and commercialization.

Improving livelihoods of local communities through sustainable forest management in the Peruvian Amazon: lessons learned and advances in Peruvian forestry legislation

Eng. Victor Raygada.

About Peru and its forests

- **Peru:** 1,285,220 sq km
- **Climate:** from tropical in the East to dry desert in the West; temperate to frigid in the Andes
- **Population:** 28,674,000
- About **170.5 million acres (69 million hectares)** of forested land, about 50 percent of its territory, and more than 80 percent of this land is classified as primary forest. Ninth in the world in forest cover.
- **Peru is the third largest country in South America and boasts the second largest area of tropical rainforest** in Latin America Second in South America. Most of them in the Amazon.
- The Peruvian Amazon forest **is one of the most biologically diverse areas on Earth**. As a nation, Peru has the largest number of bird species in the world and the third largest number of mammals; 44% of bird species and 63% of mammal species inhabit the Peruvian Amazon.



Low land forests > 45 millions of hectares

Rain forests > 15 millions of hectares

Mountain forests < 900,00 hectares

Dry forests < 3.5 hectares. Mangroves <5,800 hectares

Local communities and forest/land tenure (1)

- In Peru there are different groups of local communities: indigenous communities, peasant communities and settlers. Also different land propriety rights
- In Peru you can have the propriety over agricultural land (one that is suitable for agriculture use) but forest, wildlife and forestry / protection lands are national heritage.
- Indigenous communities: have propriety over agricultural land. Forestry lands are given using a contract of access with conservation responsibilities. This “assignment” is permanent and can not be mortgaged
- Peasant communities have full propriety of agricultural and forestry lands.
- Settlers and other local people can have individual l property rights over agricultural land

Local communities and forest/land tenure (2)

The Peruvian Amazon is one of the least populated regions of the country.
The population is very sparse and has few basic services such as water , electricity , drainage , health, education , among others.
The highest poverty rates also occur in this region, especially in rural areas
Amazon forest provide food, clothing, building materials and medicines for local communities.
Subsistence use of timber, no timber products and wildlife do not requires any permission of national or regional (like a state) authorities.
Local communities cannot sell any products used for subsistence.

- Trade of forest products and wildlife needs a permit given by national or regional autorithy. This permit requires a management plan and the payment of a fee for the use

Tamshiyacu Tahuayo experience (1)

- Lowland forests in Amazon located in Loreto region in northwest.
- Region of Loreto has enormous biological wealth, and its 36.8 million hectares (an area larger than Ecuador) are largely covered with Amazonian forests. However, there is rapidly mounting pressure on these natural resources, fueled by the region's growing population and economic activity that is based on the over-exploiting of natural resources for short-term revenues
- Forests in Tamshiyacu Tahuayo River have a high concentration of biodiversity and endemic species.
- We were interested in conserve more than two thousand five hundred square meters in an area of Regional Communal Conservation

Tamshiyacu Tahuayo experience (2)

- Project co-chaired by Regional Government of Loreto (regional forest and wildlife authority), Research Institute of the Peruvian Amazon (IIAP) and Nature and Cultute International (NCI).
- Resources: public and private (Moore Foundation)
- Presence of other institutions on the field: Wildlife Conservation Society-WCS/Peru, Durrell Institute of Conservation and Ecology - DICE - of Kent's University,, National University of the Amazonia Peruana-UNAP, National Agrarian University The Molina-UNALM, the Center Primatologist Aleman-DPZ, between others.
- Past projects on the area had some results on improving the management of lakes and fisheries. Also WCS worked in wildlife management.

Tamshiyacu Tahuayo experience (3)

- Local communities in Tamshiyacu Tahuayo don´t like protected areas due to past experiences in Loreto. They have fear and thought that we would take away the areas they occupied.
- Local communities had no formal access to ownership of their land. They were located in the buffer zone of the protected area we wanted to establish.
- Their main economic activities depends on forest management like small scale timber extraction, fishing (with baits or "ties": "pijuayo" y "huaca", fishhook and nets), subsistence agriculture, hunt (for subsistence and sale of meat and skins)

Forest and Wildlife Conservation Issues

- Since from 1970 the area was exploited extensively by local residents and foreign extractors that realized fishing with refrigerating boats, hunt for wild fauna with commercial ends, illegal extraction of wood
- During the decade of 1980, local communities of Tahuayo started to taking communal initiatives to protect the natural resources. This work reduce the illegal logging rates until government officials told the communities that did not have any authority to restrict access by outsiders. On that moment, communities left their conservation efforts
- Such exploitation caused that the natural resources in the zone were diminishing rapidly becoming scanty.

Intervention Strategy

- As regional authorities we had to gain the lost confidence
- We proposed them to work under a model of productive conservation , in which forest management and wildlife was used wisely to generate benefits for them
- Furthermore, although they had no ownership of the land , we proposed a system of co-management ; in which they were the protagonists of the management decisions
- To combat illegal logging activities we proposed them an alliance. They were organized into committees to control logging and we give them the equipment and the necessary legal support. When they stop someone we always arrive with the national police and they stand their actions

Legal challenges

- Forest law (until 2010) do not recognize community control, except if there are voluntary rangers so there was not legal mechanism to empower them.
- This system need a strong communal organization: not they all were devoting themselves to take advantage of the forest.
- Also there were illegal rafters that tried to corrupt authorities in the communities
- Communities were not informed about permissions and requirements for the managing their own forests
- The persons of the communities, did not know the value of the timber. Illegal loggers were taken advantage paying them a few percentage of the real value.

Improving livehoods: sustainable use of the forest

- At the same time we strengthened the control of illegal activities we develop productive activities to use forest
- We had chambira management programs , which is a palm tree that grows in the Amazonian forests
- I worked with women to generate additional revenue without need to go out of house. We held them to organize an artisans. The community was assigning plots to them for reforestation and managing of chambira.
- It was not necessary neither infrastructure nor equipments. We only develop skills and the knowledge for the production of crafts. If some woman wants left there group there were no problems, the knowledge always was staying there.

Improving livehoods: sustainable use of the forest

- We give assistance for capacities building in trade and sale.
- Regional government was using their products to position its institutional with renowned guest (Princess Ann, President of the Republic).
- In some communities were this women who achieve agreements to avoid illegal logging
- They can produce this handicraft without going out of their home on their free time.
- Up to today they export
- They have all de production chain form reforestation and managing up to commercialization
- Familiar Income> 300 % superior to the previous year, 500 - 1500 S/. Month. Women were more responsible with money: reinvestment of benefits> 70 %
- Products with market in USA (San Diego Zoo)
- Develop of brand, labels, web, facebook.

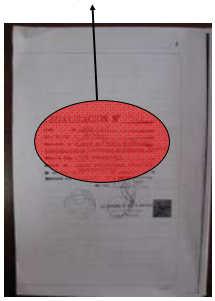
Comunal management agreements for natural resources

- Are formal agreements that regulates the use of the forest, wildlife and fisheries. They details quotas, sanctions, etc.

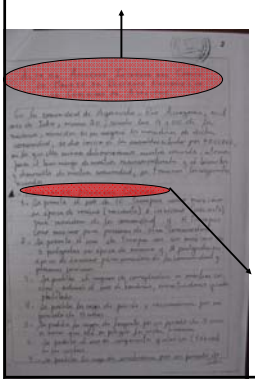
i.example:

Fisheries: it is allowed to use 10 traps in summer and summer. People from other communities can fish, but using only 5 tramps

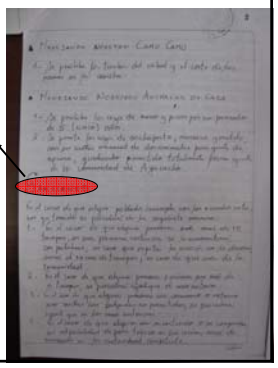
Acts book legalized for the communal agreements



Act of Internal Agreements of the committee of Ayacucho community



Sanctions



About managing our lake: zoning, how much we can fish, etc

If some one breaks this agreements, he/she will receive a sanction . The first time will be a warning . The second time the number of networks that he/she can place in the lake will be reduced seized.

What we learned

- Local communities can realize an effective control of illegal activities when the forest benefits them, they have training and forest authorities accompaniment them nearby.
- The approach of "productive conservation" is strategic to preserve the forest and natural resources. People take care of the forest only if they receive a benefit from it
- The internal regulations can be management plan plans for low scale use and self-consumption

How this experience became part of our national forestry legislation (1)

- In 2009 we had a great national conflict by the adoption of a new forestry law. People in the Amazon felt that this law limited their access to the forest
- We started a negotiation with indigenous organizations to build a new forestry law. It was the first case of Free, Prior and Informed Consent (FPIC) process in Peru. Started in 2009 finished in 2011 with Congress approval of the final proposal.
- Complex process because it was needing to construct confidence

How this experience became part of our national forestry legislation (2)

Improvements of new forestry law

•It recognizes that communal forest management is an important tool for forest conservation and their right to control illegal logging on their lands.

•Respects that communities as the right to decide management objectives and have an exclusive right to use forest.

•Government role is to give technical and legal support

•Recognize pre existing rights of local communities (we can not give new forestry concessions until we finish to give them their land´s rights.

•We have to do previous consultation of any forestry project or law that concerns PPII

•It recognizes internal regulations as a management plan (wildlife) and productive conservation as strategy for the managing of the forest

•It defines that the classification of the forest in the lands of communities will be defined by the community, with assistance.

•We have to develop a capacity-bulding plan for communities and give assistance in negotiations with rafters for the purchase and sale of products of the forest. Also we have to propose a format of contract.

•Creates the national forest and wildlife service (SERFOR)

Regulation of Forestry Law

- Led by the National Forest Service and of Wildlife
- Approximately six regulations: one of them for local communities
- A wide participative process was had and its initiating previous consultation process. We hope that can be approved in January, 2015.
- To assure the sustainability in the management of the resources of the forest and in the search of improvements, SERFOR wants that the regulation of the Forest Law and of Wildlife N° 29763 can be done in partnership with stakeholders.
- First draft was published 30 of September of 2013 in order to receive the contributions of the civil society, the regional governments and all the citizens interested in taking part.
- The conduction of the process is a responsibility of the intergovernmental group, led by the SERFOR and integrated by the Department of the Environment - MINAM, Organism of Supervision of the Forest Resources and of Wild Fauna - OSINFOR, Department of Exterior Trade and Tourism - Mincetur, Department of Culture - MINCULTURA, Department of the Production and the Regional Governments to slant of the Interregional Amazonian Council - CIAM, besides the Defense of the People who takes part as observator .

Biodiversity Conservation and Rural Livelihood in Forest Management

Luz Maria S. Lansigan

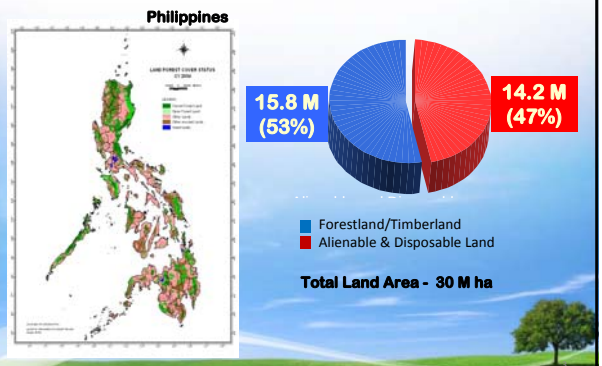
Department of Environment and Natural Resources (DENR)
Forest Management Bureau

A paper presented during the Workshop on Forest Biodiversity Conservation and Improvement of Rural Livelihoods
November 1-14, 2014, Kunming, China

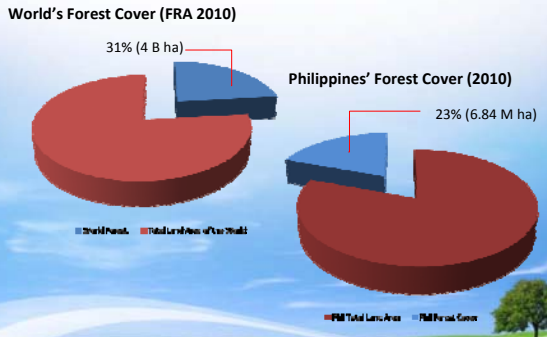
Biodiversity Profile of the Country: An Overview

- Considered as a mega-diversity country
- The forest cover can be related to the current biological diversity
- Also listed as one of the major biodiversity hot spots in the world
- Philippines is number four (4) among the World's 10 Most Threatened Forest Hotspots

LAND CLASSIFICATION

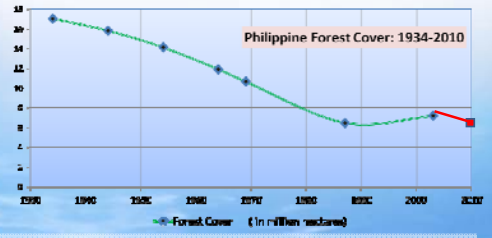


FOREST COVER



CURRENT STATE OF THE FOREST

Forest Cover change of the Philippines



- Forest cover decreased by 328,682 ha i.e. from 7,168,400 ha in 2003 to 6,839,718 ha in 2010 or an ANNUAL FOREST COVER LOSS of 46,954 ha.

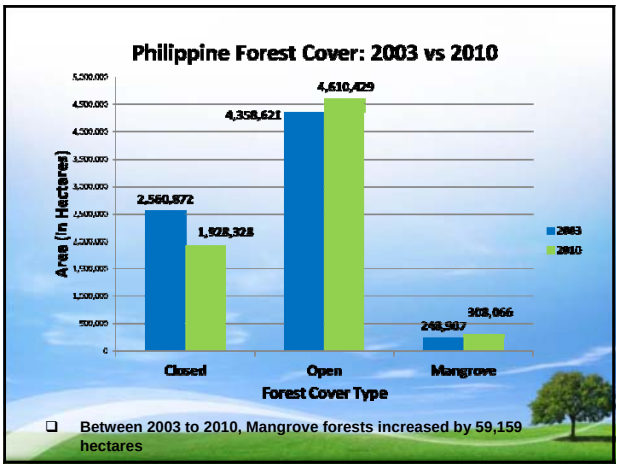
Philippine Forest Cover 2010

Forest Cover	Area (in ha)	%
Total Forest	**6,839,718**	**100.00%**
Closed forest	1,934,032	28.28%
Open forest	4,595,154	67.18%
Mangrove forest	310,531	4.54%

- 2010 Forest Cover of the Philippines was reduced to 23% of the total area of the Philippines from 24% in 2003 i.e. from 7,168,400 ha in 2003 to 6,839,718 ha in 2010

ANNUAL FOREST COVER LOSS (DEFORESTATION)
- 46,954 Hectares

ANNUAL FOREST DEGRADATION
- 142,347 hectares



- Between 2003 to 2010, Mangrove forests increased by 59,159 hectares

Towards achieving Biodiversity Conservation and Rural Development

- Issuance of tenurial instrument to communities to give access and control over forest resource
- Implementation of the National Greening Program

Tenure instruments

- Through the Community-Based Forest Management, communities and beneficiaries are allowed to utilize natural resources for a period of 25 years and renewable for another 25 years
- CBFMA holders are required to plant 60% of Indigenous Species and 40% of Exotic Species
- As of December 2012, a total of 4, 307 tenure instruments exist with an aggregate area of 2.9 M hectares

Tenure instruments

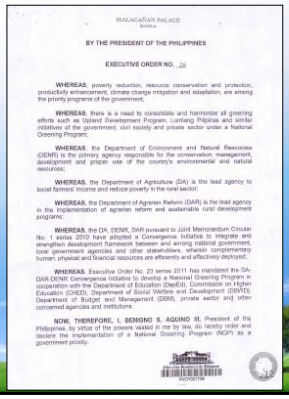
- Communities, organizations or individuals are required to establish plantations, 90% indigenous Philippine forest tree species, 10% exotic species
- This is mandated by the government to ensure quality of biodiversity in the given area.

THE NATIONAL GREENING PROGRAM

NATIONAL GREENING PROGRAM

Background

- Executive Order No. 26 signed on February 24, 2011
- Guidelines issued on March 8, 2011
- Launched on May 13, 2011


MALACAÑAN PALACE
MANILA

BY THE PRESIDENT OF THE PHILIPPINES

EXECUTIVE ORDER NO. 26

WHEREAS, poverty reduction, resource conservation and protection, productivity enhancement, climate change mitigation and adaptation, are among the priority programs of the government;

WHEREAS, there is a need to consolidate and harmonize all greening efforts such as Upland Development Program, Lumlang Pilipinas and similar initiatives of the government, civil society and private sector under a National Greening Program;

WHEREAS, the Department of Environment and Natural Resources (DENR) is the primary agency responsible for the conservation, management, development and proper use of the country's environmental and natural resources;

WHEREAS, the Department of Agriculture (DA) is the lead agency to boost farmers' income and reduce poverty in the rural sector;

WHEREAS, the Department of Agrarian Reform (DAR) is the lead agency in the implementation of agrarian reform and sustainable rural development programs;

WHEREAS, the DA, DENR, DAR pursuant to Joint Memorandum Circular No. 1 series 2010 have adopted a Convergence Initiative to integrate and strengthen development framework between and among national government, local government agencies and other stakeholders, wherein complementary human, physical and financial resources are efficiently and effectively deployed;

WHEREAS, Executive Order No. 23 series 2011 has mandated the DA-DAR-DENR Convergence Initiative to develop a National Greening Program in cooperation with the Department of Education (DepEd), Commission on Higher Education (CHED), Department of Social Welfare and Development (DSWD), Department of Budget and Management (DBM), private sector and other concerned agencies and institutions;

NOW, THEREFORE, I, BENIGNO S. AQUINO III, President of the Philippines, by virtue of the powers vested in me by law, do hereby order and declare the implementation of a National Greening Program (NGP) as a government priority.

NATIONAL GREENING PROGRAM

Coverage

The National Greening Program shall plant some 1.5 Billion trees covering about 1.5 Million hectares for a period of six (6) years from 2011 to 2016.

NATIONAL GREENING PROGRAM

NGP: BEYOND REFORESTATION

OUR MISSION

- Food Security
- Poverty Reduction
- Environmental Stability
- Biodiversity Conservation
- Climate Change Mitigation & Adaptation

Bringing together agencies, efforts, people:

Convergence Works.

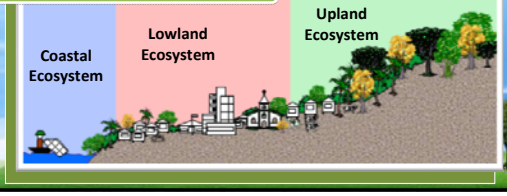
NATIONAL GREENING PROGRAM

NGP FRAMEWORK

Species

Species selection depends on objectives;
preferably indigenous/native/endemic species;
for the production zone: ***Species- Site- Market Matching***
for the protection zone: ***Indigenous/native/endemic species***

Planting Sites



NATIONAL GREENING PROGRAM

NGP Commodity Roadmap CY 2013 - 2016

Region	Timber	Fuelwood	Coffee	Cacao	Rubber	Bamboo	Rattan	Other Fruit Trees	Indigenous Species		Mangrove		Urban	Mixed Commodities*	Total
									Protection Forest	Protected Area	within PA	outside PA			
NCR												8			8
CAR	44,000	20,000	9,000	5,000	800	2,600	1,000	14,000	1,300	1,435					99,135
Region 2	8,000	20,000	1,000	2,000		5,000		4,000		850	510				41,360
Region 1	10,000	10,000	12,000	12,000	4,000	500	400	12,000		3,414	40	100			66,454
Region 3	10,000	15,000	5,000	5,000	4,000	10,000	5,000	10,000	10,000	18,004	75				92,079
Region 4	20,000	10,000	5,000	5,000	5,000	10,000	10,000	10,000		23,794	266	3,500			102,560
Region 4	20,000	15,000	5,000	5,000	5,000	1,000	1,000	20,000	13,000	1,399	14,119	5,000			107,518
Region 5	20,000	10,000	4,000	4,000		6,000	500	20,000	1,500	2,490	500	5,000			71,990
Region 6	20,000	5,000	1,000	1,000	800	1,000	2,000	8,000		6,000	600				45,400
Region 7	30,000	14,000	4,000	3,000	2,000	2,000	1,000	8,000	6,000	1,100	700	1,200			73,000
Region 8	15,000	15,000	5,000	5,000		4,000	5,000	15,000	4,000	30,400	500	4,000			122,900
Region 9	25,000	10,000	5,000	1,000	30,000	1,000	1,000	5,000	1,500	1,265	240	500			81,505
Region 10	20,000	5,087	2,000	2,000	8,200	2,000	1,000	5,000		5,844	31	300			51,462
Region 11	50,000	10,000	5,000	5,000	10,000			15,000		2,300	140				97,440
Region 12	25,000	20,000	10,000	2,000	25,000	10,000		15,000		3,735	189	300			111,224
Region 13	29,314	1,489	14,903	3,725	16,394	745		7,786	4,205			593			79,154
Subtotal	346,314	180,576	87,903	60,725	111,194	53,845	27,900	168,786	41,505	126,030	17,810	20,501			1,243,189
2013	47,711	1,542	2,554	1,477	5,675	571	78	9,741	7,867	2,535		1,315	1,250	46,342	128,558
2012	33,887	2,875	2,100	768	3,930	1,401	902	3,367	5,100	8,300	144	711	2,009	156,209	221,703
Total	774,216	365,569	180,460	125,695	231,993	109,722	56,780	350,680	85,977	262,895	35,964	41,028	3,259	202,451	2,834,699

Recommended by:

RICARDO C. CALDERON
Director, Forest Management Bureau
National Coordinator, NGP

ERNESTO D. ADOBO, JR.
Undersecretary
Staff Bureaus

DEMETRIO L. IGNACIO
Undersecretary
Field Operations

MANUEL D. GEROCHI
Undersecretary
Policy and Planning

Approved by:

RAMON J.P. PAJE
Secretary

POLICIES and PROGRAMS

- May 30, 2013, issuance of DENR-DILG JMC No. 2013-03 - Guidelines on the establishment and implementation of Barangay Forest Program and establishment of nurseries and production of planting materials in support to NGP, including development of communal tree farms for fuelwood and other domestic uses.

- May 22, 2012 – issuance of DMC 2012-01 addressed to all Regional Directors enjoining them to shift from the use of exotic species to indigenous species

- April 16, 2013 -DMC No. 2013-06 guidelines and procedure for plantation development for NGP with area coverage of 100 ha -1,000 ha within public forestlands through the engagement of services of private sectors, civil society organizations, NGOs, POs, LGUs and other government entities

- DMC No. 2013-06
  For Peoples Organization, contracting shall be made through a Memorandum of Agreement with DENR

  The Circular also outlines the responsibilities of the DENR and the PO

CONVERGENCE WORKS

- NGP works under the National Convergence Initiatives through the Joint Memorandum Circular No. 1 Series of 1999 (DENR-DA-DAR) in collaboration with all government agencies, LGUs, People's Organizations NGOs, and in partnership with the private sector and civil society

NGP MILESTONES

IMPROVED CONSERVATION, PROTECTION AND REHABILITATION OF NATURAL RESOURCES

NATIONAL GREENING PROGRAM

Accomplishments CY 2011-2013

Major Program/ Project	Performance Indicator	2011		2012		2013		Total	
		Target	Accom	Target	Accom	Target	Accom	Target	Accom
NGP	area planted (ha)	100,000	**128,558**	200,000	**221,763**	300,000	**333,161**	600,000	**683,482**

Brgy. Baluno, Naga, Zamboanga Sibugay (Mangrove Plantation)

Brgy. Banban, Ayungon, Negros Oriental (Mangium Plantation)

IMPROVED CONSERVATION, PROTECTION AND REHABILITATION OF NATURAL RESOURCES

NATIONAL GREENING PROGRAM

Accomplishments CY 2011-1st Quarter of 2014

Major Program/ Project	Performance Indicator	2011	2012	2013	1st Quarter 2014	Total
National Greening Program	**Jobs generated (no.)**	335,078	380,696	466,990	10,018	**1,192,782**
	Persons employed	47,868	55,146	65,198	3,887	**172,099**

Bagged topsoil in Mt. Malindang, Misamis Occidental

Nursery operations in Mt. Malindang, Misamis Occidental

NGP ACCOMPLISHMENT

Jobs Generations

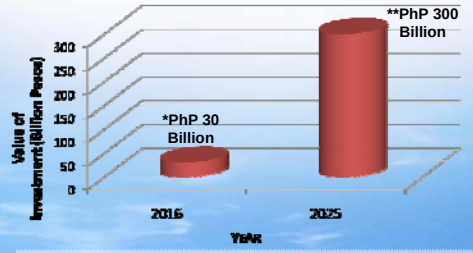
YEAR	Target (ha)	Total Area Planted (ha)	% Accom	*No. of Job Generated	*Persons Employed
2011	100,000	128,558	129%	335,078	47,868
2012	200,000	221,763	111%	380,696	55.146
2013	300,000	332,748	111%	456,389	65,198
Total	**600,000**	**683,069**	**114%**	1,172,163	168,212

*Source: Office of the Undersecretary for Policy & Planning

Paluan, Occ. Mindoro

EXPECTED PROGRAM OUTCOME

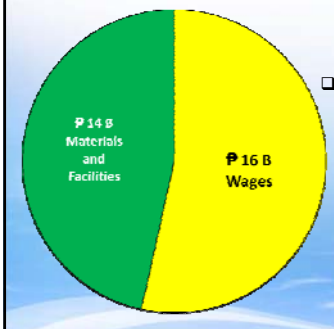
10-year Financial Return of Investment



* 1.5 Billion seedlings in 1.5 Million ha.
** 150 million seedlings (assuming 10% harvestable at year 10)
1 Tree = 1 cubic meter
1 cubic meter = Php 2,000 per cubic of Fuelwood
❑equal to ☐300 Billion in 10 years vs. ☐30 Billion investment

NGP as a Vehicle for Inclusive Growth

(Based on the engagement of the Program)



- More than half of the 2011-2016 National Greening Program budget of 30 Billion directly benefits the upland communities/Peoples Organizations

P30 Billion Investment

LESSONS LEARNED

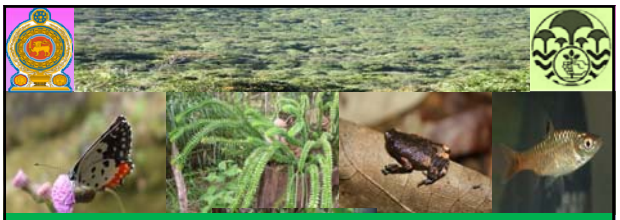
- Success of the programs can easily be achieved thru the high support from the government
- Attainable objectives with logistics and technical know-how support

Ways Forward

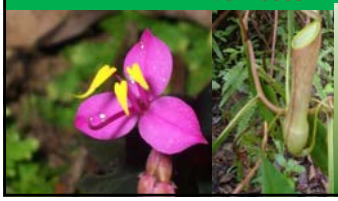
- Continuous information and education campaign
- Development of appropriate capacity building development program

Thank You!

Department of Environment and Natural Resources
FOREST MANAGEMENT BUREAU
Visayas Avenue, Diliman, Quezon City
Tel. No. 927-4788 Fax: 928-9313



Forest Biodiversity Conservation and Improvement of Rural Livelihoods in Sri Lanka



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1st Nov 2014

Location of Sri Lanka

Sri Lanka is located in the Indian Ocean

between 5^0 54'' and 9^0 52'' North Latitude 79^0 39'' and 81^0 53' East Longitude

There is no land connection with India

Administrative Provinces and Districts

9 Provinces

25 Districts

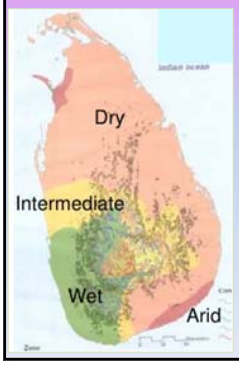
COUNTRY PROFILE

- TOTAL AREA : 65,610 KM^2
- TOTAL POPULATION : 21,481,334
- POPULATION DENSITY :322.4 persons /km^2
- POPULATION GROWTH RATE : 0.913 %
- RURAL POPULATION :78 %
- LABOR FORCE :47 %
- UNEMPLOYMENT: AMONG LABOR FORCE 4%
- ANNUAL PERCAPITA INCOME:US $2,887

Land area and other important areas

- Total Land area 62,710 Km^2 Remaining areas containing by rivers and reservoirs
- Coastal line ins about 1,620 km.
- Total natural forest cover - 1,951,472 ha (29.9%)
- Forest plantations - 76, 560 ha (1.16%)
- Major rivers 103
- Reservoirs and lakes 12000

Climatic Zone

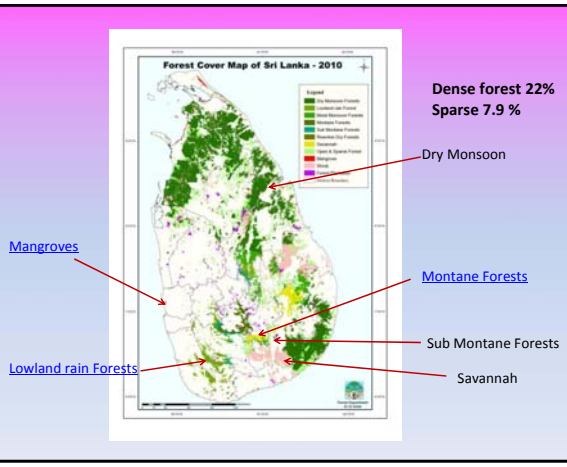


Climatic zone	Rainfall mm per annum	Average temperature
Wet	2500-5000	Average Tem < 27° C
Intermediate	1900-2500	Average Tem < 30° C
Dry	1250-1900	Average Tem 30° C
Arid	Less than 1250	Average Tem more than 30° C

Ecosystem Diversity of Sri Lanka
Forests Types of Sri Lanka

- Tropical wet evergreen forest (lowland rain forest)
- - Tropical moist evergreen forest (Moist Monsoon)
- - Tropical dry mixed evergreen forest (Dry Moist)
- - Tropical montane forest
- - Tropical sub montane forest
- - Riverine dry forest
- -Mangrove forest
- -Savannah
- -Tropical thorn forest
- -Dry montane grasslands dry patanas

} Open & Sparse Forests



Ecosystem Diversity of Sri Lanka
Coastal and marine ecosystems

- Mangroves
- - Salt marshes
- - Sand dunes and beaches
- - Mudflats
- - Seagrass beds
- - Lagoons and estuaries
- - Coral reefs
- - Coastal seas

Ecosystem Diversity of Sri Lanka
Inland wetland ecosystems

- - Flood plains
- - Swamps
- - Streams and rivers
- - Reservoirs and ponds
- - Wet Villu grasslands
- - Wet montane grasslands wet patanas

Ecosystem Diversity of Sri Lanka
Agricultural ecosystems

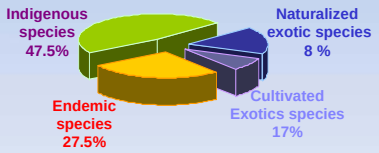
- - Paddy lands
- - Horticultural farms
- - Small crop holdings or other field crops (pulses, sesame etc)
- - Crop plantations
- - Home gardens
- - Chena lands (slash and burn cultivation)

Forest categories and Administrate Relevant Main Departments

Forests Department			Wild Life Conservation Department		
Established 1887 Forest Ordinance 1907 National Heritage and Wildness Area -No.3 0f 1988			Established 1949 Fauna and Flora Protection Ordinance -No.2 0f 1937		
Categories	Numbers	Extent (ha)	Categories	Numbers	Extent (ha)
National Heritage	01	11,187	Strict Nature Reserve	03	31,537
Conservation Forests	112	131,839.5	National Park	21	512,425
Reserved Forests	518	980,240.7	Nature Reserve	05	44,086
Residual Forests	257	563,567	Sanctuaries	64	283,326
Forests Plantations		76,560	Jungle corridors (proposed)	03	

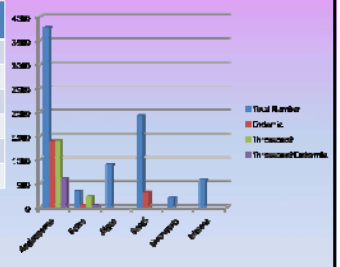
Bio-Diversity Composition of Flowering plants in Sri Lanka

3771 Angiosperm 214 Families 1522 Genera



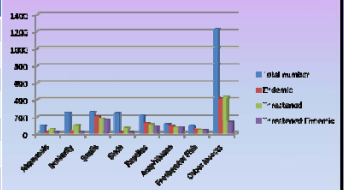
Bio-Diversity Composition of Flora in Sri Lanka

category	Total No. & (Endemic)	Threatened (Endemic0
Angiosperms	3771 (1383)	1385 (594)
Ferns	335(49)	219(33)
Algae	896	
Fungi	1920(307)	
Liverworts	190	
Mosses	575	

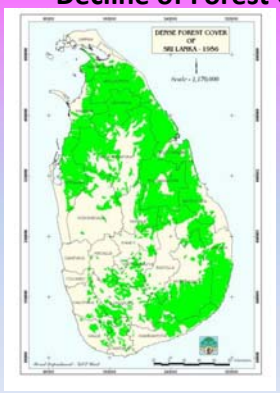


Flora and Fauna in Sri Lanka

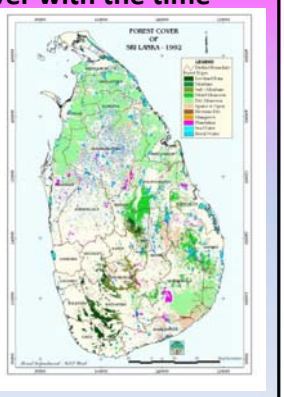
Type of Fauna	Total Spp. (Endemic)	Threatened (Endemic)
Mammals	95(21)	53(18)
Butterfly	245(26)	99(22)
Snails	253(205)	179(162)
Birds	240(18)	67(18)
Reptiles	211(124)	107(87)
Amphibians	111(95)	73(71)
Freshwater Fish	91(50)	45(39)
Other Insects	1229(413)	433(139)



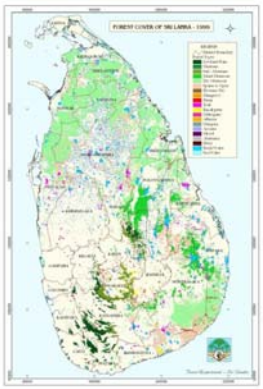
Decline of Forest Cover with the time



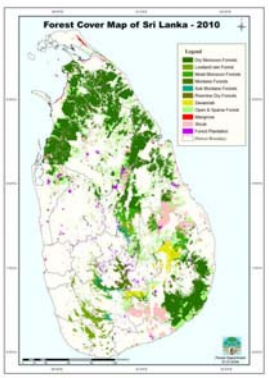
1956 Forest Cover 44%



1992Forest Cover 24%



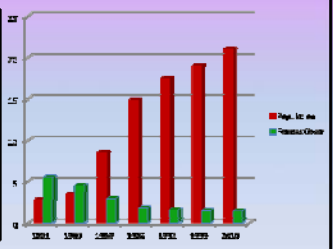
Forest Cover 22.5%



Forest Cover 22%

Relationship between Forest Cover(Closed Canopy) and Population

Year	Population (millions)	Forest Cover (million ha.)	Forest Cover (%)
1881	2.8	5.46	84.0
1900	3.5	4.50	70.0
1956	8.5	2.90	44.6
1983	14.9	1.75	26.9
1992	17.5	1.56	23.9
1999	19.0	1.46	22.4
2010	21	1.43	22.0



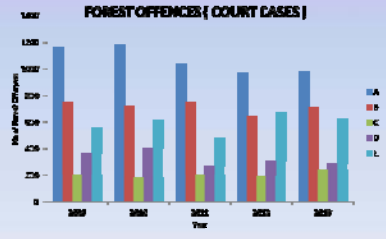
Causes of Forests Cover Decline in Sri Lanka

- Development of large scale Agriculture schemes
- Un controlling sifting or chena cultivation
- Renovation and Expansion of Irrigation channels and reservoirs
- Human settlement
- Infrastructures development
- Encroachment for Tea & other cash crops cultivation
- Establishment of Aquatic farms
- Collection of medicinal plants
- Un sustainable removal of NTFP
- Hydro and Mini Hydro development programmes
- Illegal and un planed Mining activities
- Excavation of Gravel and Sand

TOTAL NUMBER OF FOREST OFFENCES (Court Cases) – 2009 to 2013

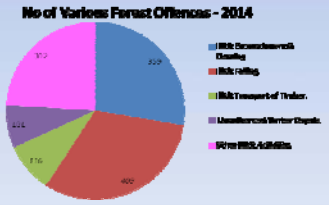
Year	A	B	C	D	E
2009	1169	756	203	365	559
2010	1183	726	179	400	616
2011	1040	750	199	274	483
2012	975	647	195	308	674
2013	983	708	246	292	626
Total	5350	3587	1022	1640	2958

A. Illicit Encroachment & Clearing.
B. Illicit Felling.
C. Illicit Transport of Timber.
D. Unauthorized Timber Depots.
E. Other Illicit Activities.



Forest Offences up to July 2014

Type of offences	Total No
Illicit Encroachment & Clearings	359
Illicit Felling	409
Illicit Transport of Timber.	116
Unauthorized Timber Depots	101
Other Illicit Activities.	312



Impact on Biodiversity in Sri Lanka

- Habitat losses
- Habitat degradation
- Habitat fragmentation and Isolation
- Loss of Traditional Crops and live stocks varieties and breeds
- Over Exploitation of Biological resources
- Spread of Alien Invasive species
- Increasing pollution
- Human wildlife conflicts
- Increasing human population
- Introducing monoculture farming systems

Legislation in Sri Lanka to Conserve Biodiversity

1.National Conservation Strategy 1988
Central Environmental Authority

2.National Policies	3.International Conventions
Forests Policy 1995	RAMSAR 1971
Wildlife Policy 2000	CITES 1973
Environment Policy 2003	Bonn 1979
Wet land Policy 2005	Biological Diversity 1992
Elephant conservation 2006	

National Forest Policy Objectives (1995)

• To conserve forests for posterity, with particular regard to biodiversity, soils, water, and historical, cultural and aesthetic values.

• To increase the tree cover and productivity of the forests to meet the needs of present and future generations for forest products and services.

• To enhance the contribution of forestry to welfare of the rural population and strengthen the national economy, with special attention paid to equity in economic development.

Forestry Sector Master Plan(1995) (Included 13 development programmes)

- *Conservation of biodiversity in forests.*
- *Soil and water conservation.*
- *Multiple- use forests.*
- *Home gardens and other non forest tree resources.*
- *Forest plantations.*
- *Wood products.*
- *Non wood forest products, Bio energy.*
- *Policy, legislation and institutions.*
- *Human resources.*
- *Forestry research.*
- *Extension and support services.*
- *Planning, monitoring and evaluation.*

Issues and Difficulties on Biodiversity Conservation

- It is difficult to carry out above tasks alone by Officials of the Forest Department.
- Crucial Involvement of Local People Participation
- Involvement and co-operation of the interest groups of general public, defense forces and other government and non-government organizations is required.
- Implemented People participation projects since 1982 in Sri Lanka

Prioritized Activities in the Forest Protection, Enhancement and Biodiversity Conservation Through People Participation Projects

Forestry Related Activities

- Establishment of nurseries
- Establishment Agro Forestry Wood lots and Block Planting (AFW /BP)
- Multiple use Buffer zone Planting and enrich planting
- Home Garden Development (HGD)
- Tree planting in public and government places (Misc)
- Establishment of Fire line and maintenance
- Rural People participation on detection and avoidance of
  - forest offences
  - forests fires
  - various illegal land clearing and encroachment activities
- Develop a mechanism to gather the information on illegal activities in forests through the public.
- Conducting awareness programmes.

Non Forestry Activities to promote rural people livelihood

- Training on Self Employment Activities for income generation
- Cottage industries development, improvement and introduce new technology
- Support to improved Agric and Aqua farming systems
- Improvement of Micro Enterprises
- Infrastructure development
- Provide Market Facilities and guidance
- Cultural centre and development
- Strengthen to formal and informal Educational programmes
- Social Involvement and provide Health camping
- Library and other facilities development (Knowledge acquiring)
- Opportunity to participate as a stakeholder to Eco tourism activities
- Introducing and improving Micro Finance Activities

FORESTRY PROJECTS WITH PEOPLE PARTICIPATION & ACHIEVEMENT

Project	Duration	Donor	Achievement
Community Forestry Project **(CFP)**	1982-1990	ADB	AFW 4055ha, Fuel wood 14,000 ha
Participatory Forestry Project **(PFP)**	1993-2000	ADB & Aus AID	AFW 9,771 ha, PWL 4,238 ha, Misc. 2028 ha.HGD 387,000 Family benefited 387,000
Participatory Forest Management Project **(PFMP)**	1996-1998	Overseas Development Agency, United Kingdom	Ordinance amended to enjoy local community to collect NTWP
Upper Watershed Management Project **(UWMP)**	1998-2004	ADB	Buffer Zone 2,328 ha Improved Farming System 12,196 BD 600km

FORESTRY PROJECTS WITH PEOPLE PARTICIPATION Con…

South West Rain Forest Conservation Project (GEF)	2000-2005	UNDP/GEF	30 CBO established & trained to participate Eco tourism & Self Employment
Forest Resource Management Project **(FRMP)**	2000-2008	ADB	AFW 3,865 ha. existing 7,479 ha AFW improved, HGD 12,321,BZ 2,300 ha Enriched 2,341 ha. Benefitted 3,300hh
Protected Area Management and Wildlife Conservation Project **(PAM&WLCP)**	2001-2007	ADB, UNDP/GEF and Govt of the Netherlands	protected areas mapped and complete socioeconomic survey of Adjacent Community
SLANRMP	2003-2009	Aus AID	55CBO established & trained 11,600 ha. Regenerated HGD 2440, 55,000 Families benefitted.
Community Forestry Program **(CFP)**	2012-2016	UNDP	Target to Improve 23,000 ha an dry and intermediate zone. 90,000 families will get benefit.

Current Strategies to achieve the National Forest Policy Objectives

- Sri Lanka is committed to increase the National Forest Cover up to 35% of the total land area within next 6 years (2020) under the concept of "*Mahinda Chinthana*" to Protect Environment, Biodiversity and welfare of the rural population and strengthen the national economy
- Preparation in progress of Forests Protection National strategy plan (2015-2020) with People Participation
- Accordingly, Forest Department is planned to ;
  - Protect and develop the existing forest areas
  - Establish of 350,000 hectares of new forest areas

To Achieve Concept of Mahinda Chinthana Honorable Minister of Environmental and Renewable Energy Mr. Susil Pram Jayantha advice to format Forests Vigilance Committee for one by one each & every Forests in the whole Island

Inauguration Meeting At Anuradhapura 01/06/2014 Preside by Honorable Minister

Structure/Composition of the "Public Vigilant Committees"

- **Lead by Range Forest Officer**

- **Other Members**
  - Beat Forest Officer
  - Police Officers
  - Religious Leaders
  - Grama Niladari
  - Samurdhi Officer
  - Agricultural Research Assistant
  - School Principles /Leaders
  - Civil Defense Committee members
  - Rural executives
  - Representatives from Other non governmental organizations
  - Forest Field Assistants

Expectations and Objectives of "Public Vigilance Committees"

- Develop a mechanism to get the involvement and participation of vigilance committee members in the forest protection activities and facilitate to prevent forests fire
- Management, Development and Improvement of existing forests and Establishment of new forests through the co-ordination of Public Vigilance Committees
- Vigilance Committee Members be a stockholder of Forestry Activities

Confront to Implement People Participation

- Difficult to promote willingness of community
- Maintain confidence of community
- Subsidy can not provide, level of community expectation
- Community that low dependency on forestry, difficult to encourage participation on forestry activities

The Way Forward

- Assess whether the program is reducing deforestation and forest degradation, based on such indicators as the change in the forest resource (Forest Offence, Quality of forest etc.)
- Provide continues awareness to community
- Assess Reduction of the dependency on forest
- Promote research on socioeconomics development in the programme areas previous and subsequent

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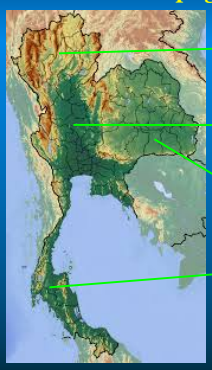
Overview of Forestry based on Biodiversity Conservation and livelihoods in Thailand

Wichan Eiadthong
Faculty of Forestry, Kasetsart University Chattujak Bangkok (THAILAND)

Topography of Thailand

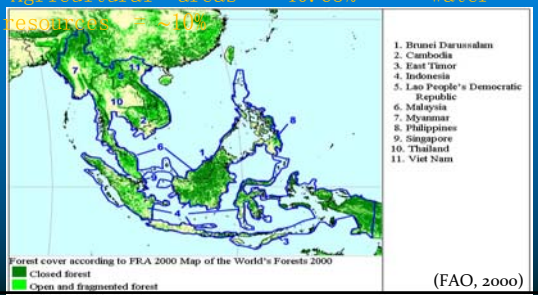


- Northern part: a mountainous region characterized by natural forests, narrow, alluvial valleys.
- Central part: the basin of the Chao Phraya River, is a lush, fertile plain.
- Norheastern part: is an arid region characterized by a

Biodiversity conservation status in Thailand

Country land area = 513, 115 km^2

- Forest area = 31.57 % (2013)
- Agricultural areas = 40.63% Water resources = <1%



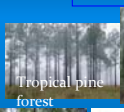
(FAO, 2000)

Forest types in Thailand

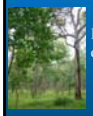
Tropical deciduous forests

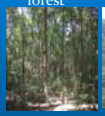
Tropical evergreen forests


Mixed deciduous forest including teak forest and without teak forest)


Tropical pine forest

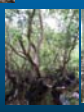

Lower montane evergreen forest

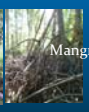

Dry deciduous dipterocarp forest


Dry evergreen forest

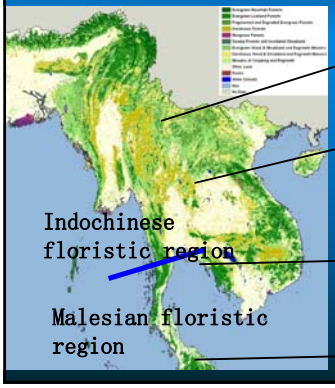

Moist evergreen forest


Beach forest

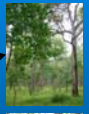

Swamp forest

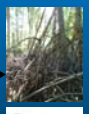

Mangrove forest

Forest types in Thailand



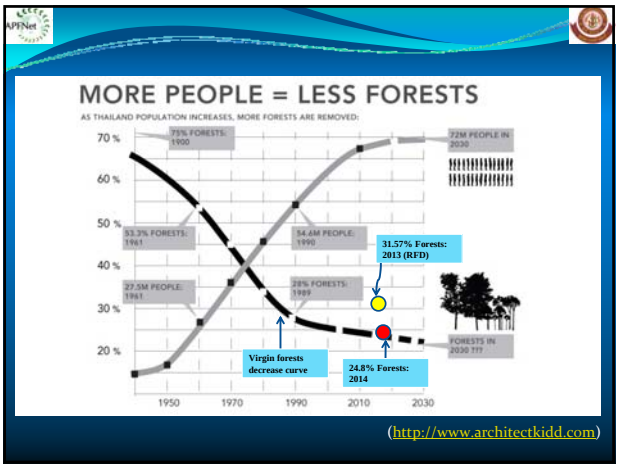

Lower montane evergreen forest


Dry deciduous dipterocarp forest


Mangrove forest


Moist evergreen forest

(http://www.grida.no)



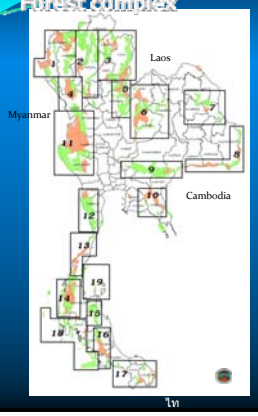
(http://www.architectkidd.com)

Protected areas in Thailand

Types of Protected areas in Thailand (totally 411 sites)

- National parks: 123 sites (11.73 % of country land area)
- Wildlife sanctuaries : 58 sites (7.18 % of country land area)
- Forest parks : 113 sites (0.24 % of country land area)
- Non-hunting areas: 60 sites (1.02 % of country land area)
- Arboreta: 56 sites (0.008 % of country land area)

Protected areas : 19 Forest complex



กลุ่มป่าสำคัญของประเทศไทย

1. กลุ่มป่าลุ่มน้ำปาย-สาละวิน (Pai - Salawin watershed areas forest complex)
2. กลุ่มป่าศรีลานนา-ขุนตาล (Sri lanna-Khuntan forest complex)
3. กลุ่มป่าดอยภูคา-แม่ยม (Doi Phuca-Mae Yom forest complex)
4. กลุ่มป่าแม่ปิง-อมก๋อย (Mae Ping-Omkoi forest complex)
5. กลุ่มป่าภูเมี่ยง-ภูทอง (Phu Miang-Phu Thong forest complex)
6. กลุ่มป่าภูเขียว-น้ำหนาว (Phu Khiew-Nam nao forest complex)
7. กลุ่มป่าภูพาน (Phu phan forest complex)
8. กลุ่มป่าพนมดงรัก-ผาแต้ม (Panom dong rak-Phataem forest complex)
9. กลุ่มป่าดงพญาเย็น-เขาใหญ่ (Dong phraya yen-Khao yai forest complex)
10. กลุ่มป่าตะวันออก(รอยต่อ 5 จังหวัด) (Eastern forest complex)
11. กลุ่มป่าตะวันตก (Western forest complex)
12. กลุ่มป่าแก่งกระจาน (Kaeng krachan forest complex)
13. กลุ่มป่าชุมพร (Chumporn forest complex)
14. กลุ่มป่าคลองแสง-เขาสก (Klong saeng-Khao sok forest complex)
15. กลุ่มป่าเขาหลวง (Khao Luang forest complex)

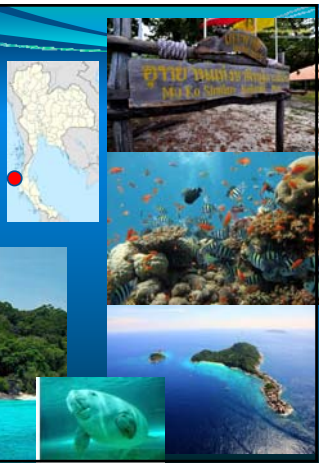
Khao Yai national park

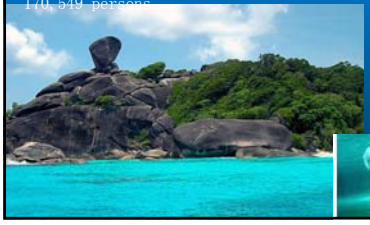
The first national park of Thailand established in 1962. Its area cover 2,168 km² and its altitude ranges from 400 to 1,350 m above sea level. There are 3,000 species of plants, 320 species of birds and 66 species o

Khao Yai national park was declared a Natural UNESCO World Heritage Site under the name *Dong Phaya Yen - Khao Yai*

Similan Islands National park

Its was established in 1982. Its area cover 12,800 ha There are 27 species of small mammals, 22 reptile & amphibian species and 39 bird species. The number of tourists in 2013 had recorded 170,549 persons

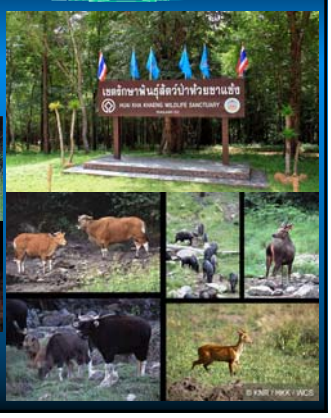




Huai Kha Khaeng Wildlife Sanctuary

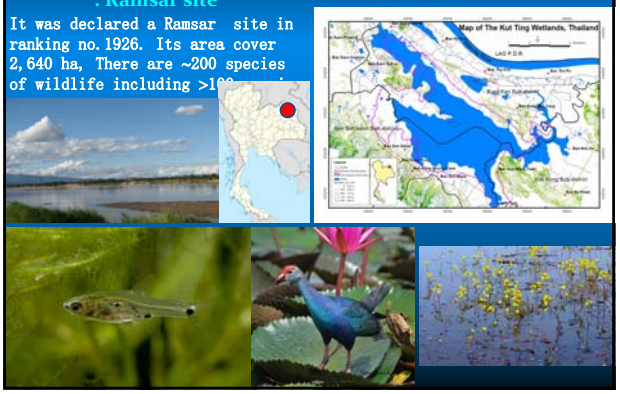
It established in 1972. Its area cover 2,574.64 km², There are 582 species of wildlife including 355 species of birds, 7

Khao Yai national park was declared a Natural UNESCO World Heritage Site under the



Kut Thing Wetland : Ramsar site

It was declared a Ramsar site in ranking no.1926. Its area cover 2,640 ha, There are ~200 species of wildlife including >1



Species diversity of plants, fungi and mushrooms in Thailand

No.	Organisms group	World (species)	Recorded in Thailand (species)
1	Bacteria	4,000	219
2	Fungi & Mushroom	80,0000	6,0000
3	Cryptogramae (non-vascular plants)	?	2,154
	3.1 Algae	> 20,000	1,600
	3.2 Bryophytes	?	925
4	Trachaeophytes (vascular plants)	>262,700	12,000 (4.6%)
	4.1 Ferns	12,000	628
	4.2 Gymnospermae	700	30
	4.3 Angiospermae	250,000	11,000

Species diversity of animals in Thailand

No.	Organisms group	World (species)	Recorded in Thailand (species)
1	Earthworms	8,000	100
2	Mollusks (shells, sea cucumbers, squids, etc.)	>300,000	5,300
3	Arachdina (spiders)	>40,000	922
4	Insects	9,600,000	>10,250
	4.1 ants	?	~1,000
	4.2 Butterflies	?	~4,000
	4.3 beetles	?	~12,000
5	Fishes	28,500	2,820
6	Amphibians	5,473	137

Convention on Biological Diversity

- Thailand's ratification & party of the convention On 29 Jan. 2004.
- Cartagena protocols: party &accession on 8 Feb 2006
- Nagoya protocol: no party

Rtf= ratification
Acs= accession

(http://www.cbd.int/)

Causes of biodiversity loss

✖ Agricultural crops invaded forest areas more than 3.76 million ha (news on 17 Oct. 2014)

During 2008-2012 (NWP) reported agricultural crops were planted in forest areas (3.76 mha)

- Para – rubber : 43.14 %
- Corn: 21.27 %
- Cassava: 4.87%
- Oil palm: 5.68%

Causes of biodiversity loss

Anthropogenic impacts

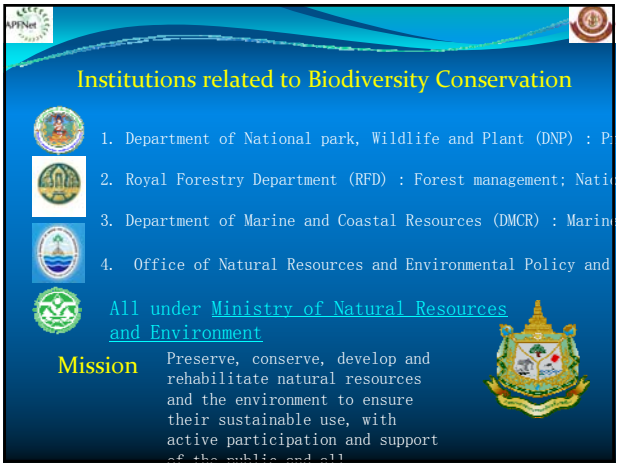
- shifting cultivation
- Monoculture (corn, cassava, sugar crane)


Corn farmland, Nan


Illegal logging : Siam rosewood (*Dalbergia*


Illegal trading for Java pangolin (*Manis*


Illegal trading for wild orchids


Institutions related to Biodiversity Conservation
1. Department of National park, Wildlife and Plant (DNP) : P
2. Royal Forestry Department (RFD) : Forest management; Nati
3. Department of Marine and Coastal Resources (DMCR) : Marin
4. Office of Natural Resources and Environmental Policy and
All under Ministry of Natural Resources and Environment
Mission
Preserve, conserve, develop and rehabilitate natural resources and the environment to ensure their sustainable use, with active participation and support


What are the main occupations of the Thai people?
Labor force by occupation (%) (CIA World Fact book, Aug 2014) (~ 35.3 million persons)
•Agriculture 38.2 (rice, rubber) mostly in rural areas

Biodiversity Conservation practices in rural areas

1. **Home garden :** all plants were planted in areas where around the house, for food, medicinal plants, ornamental plants, ct

Glochidion wallichianum for fresh vegetable.

Chili, lemon grass, Acacia insuavis for spicy and fresh vegetable.

Biodiversity Conservation practices in rural areas

2. **Agroforestry:** Trees were cultivated mixed agricultural crops (or others) in same areas, having many patterns.

2.1 Agrosilviculture (Tree + Crops) : Trees mixed cash crops;

northern part of

Teak + agar wood + spicy ginger

•**Mixed trees garden (สวนสมรม)**: Many trees (Tree & fruit trees) were planted to arrange by canopy height.,

champada durian

mangosteen

dukon

•**Multipurpose tree or shrubs on farmland**: Trees were planted intercropping with agricultural crops in paddy field, northern &

2.2 Silvipasture (Trees + pasture) :

2.3 Agrosilvipasture (Trees + crops + pasture) :

2.4 Apiculture (Trees + bees) :

Apis mellifera in longan garden

Apis cerana in mixed ees garden

3. Community forests (ป่าชุมชน) : is an evolving and dynamic concept, which underlines the significance of process of local people's participation. In accordance, with this concep luable

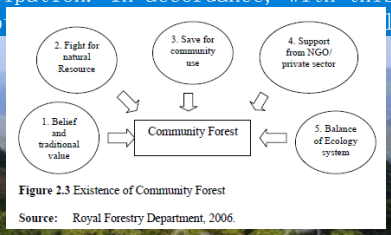


Figure 2.3 Existence of Community Forest

Source: Royal Forestry Department, 2006.

Community Forest

highest

Table 1.2 Community Forests in Thailand Under the Royal Forest Department (2000-2008)

Region	Number of Village	Number of Project	Area (Conserved Forest) Rai	Area (Forest Act.) Rai	Total Area Rai
North	2,140	2,045	999,200	172,274	1,171,599
North East	3,528	3,081	485,138	350,456	835,972
Middle	903	804	233,475	85,387	318,949
South	658	651	83,262	28,154	111,488
Total	**7,229**	**6,581**	**1,801,075**	**636,271**	**2,438,009**

Source: Royal Forest Department, 2009.

6.25 rai/ha

Table 2.3 Community Forest Classification

Type of Forest	Size	Customary Law	Local Protection by
Watershed Forest (Pa-Ton-Nam)	300-10,000 Rai (120-28,000 acres)	Strict rules and severe punishment against violation.Logging is strictly forbidden	Watershed spirit (Phii-Khun-Nam)
Ceremonial Forest (Pa-Pra-Pe-Nee)	30-300 Rai (12-120 acres)	Preserved for cremation and other ritual purpose.	Guardian Spirit
Productive Forest (Pa-Chai- Soi)	Large areas close to villages	Economic used	Less controlled than other area

Source: Yos Santasombat, 1999.

Ceremorial forests

Lampang province

Productive forests

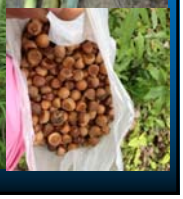


Table 2.4 Benefits of the Community Forest

Dimension	Area of Importance
1. Ecology	Community forest helps to increase the balance of ecology system. The increase number of forest facilitates rainfall, fertility of soil, and biological diversity.
2. Politics	Community forest supports development of community organization, which is fundamental to democracy.
3. Social and Culture	Community forest helps preserve local belief, norm.
4. Science and Technology	Community forest helps preserve diversity of indigenous plant and animal.

Table 2.6 Characteristics of Community Forest in Thailand

Region	Characteristics
North	The area is largely comprised of highlands and inhabited by various ethnic tribes such as the Karen, Lua, Akha, and Lahu. Most community forests in the North are original forests, conserved and managed through traditional beliefs and cultures.
Northeast	Villagers conserve patches of forest at the edge of their cultivated fields to provide source of food and medical plants.
West	This area is inhabited mostly by the Karen, who have a long tradition of forest care.
East	Most community forests are mangroves. They were set up when forest degradation became apparent and rampant through commercial logging concessions and shrimp farms.
Central Plain	The community forests in this region are scattered around Uthai Thani, Nakorn Sawan, and Supan Buri provinces. Most of forests are managed based on traditional belief.
South	The community forests range from watershed forests in the hills to coastal peat swamp forests and mangroves. The conservation of original forest trees, left growing intermixed with cultivated economic especially, is practiced at the family level.

Sufficiency economy and a healthy community to biodiversity conservation

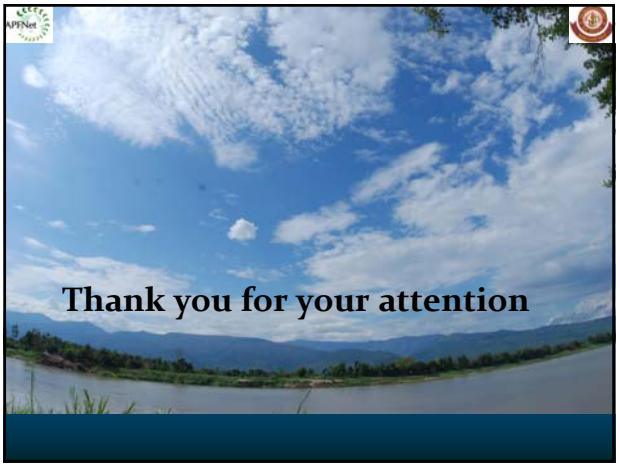
The philosophy of Sufficiency Economy (SE), bestowed by HMK, is a holistic concept of moderation that acknowledges interdependency among people and with nature. It calls for a balanced and sustainable development as its objectives of development.

Meanwhile, natural resources and environment have been deteriorated. An impact of rapid modernization on natural resources and environment has two dimensions: macro and micro. At the macro level, growth-oriented development has induced deforestation, high rate of energy consumption, wider use of hazardous chemical products without proper treatment,

Sufficiency economy and a healthy community to biodiversity conservation

- Applied SE in reducing poverty and achieving healthy community.
- Applied SE in their integrated community development activities leading to healthy

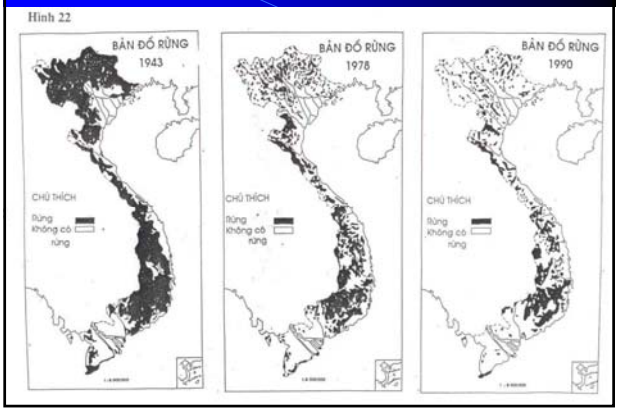
Sufficiency economy and a healthy community to biodi



Biodiversity conservation and livelihood development in vietnam

LE THI TUYET ANH
VIETNAMESE ACADEMY OF FOREST SCIENCES

CHANGE OF FOREST AREA



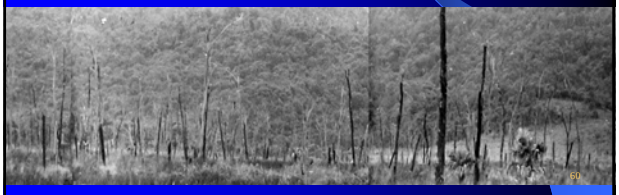
DESTRUCTION RATE

- TOTAL FOREST AREA
- 1943: 43% of total land area (14.3 million ha)
- 1980: 27.1 %
- 1985: 26.2 %
- 1999: 33.2 %
- 2002: 35.8%
- RATE OF DESTRUCTION: about 100,000 ha/yr during 1945 – 1980s.
- REASONS: long-lasting wars (3 million ha), over-exploitation, shifting cultivation,

Mangrove forest destroyed by defoliant chemicals

5

A Luoi – Hue forest destroyed during 1970s (1974)



6


A Luoi in 1987


Bomb craters in 1987
Bomb craters in A Luoi district


FOREST DESTRUCTION

FOREST RESOURCES (Million ha)

Year	Natural Forest	Plantation	Total	Coverage
1945	14.300		14.300	43%
1976	11.077	0.092	11.169	33
1985	9.308	0.584	9.892	30
1995	8.252	1.050	9.305	28
1999	9.444	1.471	10.916	33.2
2005	10.283	2.333	12.616	37
2011	10.285	3.229	13.138	39.7

Forest Area Change 2000-2005

Country	Forest area (1000 ha)	Change of forest area	
		1000 ha/yr	% change
Cambodia	10.447	- 219	**- 2%**
Myanmar	32.222	- 466	**- 1,4%**
Laos	16.142	- 78	**- 0,5%**
Thailand	14.520	- 59	**- 0,4%**
Vietnam	12.931	+ 241	**+ 2%**
Total of 5 countries	**86.262**	**- 581**	**- 0,7%**

Development strategy

	2005	2010	2020
• Forest land:	19,02	16,24	16,24
• Forest:Protect	9,47	5,68	5,68
Special-use	2,32	2,16	2,16
Production	7,1	8,4	8,4
• Coverage%:	37%	42,6%	47%

FOREST TYPES

- Natural forest:
  - Timber
  - Bamboo
  - Mixed timber-bamboo
  - Mangrove
  - Limestone
- Plantation: 3,32 million ha
- Bareland: some million ha

DIVERSITY OF PLANT

- Total: 15,000 plant species

- Wood supply : >1000 species of 100 genera,
- Material for paper : 100 species
- Essential oil supply : 500 species (160 valuable)
- Fat oil supply : 260 species
- Tannin supply : 600 species
- Dye supply : 200 species
- Medicine : >4000 species

Plant Diversity in 1997

Phyllum	Number of		
	Family	Genus	Species
Bryophyta	60	182	793
Psilotophyta	1	1	2
Lycopodiophyta	3	5	57
Equisetophyta	1	1	2
Polypodiophyta	25	137	669
Gymnospermae	8	23	63
Angiospermae	299	2175	9787
Total	378	2524	11,373
Percentage of endemics	0%	3%	20%

TIMBER SUPPLYING FOREST

DRY DIPTEROCARP FOREST

MIXED PINE FOREST

BAMBOO FOREST

MANGROVE FOREST

EXPLOITATION REDUCTION

- Ban on exploitation from natural forest
- Exploitation during 1980-1990s
  About 4 million m3/year
- Now: 300 000 m3 from natural forest
- However: 24 million people live in or near forest → they need fuelwood (about 15 million m3/year, free of charge) + other NTFPs

Acacia auriculiformis

Clone AA1

21,5 - 32,6 m³/ha/yr

Clone AA9

25,3 – 25,7 m³/ha/yr

SHIFT IN FORESTRY

- Change: from using timber exploited from natural forest to using wood from high yielding plantations
- Technology change: from processing big logs to small logs
- Change: from exploiting to planting
- Change: from large enterprises to small households

WHERE TIMBER COME FROM?

- Natural forest: 100 000 m3/yr
- Import: Timber and processed wood from other countries
- Plantation: ~ 3 million ha of commercial plantation (Eucalypts, Acacia, pines)
  - ~1 million m3 import
  - ~6-8 million m3 from plantation
- Scattered tree planting

WOOD PRODUCT EXPORT

1996: 61 million USD
2000: 219,3 m USD
2002: 435 m USD
2003: 576
2004: 1,080 billion USD
2005: 1,57
2006: 2
2007: 2.7
2012: 4.5 billion USD

Forest Ecological Service

- PFES
- 2004: the first research project was started by FSIV, finished in 2006
- 2008: Dicision from Prime Minister to apply in two provinces: Lam Dong and Son La
- 2011: Decree from Prime Minister to apply in the whole Vietnam

Forest Ecological Services

- **Who pays**:
- Hydro-electric power plants
- Clean water-supply companies
- Ecotourism companies
- **Who are benificiaries**:
- Local Farmers who protect the forest
- Forest Management Board, Enterprises

Forest Ecological Services

- **How much**:
- 20 VND/1 KWh for electricity
- 40 VND/1 m3 commercial clean water
- 1-2% of total money obtained from ecotourism
- **How to pay**:
- "**K**" coefficient recognized
- "**Forest Protection and Development Fund**"

CURRENT SITUATION

I. National Park	: 27	957.330 ha
II. Nature Reserves	: 60	1.369.058 ha
IIa. Reserves	: 49	1.283.209 ha
IIb. Species/habitat	: 11	85.849 ha
III. Landscape reserves	: 39	215.287 ha
Total	: 126	2.541.675 ha.

RED BOOK – PLANTS 1996

- The first Red Book
- MOSTE, 1996
- Total: 356 species

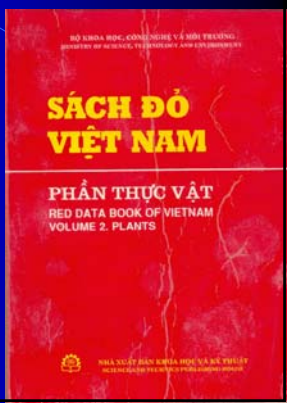
I. Magnoliophyta: 305 species

I.1.Magnoliopsida: 231 species

I.2.Liliopsida: 74 species

II. Pinophyta: 27 species

- Endangeredment: E, V, R
- T and K (unknown)



RED BOOK - REDLIST, 2007

RED BOOK 2007

MOST and Vietnamese Academy of Science and Technology

Included 462 species of which

I. Magnoliophyta: 411 species

I.1.Magnoliopsida: 294 species

I.2.Liliopsida: 117 species

II. Pinophyta: 30 species (12 Cycas)

- IUCN Categories, 1994

glyptostrobus pensilis–thuû tïng

glyptostrobus pensilis–thuû tïng

cupressus torulosa – hoµng ®µn

Flat-needle pine – *p. krempfii*

measures for conservation

1. **Seed bank**: only for orthodox tree species
2. **Collection of living trees in field**: Arboretum, Bambusetum, Botanic Gardens → a few trees (1-20 individual) per species
3. ***Ex situ* conservation stands**: only for some important species with bigger areas (1-10 ha per species, 400 trees/ha)
4. ***In situ* conservation**: in Nature Reserves

measures for conservation

1. ***In situ* conservation**: in Nature Reserves aiming at saving important, sensitive ecosystems and species:
   * Evergreen Forest Ecosystem
   * Mangrove Forest Ecosystem
   * Special (sandy, wetland, dry) Forest Ecosystems
   * Marine Ecosystem
2. ***Ex situ* conservation**: for some important species
   * Economically valuable species
   * Scientifically valuable species

Some key issues and challenges of biodiversity conservation related to livelihood improvement in Vietnam

- - Some small protected areas and their weak linkage make limit to the conservation activities;
- - The boundary of the protected areas are mostly not been clearly in the field;
- - The budget for conservation are limited, mainly from the State; Some current policies of investment and buffer management without encouragement to attract the big scale in forest production for local;
- - The local's income is still low (15 -20 kg of paddy rice/person/month in 1997 – now)

- - The activities of illegal logging on a large scale has been continuously happening.
- - The system of Vietnam classification does have some unsuitable points in comparision with IUCN's classification;
- - The current management is mostly strict protection without the integration modern outlook between conservation and development.
- - The payment policies for forest environmental services are not applied in most of biodiversity areas.
- -…

Some lessons learnt from case-study in Xuan Thuy National Park

- *- To protect diverse natural resources and migratory wild birds,* XTNP has *conducted many integrated activities* for the conservation and development, including: forest protection, reforestation, Cooperation and Scientific research , environmental education, community development.

- From Buffalos to Mushroom and Honey Production: Strengthening Community Participation through Livelihood Development in XTNP (

Buffalos in the core zone before project

Restored forest after project

Farmer cropping mushroom

Honey model in Giao An commune

- *Co-management in each core-zone with the mainstream role of women in using and managing forest resources* can manage forest more efficiently.

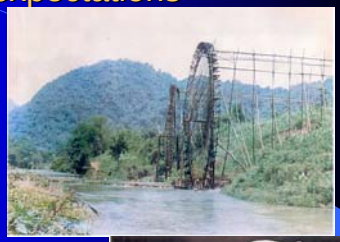
- ***Developing the tourism through international volunteers***

Some conclusion

Urgently solving some synchronization solutions:

- - Need complete and specific policies of biodiversity conservation integrated livelihood improvement to apply instantly;
- - Need have the specific policies in each area that attract all members of society engaged in biodiversity conservation;
- - Need establish some important protected areas to rescue species at high risk of extinction due to illegal hunting of man and climate change;
- - Need have the specific programs in each area to raise awareness about biodiversity protection for the community as well as the sectors and levels.
- - Need strengthen international cooperation on biodiversity conservation and climate change from region to international level.

Our expectations



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Karen and Lawa medicinal plant use: Uniformity or ethnic divergence?

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ABSTRACT

Ethnopharmacological relevance: We here tease apart the ethnopharmacological knowledge of plants in two Thai villages to determine to which degree the uses are particular to individual ethnic groups and to which degree they are part of a generalized and uniform set of widespread medicinal plants used over a large geographic range. We compared Karen and Lawa knowledge of medicinal plants in the Mae Cheam watershed of northern Thailand, where both ethnic groups have settled and share ecological conditions for resource extraction. We were interested in documenting the degree to which these two ethnic groups use the same or different medicinal plant species. The use of the same plant species by the two groups was considered a sign of uniform and cross-cultural local knowledge, whereas the use of different medicinal plants by each group was considered a sign of culturally specific local knowledge that developed within each ethnic group.
Materials and methods: We inventoried the plant species in different habitats around one Karen village and one Lawa village using stratified vegetation plots and using semi-structured questionnaires we interviewed 67 key informants regarding their use of plants for medicine. We then calculated the Fidelity level FL (FL values near 100% for a species indicate that almost all use reports refer to the same way of using the species, whereas low FL values indicate that a species is used for many different purposes) and cultural importance index CI (the sum of the proportion of informants that mention each of the use categories for a given species) to estimate the variation in medicinal plant use. We used Jaccard's Index JI (This index relates the number of shared species to the total number of species) to analyze the similarity of medicinal plant use between the two villages.
Results: A total of 103 species of medicinal plant species in 87 genera and 41 families were identified and they were used to cure 35 ailments. The FL of the medicinal plant species varied from 10% to 100%, was different for each ailment, and differed between the two ethnic groups. The most important medicinal plant species, those with the highest CI value, were not the same in the two villages. *Costus speciosus*, which is used to treat urinary infections and wounds in animals, had the highest CI value in the Karen village, whereas *Sambucus javanica*, which is used to treat wounds, fractures, bloat, and edema in humans, had the highest CI value in the Lawa village. Only 17 medicinal species (16.5%) were shared between the two villages. Methods of preparation and application were significantly different between the two villages, whereas the plant parts used, habit, and route of administration were similar.
Conclusion: Our study demonstrates that ethnic groups that live in the same geographic area can have significantly different traditional knowledge systems for medicinal plants, at least when it comes to the species used and their preparation and medicinal application. We assume that differences in cultural history and background in the two villages led to differences in medicinal plant use, preparation, and application.

1. Introduction

Up to 90% of the human population in developing countries use traditional medicinal plants to meet their primary health care needs (WHO, 2002), and local medicinal knowledge is becoming increasingly recognized in primary health care systems. The use of local knowledge is particularly common in rural and remote areas, especially among ethnic minorities. Indigenous people and ethnic groups throughout the world have developed local knowledge and medicinal practices that are often unique to individual communities. The enormous biological and cultural diversity in Southeast Asia is reflected in the variety of traditional systems of medicine. Some of the common medicinal plants, such as ginger (*Zingiber officinale* L.), are widespread and used by many ethnicities in many countries. In India 20%, of all native plant species are used as drugs, in China 19%, in Vietnam and Sri Lanka 17%, and in Thailand 16% (Schippmann et al., 2002). The

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ethnobotany of medicinal plants examines the interactions and relationships between the biological and cultural components of the environment (Bye, 1986) and, in many cases, the cultural and ecological factors that influence medicinal plant selection by ethnic groups (Joshi and Edington, 1990; Bennett, 1992; Bernstein et al., 1997).

Northern Thailand is culturally rich with several ethnic minorities. Twenty different groups of mountain people live in the northernmost one-fifth of the country (Young, 1962). These villagers, who live in remote places in the hills, still use plants extensively as medicine (Anderson, 1986a). In this region, we find similarities and differences among the ethnic communities regarding knowledge about medicinal plants. Several tribal communities use the latex from the opium poppy (*Papaver somniferum* L.) to cure many health conditions, such as problems with coagulation, and to treat fever and muscle pain (Yasamutthorn, 1996). The H'tin and Lawa use the boiled leaves and roots of *Vernonia volkameriaefolia* Wall ex. DC. to cure food poisoning (Yaso, 2000). Differences also exist in the medicinal uses of the same species. For example, the Lahu use a decoction from leaves of *Clausena excavata* Burn. to treat skin problems in babies, but the Akha use the pounded roots of the same species to treat swellings (Anderson, 1986a, 1986b). Another example of a species with different uses among different groups is *Baphicacanthus cusia* (Nees) Bremek.: the Kmu use the leaves for dying and the Lawa use its roots medicinally to cure cough (Tangtragoon, 1998). The leaves of *Blumea balsamifera* DC. are used by the H'tin as a compress for women after they have given birth, whereas the Lawa use its leaves as a compress for bloat and bone fractures (Yaso, 2000). In addition to the differences and similarities between the ethnic groups, differences can exist within a group depending on gender, age, religion, and cultural beliefs (Ayantunde et al., 2008).

Traditional knowledge of plant use in northern Thailand has been studied among most of the ethnic minorities, including the Akha (Anderson, 1986a; Srisanga et al., 2011), Hmong (Pake, 1987; Siriphon, 2006; Srithi et al., 2012a), H'tin (Thongsorn, 2000), Karen (Khamfachuea, 2008), Lahu (Anderson, 1986b), Lawa (Tangtragoon, 1998; Mahayotsanun, 1999), Mien (Srithi et al., 2009; Panyaphu et al., 2011), and Moo Soe Dam (Setbubpha and Sookchaloem, 2009). Most of these studies have viewed the ethnic groups individually, but one study looked at the effect of geographic separation on local knowledge of medicinal plants among the Akha people in Thailand and China (Inta et al., 2008). Recently, some efforts have been made to conduct comparative studies (Srithi et al., 2012b) to determine the degree to which the medicinal plant used by individual ethnic groups are distinct and to which degree the use represents a common widespread tradition that crosses cultural boundaries between ethnic groups. Comparative studies can also reveal how much the ecological conditions where the groups live influence their medicinal plant use (Inta et al., 2008). Here, we compare the use of medicinal plants by the Karen and Lawa in two villages located only 3 km apart in the same watershed. The two villages function under similar ecological conditions and have access to the same flora from which they derive their medicinal plants.

The Karen are an ethnic minority group who live mostly in Burma with a smaller part of their population in Thailand (Thomas et al., 2000). The Karen began to migrate from Burma to Thailand towards the end of the 18th century (Schmidt-Vogt, 1999). The Karen is the largest ethnic minority in Thailand, making up 51% of the overall population of ethnic minorities (Tribal Research Institute, 1992), and they have settled in both the uplands and lowlands of central and southern Thailand (Fufuang, 2000). Karen villages are found in the mountains along the Thai-Burmese border, usually at 600–1000 m a.s.l. Most Karen (47%) live in the northern provinces of Chiang Mai, Mae Hong Son, and Chiang Rai. The original religion of Karen was Animism, but after a period of Buddhism 25–30% of Karen have converted to Christianity (Tribal Research Institute, 1992). The Karen are autonomous and economically self-sufficient in remote and isolated areas and have rituals that focus on living in harmony with nature (Mischung, 1995; Yos, 2009). The Karen in the uplands practice a combination of irrigated farming and swidden cultivation, whereas lowland Karen rely on wet-rice farming (Schmidt-Vogt, 1999). The main economic base of the Karen is agriculture, particularly rice farming, followed by the cultivation of maize and cabbage crops (Schmidt-Vogt, 1999).

The Lawa live only in Thailand and are often not counted as an ethnic minority. Lawa history is long and poorly understood (Mischung, 1995). The exact origin of the Lawa has not been definitively established. Some archaeologists believe that the Lawa migrated from Cambodia, but others think that they originated in Thailand over 2000 years ago (Young, 1962) and represent the oldest stratum of settlement in northern Thailand (Schmidt-Vogt, 1999). The Lawa are a minority within the confines of their former strongholds and make up only 2% of the tribal population in northern Thailand (Tribal Research Institute, 1992). The Lawa have settled primarily within the region of Mae Hong Son, but some live in the mountains and plains of Chiang Mai province. The Lawa maintain a traditional lifestyle and their economy is based on agriculture, with rice grown according to a sophisticated rotating cultivation system (Schmidt-Vogt, 1999). The Lawa are Animist, but many of them have adopted Buddhism and some are Christians (Young, 1962). The Lawa who live in the mountains are strictly Animist; they believe that spirits dwell everywhere and in everything (Kunstadter, 1983). The economy of the Lawa is based on subsistence-oriented agriculture that combines swidden farming and wet-rice cultivation, similar to the Karen (Schmidt-Vogt, 1999). The Lawa consider themselves to be more deeply involved with the spiritual world than the other highland groups (Kunstadter, 1983). At the beginning of each season, they have ceremonies to offer the spirits payment for their good health, good products, and grant protection. They believe in spirits that protect and demand worship, including ancestral spirits, house spirits, fields spirits, and spirits of various localities, especially forest spirits (Young, 1962).

In this study we attempted to identify the widespread medicinal plant species shared by ethnic groups, and the more specialized medicinal plant species that have been discovered by the individual tribes and developed as a part of their own cultural heritage. The two ethnic groups live in the same mountainous region shared by Thailand and Burma but mostly in separate areas and under different ecological conditions and in areas with a different vegetation and flora from which to derive their medicinal plants. To make a comparison meaningful we had to find a place where the two groups lived close together with access to the same forest with the same plant species that they could use for medicinal purposes. In that way the ecological and floristic basis was factored out of the equation so that any differences or similarities would be due to factors inherent in the groups cultural and social conditions. Hence, our specific objective was to compare traditional knowledge of medicinal plants in two villages inhabited by different ethnic groups that live under identical environmental conditions and have access to the same set of plant species. We studied medicinal plant use in a Karen village and a Lawa village in Mae Cheam watershed in Chiang Mai province of northern Thailand. We asked the following questions: (1) to which degree do the two ethnic groups use the same medicinal plants, and (2) how much has cultural evolution and historic events within each group given rise to different ethnically related medicinal plant use systems?

2. Materials and methods

2.1. Study sites

The Mae Cheam watershed in northern Thailand lies approximately 75 km southwest of the city of Chiang Mai renowned for its

biodiversity, the watershed hosts several ethnic minority groups, forest types, varied vegetation, and a rich flora (Khamyong et al., 1999). We conducted our field survey in two villages 3 km apart that are located at the same elevation and in the same forest and that houses an identical flora in the immediate surroundings of the two villages. Mae Hae Tai is a Karen village with a population of 346, of which we interviewed 35 informants. Mude Lhong is a Lawa village with a population of 286 people, of which we interviewed 32 informants. Additional details about the villages and the study site can be found in Junsongduang et al. (2013).

2.2. Data sampling

Plants found around the two villages were inventoried using a stratified plot-based sample in different habitats, ranging from recent 1–2 years-old fallows over 5–6 years-old fallows to sacred, essentially untouched forest (Junsongduang et al., 2013). Plant specimens (251 in Mae Hae Tai and 229 in Mude Lhong) were collected and then identified at the Queen Sirikit Botanic Garden Herbarium (QSBG) with the help of taxonomic specialists M. Norsangsri and J. F. Maxwell. Vouchers were deposited at the herbaria of the Department of Biology, Chiang Mai University and QSBG, Chiang Mai, Thailand. Ethnobotanical data were collected between August 2011 and February 2012 using semi-structured interviews. We made 35 interviews in the Karen village and 32 in the Lawa village corresponding to 10% and 11% their populations. The informants were selected to cover the age range 15–84 years, and we only interviewed villagers who were born and had always lived in the community (Table 1). Photographs of plants and freshly collected material were shown to the informants following established methodologies (Martin, 1995; Thomas et al., 2007) and use categories (Cook, 1995). To protect the intellectual property rights of the informants communal meetings were held with all inhabitants, prior to the start of interviews concerning the medicinal use of plants, Apart from the general population of the villages, these meeting included the village leaders. During the meetings the purpose and the methods of the study were explained and approved. It was agreed that the obtained results would be shared with the villagers in the form of a popular publication once the research had been formally published. In addition it was agreed that every informant would be asked for her or his prior informed consent individually before any interview was undertaken. Consequently such consent was obtained for each interview performed.

2.3. Data analyses

Our statistical analysis is based on information obtained from 32 to 35 informants in the two villages, respectively, and we take these samples as representing the two cultures. Extending the survey to further villages would have violated the condition of examining knowledge developed under identical ecological conditions in the two cultures. We used the cultural importance index (CI) (Tardío and Santayana, 2007) to estimate the significance of each species. This index is widely used in ethnobotanical studies to determine diversity of uses and the consensus of informants. The index is defined as:

$$CI = \sum_{u=1}^{NC} \sum_{i=1}^{N} UR_{Ui}/N$$

where *UR* is the total number of use reports for each use category of a given species, *N* is the total number of informants, and *NC* is the total number of use categories. Therefore, the *CI* is the sum of the proportion of informants that mention each of the use categories for a given species. This additive index takes into account not only the spread of the use (number of informants) for each species, but also its versatility, i.e., the diversity of its uses. Another important property of the *CI* index is that each addend is a measure of the relative importance of each plant use (Tardío and Santayana, 2007).

We used the Fidelity level (FL) to determine the preferred species for the treatment of a particular ailment (Friedman et al., 1986). FL is calculated as:

$$FL(\%) = \frac{N_p}{N} \times 100$$

where N_p is the number of informants citing the use of a given species for a particular ailment and *N* is the total number of informants citing the use for any given species. High FL values (near 100%) for a species indicate that almost all use reports refer to the same way of using the species, whereas low FL values indicate that a species is used for many different purposes.

We used the Jaccard Index (JI) to determine the similarity of medicinal plants species between the two villages (Höft et al., 1999). This index is based on the presence or absence of species on each list. Relating the number of shared species to the total number, the index is expressed as:

$$JI = (c/a+b+c) \times 100$$

where *a* is the number of species unique to area *A*, *b* is the number of species unique to area *B*, and *c* is the number of species found in both areas.

The chi-square test was used to determine differences between the Karen and Lawa in methods of preparation and the plant parts used, habitat, and route of administration. Finally, the independent sample *t*-test was used to determine whether significant differences were found in the average number of medicinal plants reported by each informant among the two villages. The Pearson correlation coefficient was used to determine correlations between the age and number of known medicinal plants. All analyses were performed using the SPSS 16.0 software package for Windows.

3. Results and discussion

3.1. Diversity of medicinal plants

A total of 103 different species of medicinal plants in 87 genera and 41 families were used to treat 35 ailments in both humans and animals. Eighty-three species in 74 genera and 35 families were

Table 1
Number of informants in the Karen and the Lawa villages in northern Thailand where medicinal plants were studied.

Village name	Hill tribe	Religions	Inhabitants	Households (male/female)	Distance to nearest town (km)	Number of informants (males/females)	Number of informants for the questionnaires for each age range (males/females)					
							15–25	26–35	36–45	46–55	56–65	>66
Mae Hae Tai	The Karan	The Christian	1672	67 (172/173)	53	36 (14/22)	5 (2/3)	5 (1/4)	6 (1/4)	8 (5/3)	6 (1/5)	6 (5/1)
Mude Lhong	Lawa	The Animists- Buddhism	1762	55 (136/150)	48	32 (16/16)	5 (2/3)	5 (1/4)	6 (1/4)	6 (5/1)	4 (3/1)	6 (3/3)

Table 2
Medicinal plants used in two villages, a Karen and a Lawa, in the Mae Cheam watershed in northern Thailand.

Species—Family (Voucher no.)	Local name		Habitat	Ailments treated		Part used		Preparation	
	Karen	Lawa		Karen	Lawa	Karen	Lawa	Karen	Lawa
Acacia concinna (Willd.) DC.—FABACEAE (AJK004; AJL001)	Po chi sa	Som poi	T	Alcohol intoxication	Detergent for skin	Fr	Fr	Dc	Ba
Acrocarpus fraxinifolius Wight ex Arn.—FABACEAE (AJK 048)	Law bor dey	–	T	Diarrhea, rashes, itching	–	L	–	Dc	–
Actinodaphine henryi Gamb.—LAURACEAE (AJK 011; AJL 164)	Se glow bo	Coh yeum ngo	T	Tonic	Inflammation	R	L	Dc	Po
Aglaia elliptica Blume—MELI ACEAE (AJK 141; AJL 136)	Sey leu sa, Sey ney sa, Tur see sor	Gor dong pia, Sa nang toi	T	Wound (lip)	Wound (oral cavity)	L	L	Cw	Cw
				Diarrhea	–	L	–	Dc	–
*Aglaia lawii (*Wight) Sald. ex Rama.—MELIACEAE (AJK 200)	Sey pi	–	T	Pain (muscle), tonic	–	L	–	Ba, Dc	–
Alstonia scholaris (L.) R. Br.—APOCYNACEAE (AJK003; AJL 063)	Nor bey, Pa bor eu	Hyar, Sa weing	T	Fever	Hazy eyes	B	Ss	Dc	Dp
Aphananthe aspera (Thunb.) Planch.—ULMACEAE (AJK 230)	Pore loo too, Sa deui cwa	–	T	Gastric ulcers	–	R	–	Dc	–
Artocarpus nitidus Trec.—MORACEAE (AJK 246)	Pa da soi	–	T	Wound	–	Ss	–	Po	–
Bauhinia glauca (Wall. ex Bth.) Bth. Ssp. tenuiflora (Watt ex Cl.) K. & S.S. Lar.—FABACEAE (AJK 245)	Per na meu too	–	C	Fever	–	R	–	Dc	–
Betula alnoides Ham. ex D. Don—BETULACEAE (AJL 117)	–	Coh la pite, Hley	T	–	Wound	–	L	–	Po
Bochmeria nivea (L.) Gaud. var. *tenacissima* (Roxb.) Miq.—URTICACEAE (AJL 090)	–	Hyew	S	–	Wound (oral cavity)	–	L	–	Po
Boehmeria malabarica Wall. ex Wedd.—URTICACEAE (AJK 187; AJL 040)	See ga jeu, Bor gur	Kang poi	S	Wound	Wound (oral cavity)	L	L	Po	Cw
					Pain (muscle)	–	R	–	Dc
Boehmeria sp.—URTI CACEAE (AJK 202)	Ya bi	–	S	Rheumatoid arthritis	–	L	–	Dc	–
Breynia retusa (Dennst.) Alst.—EUPHORBIACEAE (AJK 179)	Mi ni mey	–	S	Fever	–	Wp	–	Ba	–
				Wound (animal-cattle)	–	–	–	Po	–
Bridelia tomentosa Blume—EUPHORBIACEAE (AJK240)	Pore ji braa	–	S	Inflammation	–	L	–	Cp	–
Bridelia glauca Blume—EUPHORBIACEAE (AJK 232)	Sir cwi meu	–	S	Gastric ulcers	–	St	–	Dc	–
Brucea mollis Wall. ex Kurz—SIMAROUBACEAE (AJK 045)	Sey gor wey	–	T	Muscle relaxation, pain (muscle)	–	B	–	Ba	–
Buddleja asiatica Lour.—BUDDLEJACEAE (AJK 034; AJL 077)	Pore gi braa	Sa ta a pei	S	Burn	Rashes, itching	L	–	Cp	Po
Callicarpa arborea Roxb. var. *arborea*—VERBENACEAE (AJK 023)	Poh qui	–	T	Diarrhea	–	Wp	–	Dc	–
Callicarpa rubella Lindl.—VERBENACEAE (AJK 044)	Sey paa war	–	S	Diarrhea, Rashes, itching	–	R	–	Dc	–
Calophyllum polyanthum Wall. ex Choisy—CLUSIACEAE (AJK 022)	Seu mee la	–	T	Fever	–	B	–	Dc	–
Catunaregam spathulifolia Tirveng.—RUBIACEAE (AJK 204)	Puoi sa mu	–	T	Diarrhea	–	Sh	–	Ef, Dc	–
Celtis tetrandra Roxb.—ULMACEAE (AJK 241; AJL072)	Hna jor bi	Coh tar, Ha tong soo	S	Pus (animal-cattle)	Wound (lip)	L	L	Po	Po
Chionanthus ramiflorus Roxb.—OLEACEAE (AJK 148)	Bey plor sa	–	T	Anemia	–	B	–	Dc	–
Chisocheton cumingianus (C. DC.) Harms ssp. *balansae* (C.DC.) Mabb.—MELIACEAE (AJK 100)	Sa me jeu	–	T	Urethral stones	–	R	–	Dc	–
Chromolaena odorata (L.) R. M. King & H. Rob.—ASTERACEAE (AJK 066; AJL 220)	Chor per gwe	Piaw sa non chime	S	Coagulation of bleeding	Coagulation of bleeding	L	L	Po	Po
				Peptic ulcers	–	L	–	Ef	–
Cinnamomum iners Reinw. ex Bl.—LAURACEAE (AJL 044)	–	Bai herng, Mine hoam	T	–	Carminative	–	R	–	Ef
Clausena lenis Drake—RUTACEAE (AJK 171)	Sey nur si	–	S	Fever	–	Wp	–	Ba	–
Clerodendrum disparifolium Blume—VERBENACEAE (AJK247)	Pa rad pore	–	S	Muscle relaxant	–	L	–	Po	–
Clerodendrum serratum (L.) Moon.—VERBENACEAE (AJK 212; AJL 120)	Khui doh joh	Coh song sam	S	Rashes, itching	Burns, pain (muscle)	L	L	Po	Po
						–	L	–	Po
				–					
Colebrookia oppositifolia Smith—VERBENACEAE (AJL 155)	–	Coh tia gleing	S	–	Wound	–	L	–	Po
Costus speciosus (Koeh.) J.E. Sm. var. *speciosus*—COSTACEAE (AJK002; AJL 088)	Su ley bo	Gu gi, Toh toi	H	Urinary tract infection	Lumbago	L, St	R	Dc	Dc
				Ear infection (animal-dog)	–	St	–	Dp	–
Cratoxylum formosum (Jack.) Dyer ssp. *pruniflorum* (Kurz) Gog.—CLUSIACEAE (AJL 097)	–	Gu gi, Toh toi, Sa nung kai	S	–	Diarrhea	–	L	–	Dc
Croton acutifolius Esser—EUPHORBIACEAE (AJK 161)	Sa gar hwa	–	T	Dysmennorhea	–	Wp	–	Ba	–
Dalbegia cana Graham ex. Kurz—FABACEAE (AJK 203)	Ya gaa	–	T	Fever	–	Wp	–	Ba	–
Dalbergia cultrata Graham ex Benth.—FABACEAE (AJL 217)	–	Hyu	T	–	Wound	–	B	–	Bc

Dalbergia retusa Hemsl.—FABACEAE (AJK 170)	Sa la gor	–	T	Sore throat	–	Wp	–	Dc	–
Dendrocnide stimulans (L.f.) Chew—URTICACEAE (AJL 147)	–	Tug kleing, Dian	S	–	Diarrhea	–	R	–	Dc
Desmos dumosus (Roxb.) Saff. var. *glabrior* Craib—ANNONACEAE (AJK 120)	Pore na seu	–	T	Dysmennorhea	–	L	–	Dc	–
Desmos sp.—ANNONACEAE (AJK 070)	Sir kheui hmeu	–	T	Diarrhea, anemia, poisoning (food)	–	R	–	Dc	–
					–	R	–	Dc	–
Dillenia parviflora Griff.—DILLENIACEAE (AJK 243)	Khwor	–	T	–	Wound	–	B	–	Po
Dillenia sp.—DILLENIACEAE (AJL 124)	–	Coh sa guem	T	–	Birth	–	S	–	Ba
Diospyros castanea Fletcher—EBENACEAE (AJK 038)	Sey mee joh	–	T	Sore throat	–	Fr, Sh	–	Efs	–
Dysoxylum excelsum Bl.—MELIACEAE (AJK 061)	Par se ley	–	T	Detergent for skin	–	L	–	Ba	–
Erythrina subumbrans (Hassk.) Merr.—FABACEAE (AJK 089)	Sey cher	–	T	Sore teeth	–	R	–	Cw	–
Eugenia cumini (L.) Druce var. *cumini*—MYRTACEAE (AJK 032)	Sey mee su, Sey grey gwa	–	T	Diarrhea	–	B	–	Dc	–
Eugenia fruticosa (Roxb. ex DC.) Roxb.—MYRTACEAE (AJK 074)	Sir me	–	T	Pneumonia	–	B	–	Ba	–
Eurya accuminata DC.—THEACAEA (AJL 029)	–	Coh joung, Coh hmoi	S	–	Wound	–	Ss	–	Po
Ficus auriculata Lour.– MORACEAE (AJK 007)	Ta geu ha	–	T	Indigestion, carminative	–	B	–	Dc	–
Ficus carpillipes Gagnep.—MORACEAE (AJK 201; AJL 087)	Poa hoo la	Ye ya gor	T	Sore throat	Wound	Fr	L	Ef	Cw
Flacourtia indica (Burm.f.) Merr.—FLACOURTIACEAE (AJL 234)	–	Mi gai	T	–	Diarrhea	–	Fr	–	Dc
Ficus virens Aiton var. *virens*—MORACEAE (AJK 082)	Clur sa	–	T	Wound	–	L	–	Po	–
Flemingia macrophylla (Willd.) Prain—FABACEAE (AJK 185)	Cha me mai bor dor	–	S	–	Tonic	–	L	–	Ef
				–	Wound	–	L	–	Cp
Garcinia xanthochymus Hook. f. ex. T. Anderson—CLUSIACEAE (AJK 040)	Sey soa khey	–	T	Tonic	–	B	–	Dc	–
Glochidion eriocarpum Champ.—EUPHORBIACEAE (AJK 065)	Sey pore meu pra	–	S	Nervous relaxation	–	S	–	Ef	–
Glochidion sphaerogynum (M.A.) Kurz—EUPHORBIACEAE (AJK 067)	Tur si phlaa	–	T	Nematode infection	–	B	–	Dc	–
Gmelina arborea Roxb.—VERBENACEAE (AJK 252; AJL 083)	Sey gor wey	Ga hor	T	Tonic	Tonic	B	B	Dc	Dc
				–	Pain (muscle)	–	B	–	Dc
Helicia nilagirica Bedd—PROTEACEAE (AJK 229)	Sey gor pri	–	T	Pain (muscle)	–	L	–	Cp	–
Helicteres hirsuta Lour.—STERCULIACEAE (AJK 181)	Poa ji gwey	–	S	Burn	–	L	–	Po	–
Helicteres elongata Wall. ex Boj.—STERCULIACEAE (AJK 121)	Ta gor eh	–	S	Wound	–	R	–	Cw	–
Horsfieldia amygdalina (Wall.) Warb. var. *amygdalina*—MYRISTICACEAE (AJK 129; AJL 137)	Poo see sho	Pley coh	T	Wound	Tonic	R	S	Po	Dc
Ilex umbellulata (Wall.) Loesn.—AQUIFOLIACEAE (AJK 199)	Bley bor sa	–	S	Rashes, itching	–	Fl	–	Po	–
Indigofera tinctoria Linn.—FABACEAE (AJK 244)	Sor me moo boa coa	–	S	Inflammation	–	Sh	–	Po	–
Inula cappa (Ham. ex D. Don) DC. forma *cappa* —ASTERACEAE (AJK 159)	Ta core a kha dor	–	S	Fever	–	Wp	–	Ba	–
Kopsia arborea Blume—APOCYNACEAE (AJK 182)	Ti chi cho por	–	T/S	Wound	–	L	–	Po	–
Leea indica (Burm. f.) Merr.—LEEACEAE (AJK 131; AJL 080)	Sey bor sa	Dird	S	Diarrhea	Diarrhea	R	R	Dc	Dc
Litsea cubeba (Lour.) Pers. var. *cubeba*—LAURACEAE (AJL 008)	–	Coh loh	T/S	–	Wound	–	Fr	–	Po
Litsea elongata (Wall. ex Nees) Bth. & Hk.f.—LAURACEAE (AJK 127)	Nor tu leu	–	S	Wound	–	R	–	Po	–
*Litsia monopetala (*Roxb.) Pers.—LAURACEAE (AJK 154; AJL 165)	Pey jeu ya	Hyum ngo, Hyeung	T/S	Dysmennorhea	Wound	L	R	Ba	Bc
Manglietia garrettii Craib—MAGNOLIACEAE (AJK 205)	Sey la bley	–	T	Sore throat	–	R	–	Dc	–
Mangifera coloneura Kurz—ANACARDIACEAE (AJL 233)	–	Coh pae	T	–	Inflammation	–	L	–	Po
Mallotus sp.—EUPHORBIACEAE (AJL 235)	–	Co wan	T/S	–	Indigestion	–	St	–	Dc
Maoutia puva (Wall. ex Hk.) Wedd.—URTICACEAE (AJL 177)	–	Hyei	S	–	Wound	–	L	–	Cw
Melastoma malaBaricum L. ssp. norman D. Don K. Meyer—MELASTOMATACEAE (AJK 019)	Sey la pley	–	S	Sore throat	–	R	–	Dc	–
Melicope pteleifolia (Champ. ex Bth.) T. Hari—RUTACEAE (AJK 250)	Pa sa ley	–	S	Sore throat	–	L	–	Efs	–
Millettia pachycarpa Bth.—FABACEAE (AJK 84)	Cher dui meu	–	T	Detergent	–	R	–	Ba	–
Mitragyna rotundifolia (Roxb.) Kuntze—RUBICEAE (AJK 186)	Pore moo loo	–	S	Rheumatoid arthritis	–	St, R	–	Dc	–
Morus alba L.—MORACEAE (AJL 112)	–	Coh laa	S	–	Wound	–	Ss	–	Po
Mussaenda parva Wall. ex. G. Don—RUBIACEAE (AJK 191)	Go wa sa	–	S	Tonic	–	R	–	Dc	–
Ochna integerrima (Lour.) Merr.—OCHNACEAE (AJK 228)	Ta si cra	–	S	Detergent for skin	–	Wp	–	Ba	–
Pavetta indica L.—RUBIACEAE (AJL 113)	–	Coh ca tok	S	–	Wound	–	Ss	–	Po
Phoebe lanceolata (Nees) Nees—LAURACEAE (AJK 047; AJL 122)	Sey glow bow	Coh sa loh, Hyom hngo	T	Smallpox	Diarrhea	B	R	Po	Dc
Phyllanthus emblica L.—EUPHORBIACEAE (AJK 090)	Sey ya sa	–	T	Sore throat	–	Fr	–	Ef	–
Picrasma javanica Bl.—SIMAROUBACEAE (AJL 182)	–	Sa geun	T	–	Birth	–	L	–	Ba
					Lactation stimulant		St		Dc

Table 2 (*continued*)

Species—Family (Voucher no.)	Local name		Habitat	Ailments treated		Part used		Preparation	
	Karen	Lawa		Karen	Lawa	Karen	Lawa	Karen	Lawa
Pittosporopsis kerrii Craib—ICACINACEAE (AJK 029)	Sa pee sar	–	T	Rashes, itching	–	L	–	Po	–
Rauvolfia verticillata (Lour.) Baillon—APOCYNACEAE (AJK 078)	Pla sey la	–	S	Rashes, itching	–	R	–	Ba	–
Sambucus javanica Reinw. ex Blume—CAPPARIDACEAE (AJK 088; AJL 026)	Ta si ga jeu	La oil toui	S	Wound, fractures	Bloat	L	L	Cp	Cp
					Wound		L	–	Po
					Fractures,	–	L	–	Cp
					Pain (muscle)		R	–	Dc
					Edema		L	–	Cp
Sapindus rarak DC.—SAPINDACEAE (AJL 025)	–	Glerw	T	–	Detergent	–	Fr	–	Ba
Sarcosperma arboreum Bth. ex Cl.—SAPOTACEAE (AJK 153)	Gor hor	–	T	Wound	–	B	–	Po	–
Sauropus quadrangularis (Willd.) M.–A.—EUPHORBIACEAE (AJK 144)	Ta chor dor	–	S	Migraines	–	Wp	–	Dc, Ba	–
Shorea roxburghii G.Don—DIPTEROCARPACEAE (AJK 196)	Sey bey tour, Ta glor	–	T	Mount (oral cavity)	–	St	–	Cw	–
Solanum spirale Roxb.—SOLANACEAE (AJL 085)	–	Song sam	S	–	Diarrhea	–	L	–	Dc
Solanum verbascifolium L.—SOLANACEAE (AJL 027)	–	Coh flown, Yong deum	T/S	–	Peptic ulcers,	–	R	–	Dc
					diarrhea	–	L	–	Dc
Spondias pinnata (L.f.) Kurtz—ANACARDIACEAE (AJK 249)	Sir pee tor	–	T	Sore throat	–	Fr	–	Efs	–
Suregada multiflora (A. Juss.) Baill.—EUPHORBIACEAE (AJK 027)	Sa dui dare, Gley hmor sa	–	T	Rashes, itching	–	L	–	Po	–
Terminalia chebula Retz. var. *chebula* —COMBRETACEAE (AJK 113; AJL 093)	Hor chi dor, Por hor sa	Ga gai, Bur	T	Burns	Rashes, itching	L	L	Po	Po
Toddalia asiatica (L.) Lmk.—RUTACEAE (AJK005)	Ta sai iw si, Pca sey ley	–	T	Pregnancy/Birth		R	–	Dc	–
Trema orientalis (L.) Bl.—ULMACEAE (AJK 076)	Per dor, Sa ley	–	S	Tonic	–	Wp	–	Dc	–
				Wound	–	L	–	Po	–
Triadica cochinchinensis Lour.—EUPHORBIACEAE (AJK 111)	Nor	–	T	Fever (Malaria)	–	B	–	Dc, Ba, Ef	–
Vitex sp.—VERBENACEAE (AJK 109)	Tor gloa soo, Seu ca poh jor	–	T	Sore teeth	–	R	–	Cw	–
Wendlandia scabra Kurz. var. *scabra*—RUBIACEAE (AJL 051)	–	Coh yong	T	–	Diarrhea	–	R	–	Dc
Ziziphus oenoplia var.*brunoniana* Tardieu Mill—RHAMNACEAE (AJK 015)	Bla kho dey	–	S	Sore throat	–	Sh	–	Cw, Efs	–

The family name of each plant species is indicated by the first four letters of the Latin family name in capital letters. Vouchers were collected in the number series of Auemporn Junsongduang (AJK for Karen, and AJL for Lawa) and deposited in the herbaria of the Ethnobotanical Research Unit, Department of Biology, Faculty of Science, Chiang Mai University and Queen Sirikit Botanic Garden Herbarium, Chiang Mai Thailand. Habitat: H=Herb, S=Shrub, T=Tree. Part of plant used: Br=Bark, Fr=Fruit, Fl=Flower, L=Leaves, R=Root, St=Stem, Sh=Shoot, Ss=Stem sap (latex), Wp=Whole plant. Method of Preparation: Ba=Bath, Bc=Boil for cleaning wounds, Cp=Compress, Cw=Chewed, Dc=Decoction, Dp=Dropped, Ef=Eaten as food, Pt=Poultices.

used by the Karen, and 39 species in 34 genera and 25 families were used by the Lawa (Table 2). In the Karen village, Fabaceae was the family with most ($n=11$) medicinal plant species, followed by Euphorbiaceae ($n=10$). For the Lawa, Lauraceae was the most used family of medicinal plant species ($n=5$), followed by Urticaceae ($n=4$; Table 3). Among the two ethnic groups, the Karen used a higher number of medicinal plants species compared to the Lawa, and the two-tailed independent sample showed significant differences in the average total number of medicinal plants used in the two villages ($P=0.021$; Table 4).

Several previous studies of medicinal plant knowledge in tribal communities in northern Thailand have documented differences in the medicinal plant species known by different ethnic groups. In Nan province, 67 species of medicinal plant are used by the Lawa, 86 species by the Kmu, and 55 species by the H'tin (Tangtragoon, 1998). Two hundred and twenty one medicinal plant species are used by the Akha, the smallest of the six main hill tribes in Thailand, and 68 species of medicinal plants are used by the Lahu (Anderson, 1986a, 1986b). But because those studies were done in sites with highly dissimilar ecological conditions and different floras the differences in medicinal plant uses may be a results of either different availability of plants or of different cultural traditions, such as religious differences as suggested by Anderson, 1986a, 1986b). Similar patterns have been described elsewhere in the tropics, including two adjacent Amazonian communities, the Matsigenka and Yora, who use a dramatically different selection of plant species for medicinal use, even in the same family (Shepard, 2004). The different knowledge of medicinal plant species between the two villages reported in this paper may be due to the Lawa having migrated twice in the past because of plagues, whereas the Karen had remained in the same place. Migration is one of the several causes of knowledge erosion (Pieroni and Vandebroek, 2007; Volpato et al., 2009; Ceuterick et al., 2011) and has a corrosive effect on traditional knowledge of medicinal plants (Pirker et al., 2012). Local knowledge may be lost when it depends on continued access to specific land and resources. If a particular species are unavailable for migrants, they will no longer teach their descendants the specific knowledge associated with it (Kirsch, 2001). However, arriving to a new location may also contribute to the exchange and increase of knowledge and practices (Vandebroek and Balick, 2012). Traditional knowledge of medicinal plants brought by migrants may continue to be applied if there is access to the desired plant resource or the natural conditions for the designated plant are available (Ososki et al., 2007).

Table 3
Number of medicinal species per plant family used in the two villages examined.

Family	Number of medicinal species	
	Karen	Lawa
Fabaceae	11	2
Euphorbiaceae	10	1
Verbenaceae	6	3
Lauraceae	4	5
Meliaceae	4	1
Moraceae	4	2
Rubiaceae	4	3
Apocynaceae	3	1
Rutaceae	3	–
Annonaceae	2	–
Asteraceae	2	1
Malvaceae	2	–
Magnoliaceae	2	–
Myrtaceae	2	–
Ulmaceae	2	1
Urticaceae	2	4
Clusiaceae	2	1
Solanaceae	–	2
Anacardiaceae	1	1
Aquifoliaceae	1	–
Buddlejaceae	1	1
Combretaceae	1	–
Dilleniaceae	1	1
Dipterocarpaceae	1	–
Ebenaceae	1	–
Icacinaceae	1	–
Leeaceae	1	1
Melastomataceae	1	–
Myristicaceae	1	1
Ochnaceae	1	–
Oleaceae	1	–
Proteaceae	1	–
Rhamnaceae	1	–
Sapotaceae	1	–
Simaroubaceae	1	1
Zingiberaceae	1	1
Betulaceae	–	1
Caprifoliaceae	–	1
Flacourtiaceae	–	1
Sapindaceae	–	1
Theaceae	–	1
Total species	83	39

3.2. Culturally important species

A comparison of the ten medicinal plant species with the highest cultural importance (CI) in each village, showed that the two ethnic groups relied on the same species to a very limited extent, and with different intensities of use (Table 5). *Costus speciosus* had the highest CI, followed by *Sambucus javanica*, in the Karen village. In the Lawa village, *Sambucus javanica* was the most important medicinal plant species, followed by *Boehmeria malabarica* (Table 5). We found that villagers from both groups used *Sambucus javanica* for many purposes, including the treatment of wounds, bloat, bone fractures, inflammation, diarrhea, muscle relaxation, and rheumatoid arthritis. This combination of health problems is a reflection of the day-to-day lifestyle of the villagers in both communities, who practice farming, which is associated with hard physical labor. Religious differences also contribute to the different appreciation of medicinal plants in the two villages. The Lawa believe in spirits being present everywhere and sickness is often seen as the result of having angered a spirit. So, they have traditional ceremonial practices to cure their patient by praying and using plants for the ceremony. In contrast, the Karen in the past – before becoming Christians – believed that different parts of the human body had different souls and if some of them were missing it would cause sickness which would then be cured with traditional plant medicine. The cultural importance of traditional medicinal plants and the physical isolation of communities, both in general and from primary healthcare, also influence the use of and knowledge of medicinal plants (Vandebroek et al., 2004).

3.3. Similarities between medicinal plant species and their FLs

Only 17 (JI value 16.5%) of the 103 medicinal plants species were shared between the Karen and Lawa villages (Table 6). However, even when the villages did use the same species, the pattern of use and application were often different. For example, the Karen used *Actinodaphine henryi* as a tonic with a FL value of 100%, whereas the Lawa used the same species to treat wounds with a FL value of 100%. Some species were used for the same purpose in the two communities, such as *Acacia concinna*, which the Karen used as a detergent for the skin with a FL value of 33% and to treat alcohol intoxication with a FL value of 66%, whereas

Table 4
Results of independent sample *t*-tests comparing the average total number of medicinal plants known by the two villages examined.

Number of medicinal plants known	Karen	Lawa
Mean	5.77	2.08
Variance	10.56	3.12
Hypothesized mean difference	0	
Degree of freedom	41	
T Stat	5.116	
P-value (Sig. 2-tailed)	0.000*	
t Critical	2.019	
Males only		
Mean	2.95	1.72
Variance	16.79	12.58
Hypothesized mean difference	0	
Degree of freedom	43	
T Stat	1.077	
P-value (Sig. 2-tailed)	0.280	
t Critical	2.016	
Females only		
Mean	4.37	1.90
Variance	21.63	10.94
Hypothesized mean difference	0	
Degree of freedom	42	
T Stat	2.084	
P-value (Sig. 2-tailed)	0.043*	
t Critical	2.018	

* $P < 0.05$.

Table 5
Cultural importance index (CI) of the 10 most important medicinal plant species in the two villages examined.

Karen	CI	Lawa	
Species		**Species**	**CI**
Costus speciosus var. *speciosus*	0.555	*Sambucus javanica*	0.281
Sambucus javanica	0.333	*Boehmeria malabarica*	0.093
Chromolaena odorata	0.305	*Acacia concinna*	0.062
Desmos sp.	0.222	*Sapindus rarak*	0.062
Buddleja asiatica	0.222	*Buddleja asiatica*	0.062
Callicarpa rubella	0.194	*Gmelina arborea*	0.062
Triadica cochinchinensis	0.138	*Solanum spirale*	0.062
Clausena lenis	0.138	*Morus alba*	0.062
Callicarpa arborea var. *arborea*	0.111	*Aglaia elliptica*	0.062
Terminalia chebula var. *chebula*	0.083	*Chromolaena odorata*	0.062

the Lawa used it as a detergent of the skin with a FL value of 100% (Table 6).

Low JI and differences in FL for the same species indicate unique medicinal plant knowledge in each of the two villages. This agrees with the studies by Anderson (1986a, 1986b), who found different medicinal plant species in two distinct ethnic groups: the Aka and Lahu in northern Thailand. In that study, 30 species (44%) of the medicinal plants used by the Lahu were not used by the Akha, and 95 species (79%) of medicinal plants used by the Akha were not used by the Lahu. Only 21 medicinal plant species were shared by the two groups even though they often live in the same region. Both groups migrated to Thailand within the past 100 years (Anderson, 1986a, 1986b), and little communication has occurred with regard to the treatment of disease and injuries. A study of the effects of geographical separation of the medicinal knowledge (Inta et al., 2008), showed that the Akha in Thailand and China used different medicinal plant species but maintained similar traditions of preparation and used the same plant parts. Similarly, the selection of plant species for medicinal use in two adjacent Amazonian societies overlapped only 18% (Shepard, 2004).

Table 6
The most important medicinal plant species used in both the Karen and the Lawa villages (Fidelity level).

Species	Ailments treated (% Fidelity level)	
	Karen	**Lawa**
Acacia concinna	Detergent for skin (33)	Detergent for skin (100)
	Alcohol intoxication (66)	–
Actinodaphine henryi	Tonic (100)	Wound (100)
Aglaia elliptica	Mount (oral cavity) (100)	Mount (oral cavity) (50)
	–	Diarrhea (50)
Alstonia scholaris	Fever (100)	Visually impaired (100)
Boehmeria malabarica	Wound (100)	Mount (oral cavity) (66)
	–	Muscle relaxation (33)
Buddleja asiatica	Burn (100)	Wound (50)
	–	Rashes, itching (50)
Celtis tetrandra	Pus (animal-cattle) (100)	Wound (lip) (100)
Chromolaena odorata	Coagulation of bleeding (90)	Coagulation of bleeding (100)
	Peptic ulcers (10)	–
Clerodendrum serratum	Rashes, itching	Burn (50)
	–	Muscle relaxant (50)
Costus speciosus	Urinary tract infection (33)	Lumbago (100)
	Wound (animal) (66)	–
Ficus carpillipes	Sore throat (100)	Wound (100)
Horsfieldia amygdalina var. *amygdalina*	Wound (100)	Tonic (100)
Leea indica	Diarrhea (50)	Diarrhea (100)
	Inflammation (50)	
Litsia monopetala	Dysmennorhea (50)	Wound (100)
	Fever (50)	–
Phoebe lanceolata	Smallpox (100)	Diarrhea (100)
Sambucus javanica	Wound (10)	Bloat (28)
	Muscle relaxant (30)	Bone fractures (14)
	Diarrhea (10)	Wound (14)
	Rheumatoid arthritis (50)	Inflammation (14)
	–	Edema (57)
Tarennoidea wallichii	Wound (100)	Rashes, itching (100)

The Fidelity level ranged from 1 (low) to 100 (high).

3.4. Ailments treated

In the Karen village, most medicinal plants were used for curing diarrhea and fever (12 species each), whereas among the Lawa, diarrhea and wounds (in humans) were treated with the highest number of medicinal plant species (8 species each) (Fig. 1). The ailments treated by medicinal plants in the two villages was significantly different ($P=0.003$; Table 7).

Diarrhea was a common ailment among both the Karen and the Lawa in this study, but this is also true in many other places in Southeast Asia, including India and West Bengal (Dey and De, 2012), Manipur state (Pfoze et al., 2012), Sumatra, Indonesia (Grosvenor et al., 1995), and Sudan in the Blue Nile State (Musa et al., 2011). Inhabitants of these regions likely have inadequate diet, poor hygiene, and are forced to use common ponds for drinking water, washing, and bathing, for both humans and cattle. These practices result in poor water quality and often lead to gastrointestinal problems (Collins et al., 2006). Similar conditions were also found in our study site; people from both villages drank water from forest streams without any antiseptics and used the same water for bathing, watering livestock, and sewage disposal in both communities.

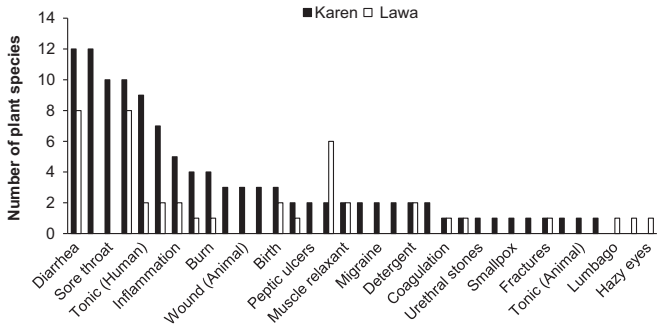

Fig. 1. Number of medicinal plant species used to treat 35 different health conditions in the two villages examined.

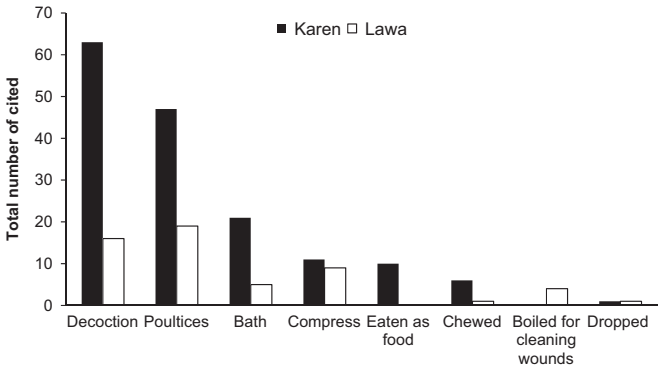

Fig. 2. Preparation methods for medicinal plants in the two villages examined.

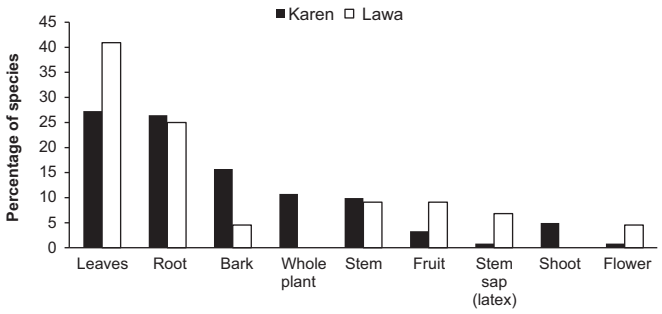

Fig. 3. The frequency of use of different plant parts for medicinal purposes in the two villages examined.

Table 7
Chi-square test of the differences between traditional medicinal plants in the two villages examined.

Category	Degree of freedom	χ^2-test	*P*-value
Method of preparation	6	21.65	0.001*
Plant part used	8	15.23	0.055
Ailments treated	35	61.11	0.003*
Habit	3	2.54	0.466
Route of administration	1	0.94	0.332

* $P < 0.05$.

3.5. Preparation of medicinal plants

The most common method of preparation of medicinal plants in the Karen village was decoction, which was used to prepare 63 of the species, whereas grinding the plants for poultices was the most common method in the Lawa village where this method was used for 19 species. The second most common mode of preparation in the Karen village was grinding the plants for poultices; this was done for 47 species and decoction was the second most common method of preparation in the Lawa village with 16 species. In addition, the Karen had the highest number of medicinal plants that were not prepared in any way before they were ingested ($n=6$), whereas the Lawa had only one species that was ingested without preparation. Only the Lawa boiled medicinal plants ($n=4$) to use the decoction for washing the patient (Fig. 2). The methods of preparation in the two villages were significantly different ($P=0.001$; Table 7).

Extraction of the medicinal plants in hot water is the most common way of preparing medicinal plants for use among most ethnic groups in northern Thailand (Anderson, 1993). The same method of preparing medicinal plants is common in many other regions, including West Bengal (Dey and De, 2012), Northeast India (Pfoze et al., 2012), and Sudan (Musa et al., 2011).

3.6. Plant parts used

Different parts of the medicinal plants were used to treat different ailments. Leaves were the most important plant part used in both villages. The Lawa used leaves from 40% of medicinal plant species, whereas the Karen used the leaves of 27% of the medicinal plants. The next most important plant part used was the roots, which the Karen used from 26% of the medicinal plants and the Lawa from 25% (Fig. 3). Flowers and stem sap (latex) were the least used parts in the Karen village (1% each). Among the Lawa, the least used plant parts were flowers and bark (4% and 5%, respectively). However, no significant differences were found between the plant parts used in the two villages ($P=0.055$; Table 7).

Several studies in northern Thailand have found similar results. Leaves are the most common (52–61%) plant part used to treat postpartum women among the Mien (Yao) in Nan province (Srithi et al., 2009; Panyaphu et al., 2011). The Akha in northern Thailand and China use the leaves of 54% of their medicinal plant species (Inta et al., 2008). The Kry in Lao use leaves for medicinal purposes more often (34%) than other plant parts during pregnancy, childbirth, and the postpartum period (Lamxay et al., 2011). Leaves are also the most commonly used plant part for medicine in India (30–42% of species) (Tetali et al., 2009; Pfoze et al., 2012). In Indonesia, the leaves are used from 59% of medicinal plants (Mahyar et al., 1991). The reason for these similarities may be that the leaves are more easily gathered than other plant parts (Tetali et al., 2009), or that leaves are the part that contains the highest concentrations of bioactive secondary compounds (Bhattarai et al., 2006). Because leaves grow continuously in tropical climates they may be the most easily accesible part of the plant (Pfoze et al., 2012). However, the roots were the second most preferred part in the two villages, possibly because they contain high levels of bioactive compound related to their function as a reservoir (Srithi et al., 2009). In contrast to harvesting the leaves, harvesting the roots is destructive to the individual plant and, therefore, less sustainable.

3.7. Routes of administration

Both groups used medicinal plants by applying them to the skin of the patients; the Lawa used 64% of the medicinal plants in this way and the Karen 56%. Medicinal plants were administered orally for 43% of the plant species in the Karen village and 36% in the Lawa village. The routes of administration for medicinal plants were not significantly different between the two villages ($P=0.332$; Table 7).

As we found in this study, grinding the plants for poultices or compresses and by water decoction for application on the skin seems to be a common practice among ethnic groups in northern

Thailand (Anderson, 1993) and elsewhere in Asia such as Lao PDR (Lamxay et al., 2011), Indonesia (Mahyar et al., 1991), and India (Pfoze et al., 2012).

3.8. Gender, age, and medicinal plant knowledge in the two cultures

Females in both villages knew more medicinal plants on average than the males knew. In this respect, we found a significant difference between the two villages because the Karen women knew more medicinal plants than the Lawa women (*t*-test, $P=0.043$), but we did not find significant differences between the males in the two villages (*t*-test, $P=0.280$; Table 4). The total number of medicinal plants known by informants in both villages was positively correlated with the informant's age, but the correlation was not significant (Karen, $P=0.521$; Lawa, $P=0.861$).

In general, women tend to know more medicinal plants than men (Panyaphu et al., 2011; Srithi et al., 2012a). Elsewhere, such as in Brazil (Almeida et al., 2012), women are responsible for the family's well-being by collecting and processing plant products for food, fuel, and medicine as demonstrated here.

4. Conclusions

Although both villages are located in the same region and under similar environmental conditions (i.e., isolation on steep mountains with sacred forest and swidden cultivation fields), and even if they had the same plant species in their environment, they still used different sets of medicinal plants and had different pattern of use of them. The Karen and Lawa villagers also used different numbers of medicinal plants, they considered different species culturally important, and had different Fidelity level (FL) values for each species in regards to the ailments treated and the method of preparation. The number of medicinal plants shared between the two villages was limited (16.5%). We assume that the different selection of medicinal plants in the two villages were driven by ethnicity and religious and cultural beliefs, as the two ethnic groups that inhabited the villages had differences in their cultural evolution and had experienced different historic events. Thus, we conclude that, even if a limited set of medicinal plant species with broad distribution is being used by a large number of ethnic groups, the way that the majority of medicinal plants are prepared and the health conditions to which they are applied are different.

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References

Almeida, C.F.C.B.R., Ramos, M.A., Silva, R.R.V., Melo, J.G., Medeiros, M.F.T., Araú, T.A.S., Almeida, A.L.S., Amorim, E.L.C., Alves, R.R.N., Albuquerque, U.P., 2012. Intracultural variation in the knowledge of medicinal plants in an urban-rural community in the Atlantic forest from northeastern Brazil. Evid. Based Complement. Altern.e Med. , http://dx.doi.org/10.1155/2012/679373.

Anderson, E.F., 1986a. Ethnobotany of hill tribes of northern Thailand I. Medicinal plant of Akha. Econ. Bot. 40, 38–53.

Anderson, E.F., 1986b. Ethnobotany of hill tribes of northern Thailand II. Lahu medicinal plants. Econ. Bot. 40, 442–450.

Anderson, E.F., 1993. Plant and People of the Golden Triangle: Ethnobotany of the Hill Tribe of the Northern Thailand. Whitman College and Desert Botanical Garden, Portland, Oregon.

Ayantunde, A.A., Briejer, M., Hiernaux, P., Udo, H.M.J., Tado, R., 2008. Botanical knowledge and its differentiation by age, gender, and ethnicity in southwestern Niger. Hum. Ecol. 36, 881–889.

Bennett, B.C., 1992. Plants and people of the Amazonian rainforests: the role of ethnobotany in sustainable development. BioScience 42, 599–607.

Bernstein, J.H., Ellen, R., Antaran, B.B., 1997. The use of plot surveys for the study of ethnobotanical knowledge: a Brunei Dusun example. J. Ethnobiol. 17, 69–96.

Bhattarai, S., Chaudhary, R.P., Taylor, R.S., 2006. Ethnomedicinal plants used by the people of Manang district, central Nepal. J. Ethnobiol. Ethnomed. 2, 41.

Bye Jr., R.A., 1986. Medicinal plants of the Sierra Madre: comparative study of Tarahumara and Mexican market plants. Econ. Bot. 40, 103–124.

Ceuterick, M., Vandebroek, I., Pieroni, A., 2011. Resilience of Andean urban ethnobotanies: a comparison of medicinal plant use among Bolivian and Peruvian migrants in the United Kingdom and in their countries of origin. J. Ethnopharmacol. 136, 27–54.

Collins, S., Martins, X., Mitchell, A., Teshome, A., Arnason, J.T., 2006. Quantitative ethnobotany of two east Timorese cultures. Econ. Bot. 60, 347–361.

Cook, F.E.M., 1995. Economic Botany Data Collection Standard. Royal Botanic Gardens, Kew, UK.

Dey, A., De, N., 2012. Ethnobotanical survey of Purulia district, West Bengal, India for medicinal plants used against gastrointestinal disorders. J. Ethnopharmacol. 143, 68–80.

Friedman, J., Yaniv, Z., Dafni, A., Palewitch, D., 1986. A preliminary classification of the healing potential of medicinal plants based on a rational analysis of an ethnopharmacological field survey among Bedouins in the Negev desert, Israel. J. Ethnopharmacol. 16, 275–287.

Fufuang, T., 2000. The History of Hill Tribes: Understanding of Different Cultures. Hill Tribes Research Institute, Chiang Mai, Thailand. (Unpublished results).

Grosvenor, P.W., Gothard, P.K., McWilliam, N.C., Supriono, A., Gray, D.O., 1995. Medicinal plants from Riau Province, Sumatra, Indonesia. Part 1: Uses. J. Ethnopharmacol. 45, 75–95.

Höft, M., Barik, S.K., Lykke, A.M., 1999. Quantitative Ethnobotany. Applications of Multivariate and Statistical Analysis in Ethnobotany. People Plant Working Paper, UNESCO, Paris.

Inta, A., Shengji, P., Balslev, H., Wangpakapattanawong, P., Trisonthi, C., 2008. A comparative study on medicinal plants used in Akha's traditional medicine in China and Thailand: cultural coherence or ecological divergence? J. Ethnopharmacol. 116, 508–517.

Joshi, A.R., Edington, J.M., 1990. The use of medicinal plants by two village communities in the central development region of Nepal. Econ. Bot. 44, 71–83.

Junsongduang, A., Balslev, H., Inta, A., Jampeetong, A., Wangpakapattanawong, P., 2013. Medicinal plants from swidden fallows and sacred forest of the Karen and the Lawa in Thailand. J. Ethnobiol. Ethnomed. 9, 14, http://dx.doi.org/10.1186/1746-4269-9-44.

Khamfachuea, K., 2008. Ethnobotany of the Karen at Ban Chan and Cheam Luang Sub districts, Mae Cheam District, Chiang Mai Province. M.Sc. Thesis (Biology). Chiang Mai University, Chiang Mai. (Unpublished).

Khamyong, S., Seramethakun, A., Naktippawan, C., 1999. Biodiversity Assessment of Natural Forest in the Mae Cheam Watershed, Chiang Mai Province, Thailand. Final Report: International Center of Research in Agroforestry (ICRAF), Chiang Mai, Thailand. (Unpublished).

Kirsch, S., 2001. Lost worlds. Curr. Anthropol. 42, 167–198.

Kunstadter, P., 1983. Animists, Buddhism, and Christianity: religion in the life of the Lue people of Pa Pae in northwestern Thailand. In: Mckinnon, J., Bhruksasri, W. (Eds.), Highlanders of Thailand. Oxford University Press, Kuala Lumpur, pp. 135–154.

Lamxay, V., Boer, H.J., Björk, L., 2011. Traditions and plant use during pregnancy, childbirth, and postpartum recovery by the Kry ethnic group in Lao PDR. J. Ethnobiol. Ethnomed. 7, 14.

Mahayotsanun, A., 1999. Food Crop Diversity and Utilization among Lawa in Nan Province. M.Sc. Thesis (Agricultural extension). Kasetsart University, Bangkok. (Unpublished).

Martin, G.J., 1995. Ethnobotany, A methods Manual.

Mahyar, U.W., Burley, J.S., Gyllenhaal, C., Soejarto, D.D., 1991. Medicinal plants of Seberida (Riau Province, Sumatra, Indonesia). J. Ethnopharmacol. 31, 217–237.

Mischung, R., 1995. The hill Tribes of Northern Thailand: current trends and problems of their integration into the modern Thai nation. In: Grabowsky, V. (Ed.), Regional and National Integration in Thailand, 1892–1992. Harrassowitz Verlag, Wiesbaden, Germany, pp. 94–104.

Musa, M.S., Fathelrhman, E.A., Elsheikh, E.A., Ahmed, L.A.M.N., Mahmoud, A.L.E.M., Yagi, S.M., 2011. Ethnobotanical study of medicinal plants in the Blue Nile state, southeastern Sudan. J. Med. Plants Res. 5, 4287–4297.

Ososki, A.L., Balick, M.J., Daly, D.C., 2007. Medicinal plants and cultural variation across dominican rural, urban, and transnational landscapes. In traveling cultures and plants. In: Pieroni IV, A. (Ed.), The Ethnobiology and Ethnopharmacy of Human Migrations. Berghahn Books, New York, pp. 14–39.

Panyaphu, K., On, T.V., Sirisa-ard, P., Srisanga, P., Kaow, S.C., Nathakamkitkul, S., 2011. Medicinal plants of the Mien (Yao) in northern Thailand and their potential value in the primary healthcare of postpartum women. J. Ethnopharmacol. 135, 226–237.

Pake, C.V., 1987. Medicinal ethnobotany of Hmong refugees in Thailand. J. Ethnobiol. 7, 13–26.
Pfoze, N.L., Kumar, Y., Myrboh, B., 2012. Survey and assessment of ethnomedicinal plants used in Senapati district of Manipur state, northeast India. Phytopharmacology 2, 285–311.
Pieroni, A., Vandebroek, I., 2007. Traveling Cultures and Plants. The Ethnobiology and Ethnopharmacy of Human Migrations. Berghahnbook, Oxford.
Pirker, H., Haselmair, R., Kuhn, E., Schunko, C., Vogl, C.R., 2012. Transformation of traditional knowledge of medicinal plants: the case of Tyroleans (Austria) who migrated to Australia, Brazil, and Peru. J. Ethnbobiol. Ethnomed. 8, 26.
Schippmann, U., Leaman, D.J., Cunningham, A.B., 2002. Impact of Cultivation and Gathering of Medicinal Plants on Biodiversity: Global Trends and Issues. FAO: Biodiversity and the Ecosystems Approach in Agriculture, Forestry and Fisheries, pp. 21.
Schmidt-Vogt, D., 1999. Swidden Farming and Fallow Vegetation in Northern Thailand. Franz Steiner Verlag, Stuttgart.
Setbubpha, K., Sookchaloem, D., 2009. Ethnobotany of Moo Soe Dam at Ban Huai Pla Lod, Dan Mae Lamao Subdistrict, Maesod District, Tak Province. Thai J. For. 28, 29–39.
Shepard Jr., G.H., 2004. A sensory ecology of medicinal plant therapy in two Amazonian societies. Am. Anthropol. 106, 252–266.
Siriphon, A., 2006. Local knowledge, dynamism, and the politics of struggle: a case study of the Hmong in northern Thailand. J. Southeast Asian Stud. 37, 65–81.
Srisanga, P., Wongpakam, S., Kamkuan, W., Pekthong, T., Tovaranonte, J., Yaso, T., Nontachaiyaphoom, S., 2011. Ethnobotany of Akha in Huay Yuak Pa So village, Mae Fah Luang district and Ban Mai Pattana village, Mae Suai district, Chiang Rai province. Thai J. Bot. 3, 93–114.
Srithi, K., Balslev, H., Wangpakapattanawong, P., Srisanga, P., Trisonthi, S., 2009. Medicinal plant knowledge and its erosion among the Mien (Yao) in northern Thailand. J. Ethnopharmacol. 123, 335–342.
Srithi, K., Trisonthi, C., Wangpakapattanawong, P., Balslev, H., 2012a. Medicinal plant used in Hmong women's healthcare in northern Thailand. J. Ethnopharmacol. 123, 335–342.
Srithi, K., Trisonthi, C., Wangpakapattanawong, P., Srisanga, P., Balslev, H., 2012b. Plant diversity in Hmong and Mien homegardens in northern Thailand. Econ. Bot. 66, 192–206.
Tangtragoon, T., 1998. Ethnobotany of Khamu, Lua, and H'tin in Some Areas of Nan Province. M.Sc. Thesis (Biology). Chiang Mai University. (Unpublished).
Tardío, J., Santayana, M.P., 2007. Cultural importance indices: a comparative analysis based on the useful wild plant of southern Cantabria (northern Spain). Econ. Bot. 62, 24–39.
Tetali, P., Waghchaure, C., Daswani, P.G., Antia, N.H., Birdi, T.J., 2009. Ethnobotanical survey of antidiarrhoeal plants of Parinche valley, Pune district, Maharashtra, India. J. Ethnopharmacol. 123, 229–236.
Thomas, D., Weyerhaeuser, H., Saipathong, P., Onpraphai, T., 2000. Negotiated land use patterns to meet local and societal needs. In: Jianchu, W., Wilkes, A., Tilmann, H., Salas, M., Grinter, T., Shaoting, Y. (Eds.), Links between Cultures and Biodiversity: Proceedings of the Cultures and Biodiversity Congress, 20–23 July 2000. Yunnan. Science and Technology Press, Yunnan, pp. 414–433.
Thomas, E., Vandebroek, I., Van Damme, P., 2007. What works in the field? A comparison of different interviewing methods in ethnobotany with special reference to the use of photographs. Econ. Bot. 61, 376–384.
Thongsorn, P., 2000. Ethnobotany of H'tin Minority in Dongpaya Subdistrict, Bo Klua District, Nan Province. M.Sc. Thesis (Biology). Chiang Mai University, Chaing Mai. (Unpublished).
Tribal Research Institute, 1992. Tribal Population Summary in Thailand. Tribal Research Institute, Chiang Mai, Thailand.
Vandebroek, I., Balick, M.J., 2012. Globalization and loss of plant knowledge: challenging the Paradigm. PLoS One, 7; . (e37643).
Vandebroek, I., Calewaert, J.B., De Jonckhneere, S., Sanca, S., Semo, L., Van Damme, P., Van Puyvelde, L., De Kimpe, N., 2004. Use of medicinal plants and pharmaceuticals by indigenous communities in the Bolivian Andes and Amazon. Bull. World Health Organiz. 82, 243–250.
Volpato, G., Godinez, D., Beyra, A., Barreto, A., 2009. Uses of medicinal plants by Haitian immigrants and their descendants in the Province of Camaguey, Cuba. J. Ethnobiol. Ethnomed. 5, 16.
World Health Organization (WHO), 2002. Traditional Medicine-Growing Needs and Potential-WHO Policy Perspectives on Medicines No. 002, p. 6.
Yasamutthorn, V., 1996. Pakinnaka of Chao Kao. Hill Tribes Research Institute, Chiang Mai, Thailand. (Unpublished).
Yaso, T., 2000. Ethnobotany of H'tin and Lua in Phuphaa subdistrict, Baugleua District, Nan Province. M.Sc. Thesis (Biology). Chiang Mai University. (Unpublished).
Yos, S., 2009. Biodiversity and Indigenous Knowledge for Sustainable Development. Biodiversity and Indigenous Knowledge Studies Center for Research and Anthropology Department, Faculty of Science, Chiang Mai University. Thailand.
Young, G., 1962. The Hill Tribes in Northern Thailand. Siam Society, Bangkok, Thailand, pp. 1–132. (Monograph no. 1).

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Contributed Paper

Woody Plant Diversity in Sacred Forests and Fallows in Chiang Mai, Thailand

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ABSTRACT

All woody plant and seedling diversity was compared in a Karen and a Lawa hill-tribe village in northern Thailand in four different habitats: sacred forests and fallow fields of three ages derived from rotational shifting cultivation (young fallows, 1–2 years old; medium-age fallow, 3-4 years old; old fallow, 5-6 years old). All woody plant species were identified and counted in three transects (20 x 40 m). Seedlings were inventoried in 12 circular (5 m diam.) plots. The highest species richness of all woody species and seedlings were found in the sacred forests in both villages. The highest values of the Shannon-Wiener index for both trees and seedlings were in the sacred forest of the Karen village. There were significant differences in species richness between the four studied habitats surrounding both villages ($p<0.05$). All woody plant and seedlings species compositions in the sacred forests of both villages were distinct from all the fallow plots as revealed by cluster analysis. Pearson's correlation test showed that only the Simpson diversity index was significantly and positively related to distances from the fallows to the sacred forest. The percentages of plants originating from sprouts were highest in the young fallow and decreased when the fallows aged in both villages, and vice versa for plants originated from seedlings. Furthermore, the sacred forest of both villages harbored endemic and threatened species in Thailand.

Keywords: Fallow; Karen; Lawa; Seedlings; Sprouts; Succession

1. INTRODUCTION

Since ancient times forests have been the fundament for people's existence, not only supporting their livelihoods, but also contributing to the maintenance of their culture. Forest resources are declining due to increasing human populations, rapid industrial growth, and increasingly intensive land use. Many regions of the world have been vigilant to preserve the natural resources. One of the ways of conserving forests is to maintain them

as sacred forests [1]. Sacred forests are often part of the cultures of indigenous people living in remote areas. Villagers respect the sacred forests with their traditional beliefs that include nature worshiping in ceremonies inherited from their ancestors [2]. These sacred forests have been preserved as a part of the natural environment for many reasons and they are usually informally managed by local cultural traditions without intervention from the government [3]. Many studies show that sacred forests have become well-preserved areas with higher biological diversity than degraded surrounding environments. This is true in many parts of the world such as Africa [4], China [5], India [6], Indonesia [7], Israel [8], and Vietnam [9]. Recently, sacred forests were listed as one of the six protected categories recognized by the International Union for Conservation of Nature [10].

Sacred forests are found throughout Thailand and they differ in types and sizes, ranging from a single tree to forests covering entire mountains [11]. Sacred forests are more common in the northern regions than in the rest of Thailand [12]. These forests are often found around hill-tribe communities such as those of the Karen, the Hmong, the Lisu, the Lawa and the Tai lue [13]. Local norms, laws and customs usually limit human activity in these forests. Hunting, grazing and logging may be prohibited or restricted and villagers take care not to damage them.

In northern Thailand, shifting cultivation is still performed, particularly in the upland areas and it is considered to be a major driver of deforestation in those regions [14]. This land use is also wide-spread in other parts of Southeast Asia [15]. Fallow forests, generated by shifting cultivation, therefore cover over 5% of the highlands of northern Thailand [16]. After cultivation the land is abandoned and left to recover without any further use for 5–15 years, after which the farmers return to cultivate the land again. The recruitment of pioneer species and the ecological succession on abandoned lands after shifting cultivation is affected by several factors including the seed bank, seed rain [17], survival and growth of seedlings [18], light conditions [19], and various forms of soil disturbance [20]. Seeds and sprouts are the two main sources of regeneration depending on type of disturbance and age of fallow [21]. Sprouts are important in sites that were manually cleared under shifting cultivation [22]. If the roots and stumps are not destroyed by intensive site preparation or burning, then pioneers and vegetative sprouts are quick to colonize and occupy the land after abandonment [23]. Several studies found the number of sprouts and stems that produce sprouts is reduced with advancement of succession [24–25]. Simultaneously, the the number of plants that grow from seeds increase with fallow age [26]. Furthermore, seed dispersal accelerates with forest recovery [27]. In general, succession of the pioneer vegetation that follows the abandonment of cultivation is rapid in the early stages of regeneration, followed by delayed recovery of woody biomass [28]. There have been many studies of the recovery process and fallow vegetation on rotational shifting cultivation fields in Southeast Asia including studies in Thailand [14, 16, 29], Myanmar [23], Laos [30], and Vietnam [31]. From these studies we know, that even if the first stage of the ecological succession can be successful in terms of seedlings achieving high survival rate and fast growth, the success of the later stages depends to a large extent on seedling recruitment by various means. Furthermore, the distance to intact primary forest affects the seed availability to abandoned tropical forest plots after farming [26]. There have been only a few studies of the floristic diversity of sacred forests in Thailand and little is known about how sacred forests function in these fragmented landscapes. Sponsel et al.

[1, 11] studied social and management aspects and they pointed to the need of biodiversity studies of plants from these forests. The only known study of vegetation diversity is from a Hmong sacred forest in Chiang Mai [32]. Which showed that the ground flora and tree diversity in natural (sacred) forest were higher than in restoration areas. In this study tree species in natural forest (sacred forest) and seedlings in planting plots were compared, and we demonstrate that most seedling in sacred forest and planting plots were the same species.

Empirical evidence of the ecological benefits of sacred forest is very scarce. Here, we examined the impact that sacred forest has on the ecological succession of woody plant species and seedling during the fallow period of rotational shifting cultivation. Our specific objectives were: 1) To assess plant diversity, species composition and similarities between sacred forests and fallow fields in various stages of secondary succession. 2) To assess the role that sacred forests play as sources of seeds for the regeneration of fallow fields near them. 3) To determine the relation between diversity indices of the fallow fields in different ages and distance to sacred forest.

2. MATERIALS AND METHODS

2.1 Study Sites

The study was done in two villages in the Mae Cheam watershed in Chiang Mai province in northern Thailand where the landscape is a mosaic of sacred forest, fields that are cultivated for short periods, and fallows that may be up to six years old. The Mae Cheam watershed covers about 4000 km^2 [59] and Mae Cheam river is a tributary of the Ping river which is one of the four main rivers in northern Thailand (Figure 1). The highlands of northern Thailand are composed of landscape complexes featuring steep mountains with slopes >35% interspersed with small narrow valleys. The soils on the upper, middle, and

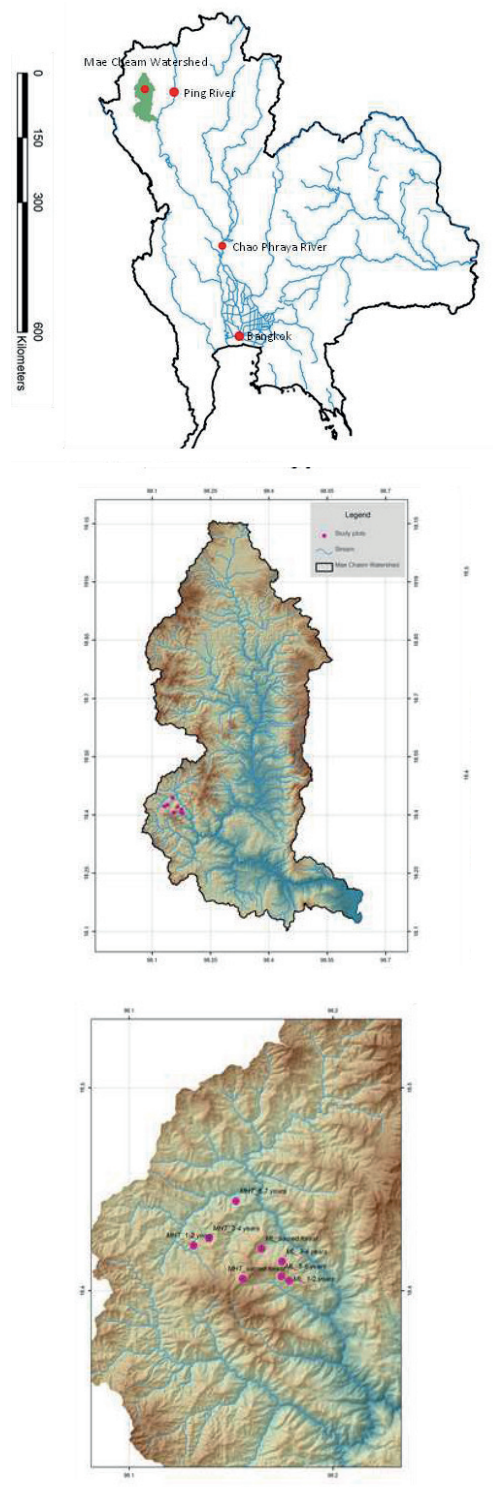


Figure 1. Map of Thailand excluding southern Thailand, showing the location of Mae Cheam watershed and the study sites; MHT= Mae Hae Tai, ML= Mude Lhong [52].

lower slopes have different moisture regimes which is reflected in different plant communities. Politically the watershed covers most of Mae Cheam district in Chiang Mai province. It is known for its forest biodiversity including a variety of vegetation types and plant species. Many different land use systems have been practiced in this watershed including human communities, paddy fields in the valleys, permanent agriculture on slopping areas, shifting cultivation, different stages of forest succession, forest plantation and primary forest or protected forest.

Two villages were selected for this study, the Christian Karen village, Mae Hae Tai and the Animist-Buddhist Lawa village, Mude Lhong (Table 1, Figure 2). In the sacred forests of both communities, the villagers are only allowed to extract minor forest products in quantities agreeable to the village committees. For the Karen in Mae Hae Tai village, one of many natural worshiping done by the villagers involves forest or tree ordination ceremonies every two or three years in the sacred forest. The villagers cover the trees with fabric of different colors. That means that regulations limit their use of the forest, forbidding cutting of trees or killing of any wildlife within it. The Lawa in Mude Lhong village are now Animist-Buddhists. Generally, animists believe that every living things on earth, both animals and plants, possess a soul. The Lawa are usually seen as more deeply involved with spirits than other ethnic group in the northern Thailand highlands. Every year, in the beginning of each season the Lawa have payment ceremony to the spirits for their good health and good products. They believe in spirits, such as ancestral spirits, house spirits, field spirits, and spirit of various localities, especially forest spirit, which demand worshiping. Further details about the study site and conditions can be found in [29].

Table 1. Base line information and study plots location in the two villages.

	Mae Hae Tai - Karen village (Sampling plots)				**Total areas of swidden fallow fields (ha)/ Percentage of total areas of fallow fields of total areas of the village (%)**	**Total areas of sacred forest (ha)/ Percentage of total areas of sacred forest of total areas of the village (%)**
	1-2 years fallow	3-4 years fallow	6-7 years fallow	Sacred forest		
Aspect	Southeast	East	South	North	540/63	325/34
Elevation (m)	1,066	1,112	1,104	1,342		
Location co-ordinates	N 18° 25' 20.22" E 98° 7' 53.91"	N 18° 25' 32.77" E 98° 8' 21.20"	N 18° 26' 38.83" E 98° 9' 8.65"	N 18° 24' 21.4" E 98° 9' 20.5"		
Distance from the sacred forest (km)	1.95	2.12	4.36	-		
	Mude Lhong- Lawa village (Sampling plots)				**Total areas of swidden fallow fields (ha)/ Percentage of total areas of fallow fields of total areas of the village (%)**	**Total areas of sacred forest (ha)/ Percentage of total areas of sacred forest of total areas of the village (%)**
	1-2 years fallow	3-4 years fallow	6-7 years fallow	Sacred forest		
Aspect	South	East	South	Northeast	590/63	330/43
Elevation (m)	1,040	1,063	1,093	950		
Location co-ordinates	N 18'24'17.6" E 98'10'43.2"	N 18'24'51.9" E 98'10'30.3"	N 18'24'25.6" E 98'10'29.0"	N 18'25'14.6" E 98'09'54.1"		
Distance from the sacred forest (km)	2.26	1.27	1.82	-		

Figure 2. Landscape of the stydy sites; A= Mae Hae Tai, the Karen village; B= Mude Lhong, the Lawa village

2.2 Sampling of Field Data

Field sampling was done in the two villages between October, 2009, and December, 2010. The area belonging to each village was divided into fallow I (1–2 years), fallow II (3–4 years), fallow III (5–6 year), and sacred forest. Around each village, and in each habitat type (Fallow I, II, III and sacred forest) we placed one 20x40 m (=800m^2) plot parallel to the contour lines in each of three slope positions (lower, middle, upper slope) giving a total of 24 plots that together covered 1.92 hectares. The geographic locations of the plots were determined with a GPS in order to calculate distances between plots. To facilitate data-recording in the field, each 20x40m plot was subdivided into 8 subplots of 10x10m. The definitions of the vegetation types in this study are given in Table 2. Trees were measured in order to calculate total basal area, which was used to calculate the importance value index (IVI), along with density and frequency. For seedlings, 12 circular plots 5 m in diameter were placed at the corner of each subplot. Species richness and plant numbers were recorded for the seedlings. For each seedling we excavated the soil around its base to 10 cm depth to determine whether it was an independent genet derived from a seed or if it was had sprouted from another individual (Figure 3).

Table 2. Definition of plants in this study

Categories (References)	Definitions		Note
	DBH	Tall	
Tree species [24]	>10 cm	> 1.3 m	-
Saplings [53]	< 5 cm	> 1-1.3 m	-
Seedlings [25, 27]	< 2 cm	< 1m	Growing from seeds
Sprouts [25, 27]	< 2 cm	< 1m	Regenerated from coppicing, stem or root
All woody plants species [53]	-	-	Tree + Sapling + Seedling
Mature/ mother woody species [53]	-	-	Woody species that there have own fruits or flowers

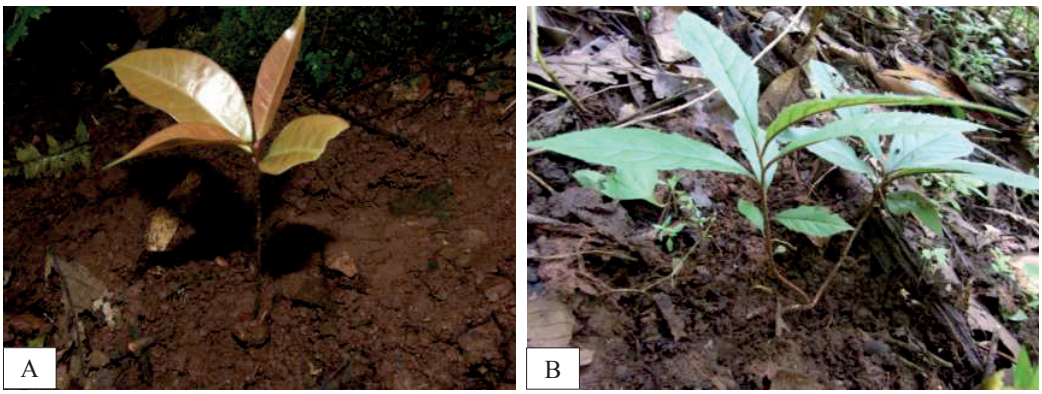


Figure 3. Example of seedling and sprout in study sites; A= Seedling of Apodytes dimidiate., B= Sprouts of Antidesma sootepensis.

2.3 Dispersal Mode

Dispersal mode of each species was assessed by questioning the villagers, visually examining the diaspores, and reviewing existing literature.

2.4 Plant Identification

Specimens of all species were taxonomically identified using taxonomic literature [33] and cross checking with specimens in the Queen Sirikit Botanic Garden Herbarium (QSBG), Chiang Mai, Thailand.

2.5 Data Analyses

Species diversity of all woody plants and seedlings was calculated using the Shannon-Wiener index of diversity, Shannon's evenness index and Simpson's index of diversity . Shannon-Wiener index is an information statistic index [34], it was calculated in order to know the species diversity in different habitat based on the abundance of the species, which means it assumes all species are represented in a sample and that they are randomly sampled by the following formula:

$$H' = -\sum_{i-1}^{S} p_i \ (ln\ pi)$$

Simpson's Index (D) is a dominance index giving more weight to common or dominant species. This index calculates the probability that two organisms sampled from a community will belong to different species (the more even the abundance of individuals across species, the higher the probability that the two individuals sampled will belong to different species). Simpson's Index values range from 0 to 1, with 1 representing perfect evenness (all species present in equal numbers) [35]. It has been measured by the given formula:

$$D = 1\text{-}\{\sum n_i(n_i - 1)\,|N(N-1)\}$$

Where as; H' = Shannon-Wiener Diversity Index , D= Simpson's Index, p_i = relative abundance of species " i " ($p_i = \frac{n_i}{N}$), n_i = number of individuals of species " i ", N = total number of individuals of all species, S = total number of species

Shannon's evenness index [34] is a measure of the relative abundance of different species making up the richness of an area. This evenness is an important component of diversity indices and expresses evenly distribution of the individuals among different species. It has been measured by the given formula:

$$E_H = H/H_{max}; = H/ln\ S$$

Where as; E_H = Shannon's evenness index, H= Shannon-Wiener Diversity Index

The relative ecological importance of each tree species was expressed using the Importance Value Index (IVI) [36].

IVI of a species is defined as the sum of its relative dominance, its relative density and its relative frequency, and was calculated as follows:

IVI= RDo +RD+RF

Where as; RDo= Relative dominance, RD= Relative density, RF= Relative frequency.

Rdo = (total basal area of a species/total basal area of all species) x 100

RD = (number of individuals of a species /total number of individuals) x 100

RF = (frequency of a species/sum frequency of all species) x 100

For seedlings we used the Species Importance Value (SIV) [37] to identify the most important seedling species. SIV of a species is defined as the sum of its relative density and its relative frequency:

SIV= RD+RF

One-way ANOVA (multiple comparisons) was used to examine differences in species richness of all woody plants and seedlings at each village and site using SPSS software

(version 17). Pearson's correlation test was used to examine relationships between ecological parameters and distances from the sacred forests to fallows of different ages. PC-ORD (version 5) program [38] was used to determine similarities and species groupings at all the sites. Each species in each plots in the two villages was grouped according to the similarity of presence/absence data by cluster analysis.

3. RESULTS

3.1 Species Richness and Diversity

For all woody plant as well as for seedlings separately, species richness in both villages increased with the age of the fallow plots and were highest in the sacred forests; all woody plant together were represented by more species than the seedlings alone in all plot (Table 3). Basal area of trees also increased with fallow age and topped in the sacred forests. Densities of all woody plant, seedlings (mean±S.D.) and of tree (stem/ha) varied less consistently but tended to fall with fallow age in both villages but with the sacred forests showing opposite patterns in this respects (Table 3). In general both the Shannon-Wiener and the Simpson's diversity indices increased with increasing age of the fallows and culminated in the sacred forests with values of 3.9 and 3.2 for the all woody plants and 3.6 and 3.0 for the seedlings. The 3–4 years old fallow around the Lawa village did not fit the pattern having higher values than the other Lawa habitats. The Shannon evenness index varied less dramatically but tended to increase with age of the habitat around the Karen village and reamain more constant with age of habitat around the Lawa village (Table 3). The one-way ANOVA test of species richness of both all woody plant species and seedlings separately were significantly different among the sampling sites in both villages (Table 4). Different tree

Table 3. Species diversity and evenness of woody plant and seedling (number in parentheses) species in fallow fields of different age and sacred forest around two villages in the Mae Cheam watershed.

	Karen village (Mae Hae Tai)				Lawa village (Mude Lhong)			
	1–2 years	3-4 years	5-6 years	Sacred forest	1-2 years	3-4 years	5-6 years	Sacred forest
All woody plants								
Number of plots	3	3	3	3	3	3	3	3
Areas (m2)	2400	2400	2400	2400	2400	2400	2400	2400
Number of species	60	72	89	136	62	100	103	141
Density (m-2) (mean ± S.D.)	0.74±1.57	0.39±0.91	0.18±0.31	0.14±0.28	0.46±1.89	0.26±0.48	0.26±0.77	0.43±1.38
Density of trees (stems/ha)	25	379	1200	1258	25	629	1854	766
Total basal area of trees (m2/ha)	0.79	0.95	12.04	21.58	1.12	1.54	15.12	28.20
Shannon-Wiener diversity	2.74	2.95	3.63	3.94	2.17	3.65	3.29	3.32
Simpson diversity	0.90	0.91	0.95	0.96	0.71	0.95	0.90	0.92
Shannon Evenness	0.32	0.37	0.80	0.80	0.52	0.79	0.70	0.67
Seedlings								
Number of plots	12	12	12	12	12	12	12	12
Areas (m2)	943	943	943	943	943	943	943	943
Number of species	49	57	64	66	35	48	37	62
Density (m-2) (mean ± S.D.)	0.92±1.88	0.98±1.88	0.54±0.83	0.24±0.32	0.28±0.05	0.30±0.44	0.33±0.51	0.58±1.35
Density of seedlings (stems/ha)	9480	11664	7242	3329	2311	3075	2545	7507
Shannon-Wiener diversity	2.76	3.07	3.41	3.57	2.48	3.21	2.90	3.00
Simpson diversity	0.89	0.91	0.94	0.96	0.88	0.93	0.90	0.90
Shannon Evenness	0.71	0.75	0.81	0.85	0.69	0.82	0.80	0.70

Table 4. One-way ANOVA test of species richness for all woody plant and seedlings separately in the two villages.

Sources	DF	Sum of Squares	Mean Squares	F- ratio	F- probability
Karen village					
All woody plants					
Between group	3	2060.865	686.955	27.607	0.000*
Within group	92	2289.296	24.884		
Total	95	4350.156			
Seedlings					
Between group	3	468.167	156.056	3.413	0.025*
Within group	44	2011.833	45.723		
Total	47	2480.000			
Lawa village					
All woody plants -					
Between group	3	4104.375	1368.125	45.272	0.000*
Within group	92	2780.250	30.220		
Total	95	6884.625			
Seedlings					
Between group	3	948.083	316.028	38.715	0.000*
Within group	44	359.167	8.163		
Total	47	1307.250			

Table 5. Relative Importance Value Indices (IVI, %) and dispersal mode (in parentheses) of the dominant tree species in the sacred forests and the fallows of the Karen and the Lawa villages. For each species is dispersal agent is indicated (An=Ant, Bd=Barking deer, Bi= Bird, Co=Cow, Fl=Flying lemur, Hu=Human, Ra=Rat, Ru=Ruminant, Wi=Wind, Wp=Wild pig, Sq= Squirrel, (-) =No data).

Trees dbh > 10 cm								
	1–2-years fallow	**IVI**	**3–4-years fallow**	**IVI**	**5–6-years fallow**	**IVI**	**Sacred forest**	**IVI**
	Flueggea virosa (-)	18.1	*Lithocarpus polystachyus* (Bi,Wp,Hu,Ra)	21.4	*Lithocarpus polystachyus* (Bi,Wp,Hu,Ra)	18.0	*Lithocarpus mekongensis* (Wp)	13.5
The Karen village	*Eugenia cumini* var. *cumini* (Hu,Bi,Ra,Sq)	15.2	*Aporosa villosa* (Hu)	20.9	*Gluta usitata* (-)	6.1	*Castanopsis diversifolia* (Hu,Sq)	10.4
	Albizia odoratissima (Wi)	7.8	*Schima wallichii* (Bi,Wi,Fl)	20.5	*Tristaniopsis burmanica var. rufescens* (Wi)	6.0	*Calophyllum polyanthum* (-)	10.2
	-	-	*Lithocarpus elegans* (Sq,Hu,Wp)	12.4	*Shorea roxburghii* (Wi)	5.9	*Mitrephora vandaeflora* (-)	4.2
	-	-	*Callicarpa arborea* (Bi)	6.8	*Aporosa villosa* (H)	5.7	*Lithocarpus polystachyus* (Bi,Wp,Hu,Ra)	3.6
	1–2-years fallow	**IVI**	**3–4-years fallow**	**IVI**	**5–6-years fallow**	**IVI**	**Sacred forest**	**IVI**
	Gmelina arborea (Bi,Bd,Hu,Co)	27.8	*Diospyros glandulosa* (Ru)	29.6	*Quercus kerrii* (Hu, Sq)	11.3	*Schima wallichii* (Bi,Wi,Fl)	6.9
	Dalbergia cultrata (Wi)	25.3	*Castanopsis calathiformis*	9.5	*Dalbergia rimosa* (Wi,Sq)	9.0	*Aphananthe aspera* (An)	5.8
The Lawa village	*Lagerstroemia undulata var. subangulata* (Wi)	24.0	*Quercus kerrii* (Hu,Sq)	9.3	*Kydia calycina* (Wi)	7.9	*Alangium kurzii* (Hu, Bi)	5.4
	Phyllanthus emblica (Hu,Bd)	11.4	*Glochidion sphaerogynum* (Wp,Hu)	7.4	*Phyllanthus emblica* (Hu,Bd)	6.3	*Engelhardia spicata* (Wi)	4.7
	Diospyros coaetanea (Co,Hu)	11.2	*Schima wallichii* (Wi)	7.1	*Dalbergia cultrata* (Wi)	5.1	*Protium serratum* (Hu,Sq,Wp,Bi)	4.4

species were dominant at the different sites (Tables 5). *Flueggea virosa* had the highest IVI in the Karen 1–2 years fallow, while in the Lawa village, *Gmelina arborea* had the highest ranking. In the other Karen sampling sites, members of Fagaceae had the highest IVI values, for example, *Lithocarpus mekongensis* in the sacred forest, and *L. polystachyus* in the 3-4 years and the 5-6 years fallows. In contrast, in the Lawa village, there were different dominant tree species in the different aged fallows and forest, for example *Schima wallichii* in the sacred forest, *Quercus kerrii* in the 5–6-years fallow and *Diospyros glandulosa* in the 3-years fallow. Furthermore, some species that are endemic and threatened in Thailand were found in both sacred forests *Antidesma bunius* var. *bunius, Archidendron clypearia, Kopsia arborea, Ilex umbellulata,* and *Ostodes paniculata.*

3.2 Species Composition of Seedlings

The species compositions of seedlings were different in each of the plots. The SIV (%) ranking of the species in the sacred forest of the Karen village was topped by *Kopsia arborea*, while in the Lawa village *Combretum latifolium had the highest score*. In the fallows of different ages, different species had the highest SIV (%). For example, in the Karen village, it was *Kydia calycina* in the 5–6 years fallow, *Aporosa villosa* in the 3–4 years fallow and *Helicteres isora* in the 1-2 years fallow. In the Lawa village, it was *A. villosa* in the 5–6 years fallow, *A. octandra* var. *octandra* in the 3–4 years fallow and *Diospyros coaetanea* in the 1–2 years fallow (Table 6).

Table 6. Relative Seedling Importance Value Indices (SIV, %) and dispersal mode (in parentheses) of the dominant seedlings in the sacred forests and the fallows of the Karen and the Lawa villages (An=Ant, Bd=Barking deer, Bi= Bird, Co=Cow, Fl=Flying lemur, Hu=Human, Ra=Rat, Ru=Ruminant, Wi=Wind, Wp=Wild pig, Sq= Squirrel, (-) =No data).

	1-2 years fallow	SIV	3-4 years fallow	SIV	5-6 years fallow	SIV	Sacred forest	SIV
The Karen village	*Helicteres isora* (-)	26.9	*Aporosa villosa* (Hu,Bi)	24.6	*Kydia calycina* (-)	16.9	*Kopsia arborea* (Hu,Wi)	18.1
	Cratoxylum formosum ssp. *pruniflorum* (Hu,An)	21.6	*Clausena lenis* (-)	20.2	*Olea salicifolia* (-)	14.5	*Lithocarpus mekongensis* (Wp)	13.1
	Ficus semicordata (Bi,Hu,Sq,Wp,Bd,R)	14.7	*Fluggea virosa* (-)	12.2	*Lithocarpus polystachyus* (Bi,Wp,Hu,Ra)	10.2	*Cinnamomum iners* (Hu)	12.2
	Aporosa villosa (Hu,Bi)	14.5	*Aporosa octandra var. octandra*	12.1	*Styrax benzoides* (Bi,Sq)	9.9	*Quercus kingianus* (Wp)	11.8
	Solanum torvum (Hu)	12.8	*Helicteres elongata* (Hu,Wp)	11.1	*Dalbergia cultrata* (Wi)	9.6	*Wendlandia tinctoria* (Bi,Wi)	10.7

	1-2 years fallow	SIV	3-4 years fallow	SIV	5-6 years fallow	SIV	Sacred forest	SIV
The Lawa village	*Diospyros coaetanea* (Co,Hu)	45.0	*Aporosa octandra var. octandra* (-)	23.6	*Aporosa villosa* (Hu,Bi)	33.9	*Combretum latifolium* (Wi)	34.3
	Helicteres elongata (Hu,Wp)	16.0	*Aporosa villosa* (Hu,Bi)	18.7	*Antidesma sootepense* (Hu,Bi,Rab,)	20.5	*Siphonodon celastrineus* (-)	22.1
	Antidesma sootepense (Hu,Bi,Rab,)	12.9	*Helicteres elongata* (Hu)	16.1	*Kydia calycina* (-)	12.7	*Cinnamomum iners* (Hu)	12.6
	Cratoxylum formosum ssp. *pruniflorum* (Hu,An)	11.5	*Macaranga denticulata* (Bi,Ra,Hu)	9.8	*Theapesia lampas var. lampas* (-)	11.8	*Clerodendrum disparifolium* (-)	8.7
	Lagerstroemia undulata var. subangulata (Wi)	10.0	*Dalbergia cultrata* (Wi)	9.7	*Helicteres elongata* (Hu,Wi,Wp)	10.3	*Engelhardia spicata var. spicata* (Wi)	6.3

3.4 Plant Regeneration in Fallows

The relative proportion of seedling species gradually increased with the age of the fallow in both villages. Concomitantly, the relative proportion of the sprouts decreased with increasing age of the fallows (Figure 4). Furthermore, we also compared similarity of seedling and mature woody species among the fallow plots and the sacred forests. The highest proportion of seedlings species as well as mature tree species from the sacred forest was found in the older fallows (5–6 years and 3–4 years) of the Karen village. Meanwhile, the highest percentage of total number of seedlings species as well as mature tree species within fallow plots was found in the same age class but different village (Figure 5). The lowest proportion of seedlings species as well as mature tree species in sacred forest was found in 3-4 years fallow followed by 5-6 years fallow in the Lawa village.

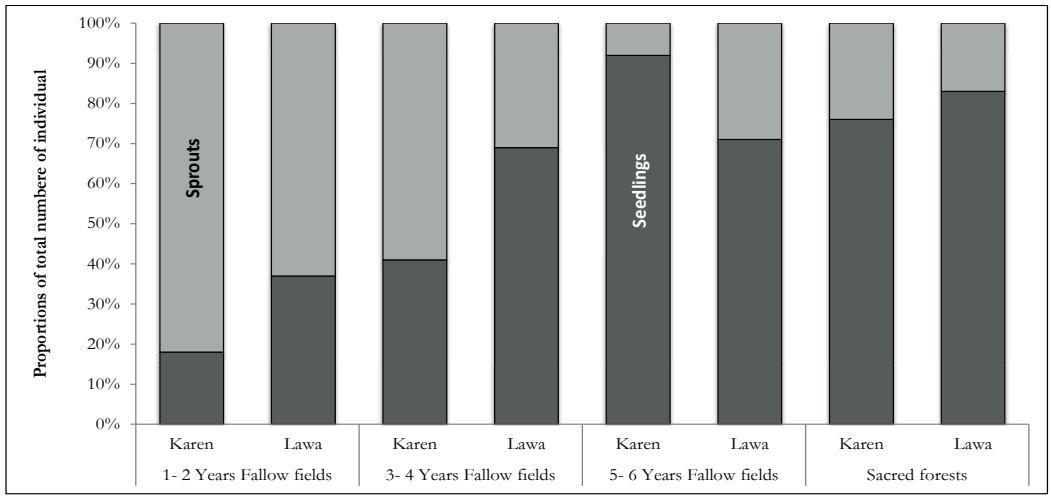


Figure 4. Proportions of total number of individuals of seedlings and sprouts in the Karen and Lawa villages.

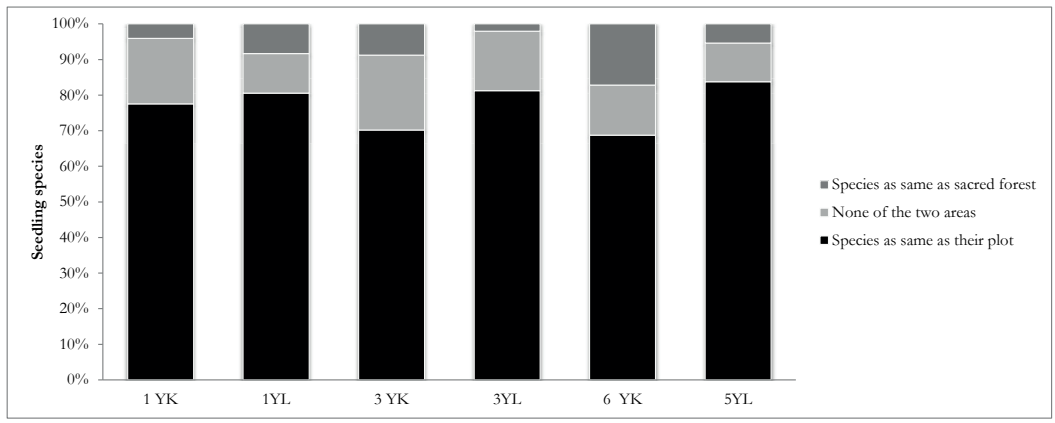


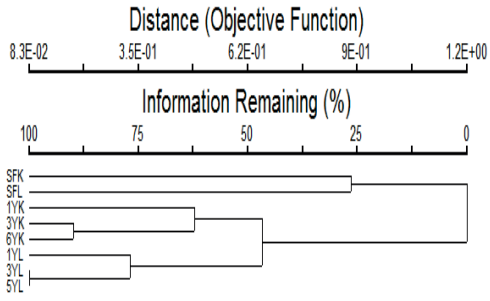
Figure 5. Percentages of seedlings species and mother tree species within their plot and in the sacred forest in two villages (1-2YK=1-2 years fallow plot of Karen, 1-2 YL=1-years fallow plot of Lawa, 3-4YK=3-4 years fallow plot of Karen, 3-4YL=3-4 years fallow plot of Lawa , 5-6YK=5-6 years fallow plot of Karen, 5-6YL=5-6 years fallow plot of Lawa).

3.5 Diversity and Distance from the Sacred Forest

Pearson's correlation test was used to examine the relationship between ecological parameters such as species richness, Shannon-Wiener diversity index, Simpson's diversity index and Evenness index and distances between the sacred forest and the fallow plots. For all woody plants, there was only a significant positive linear relationship between distances and Simpson's diversity index at 99% ($P<0.05$) in the Karen village while, in the Lawa village, there were no relationship with all the parameters. For seedlings, there was no statistically significant relationship between distances from sacred forests and fallow plots in all sampling sites in the two villages ($P>0.05$).

3.6 Cluster Analysis

All woody plants and seedlings species in all the sampling sites in both villages were separated into two groups corresponding to sacred forest and fallow fields according to the presence-absence data for each species (Figure 6). Within the fallow fields, the groupings were also separated into two groups reflecting the differences of species in each village (Figure 6).



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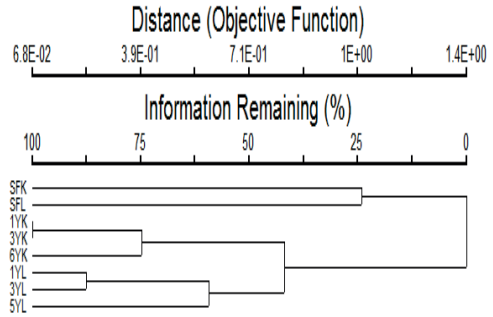

B

Figure 6. Cluster analysis of; all woody plants species (A) and of only seedlings (B) in all sampling sites of the Karen and the Lawa villages (1YK=1-2 years fallow of Karen, 1YL=1-2 years fallow of Lawa, 3YK=3-4 years fallow of Karen, 3YL=3-4 years fallow of Lawa , 6YK=5-6 years fallow of Karen, 5YL=5-6 years fallow of Lawa, SFK= Sacred forest of Karen, SFL= Sacred forest of Lawa).

4. DISCUSSION

4.1 Species Richness of all Woody Plant Species and Seedlings in Sacred Forests and Fallow Fields

The highest species richness and the highest measures of the ecological diversity indices of all woody plants and seedlings were found in the sacred forest in both villages. The density of all woody plants and seedling species of Karen village were highest in the young fallow plots. These results agree with the many studies of sacred forests in India that sacred forests had higher plant diversity than surrounding areas [39-40]. The higher species richness and diversity in the Karen sacred forests might be explained by the fact that these forests have been protected more strongly by villagers compared to the Lawa village. The villagers are not allowed to disturb by logging but they can extract minor forest products from the sacred forests. The

species compositions of the sacred forests in two villages were different from the fallows surrounding them. These results were confirmed by cluster analysis and statistical tests. The species compositions in the fallow plots in the two villages were different among sampling sites. We can see these results expressed as IVI and SIV rankings in each plot. The differences in vegetation in the same year or same fallow periods in early successional stages were caused by variations in environmental factors such as site condition, seed dispersal, germination and predation [41]. Furthermore, human over-exploitation based on ethnobotanical knowledge for food, medicine, fuel, and construction material also affected the variation of vegetation. Additionally, the forest that grows back from the original vegetation was in many sites qualitatively and quantitatively different after major disturbance [42] and in some cases the species composition of secondary forests may not develop towards that of the primary forests [40]. One important reason for the differences of woody plant species and seedling species composition in our study may be the fact that the majority of species in fallow plots are pioneer species of early successional stages, including species as Aporosa villosa, Clausena lenis, Diospyros coaetanea, Wendlandia tinctoria, and Schima wallichii, that are all species that can only germinate under full sunlight [43]. The species in both sacred forests in our study are evergreen forest species such as Kopsia arborea, Cinnamomum iners, Lithocarpus mekongensis [33]. These results are similar to the situation in the sacred groves of Jaintia Hills in northeast India which have a large number of evergreen species [39]. Our results also agree with the situation in uncultivated forest stands, where Castanopsis acuminatissima and other Fagaceae were the dominant while Schima wallichii was the most dominant species in succession of secondary forest. Many species were absent in fallow plots but present in sacred forests. This may be the result of history and human use such as food resources, structure plants and also medicinal purpose were affected on species richness and plant diversity in the sacred forests and the fallows fields. The villagers usually cut and burn vegetation in fallow fields before growing rice and sometime they have left some trees in their field especially in 1 year fallow fields because some trees were either too thick or their wood is too big for cutting. The presence or absence patterns suggest that some species can cope with the environment such as fire or shade tolerance species. However, the adaptation of plant species in the areas was considered in this case. This phenomenon can explain that, when seedlings are established during the fallow periods, the ecosystem conditions at that time will determine seedlings survival. Furthermore, we also found higher species richness and values of diversity indices than what was found in a previous study at the same site [29] in a study of regeneration of secondary forest through several successional stages but with younger ages of the fallow fields. These results are similar to what was found in the swidden farming and fallow vegetation in northern Thailand where vegetation change induced by shifting cultivation is a highly diversified process [14]. The different shifting cultivation techniques and the variation in length of cultivation- and fallow periods, cause a strongly differentiating influence on the process of secondary succession and the composition and structure of secondary vegetation on fallow swidden. The ages of old fields significantly affect trees species richness and composition along a chronosequence [44]. The longer a pasture had been abandoned the greater similarity of its vegetation structure and community composition to the mature forest. The dominant tree species and seedlings, when measured as IVI and SIV rankings, were mostly animal dispersed. However, we found some species in

the young fallow that were dispersed by wind such as Albizia odoratissima, Dalbergia cultrata and Schima wallichii. The seed rain of animal dispersed species decreased dramatically in the pasture >5m from the forest/ pasture edge and woody plant species in the pasture were mostly dispersed by wind so they always regenerate in the pasture rather than in the forest. However, the difference was much less than for animal dispersed seeds [45]. Limited dispersal of seeds and seedlings is known to influence spatial distribution of pioneer trees [46]. Several studies revealed that the tropical tree species vary in their ability to disperse seeds and is determined by their dispersal mode. Limited seed dispersal often results in aggregated patterns of recruitment for seeds and seedlings [47]. Tree species with limited seed dispersal would be expected to have more aggregated spatial patterns than those that have mechanisms for long-distance seed dispersal. The two most important barriers to the restoration of tropical montane forest on abandoned pasture are the lack of dispersal of forest seeds and seedling competition with pasture grasses [48].

4.2 The Relationship Among Ecological Parameters and Distance from the Fallow Plots to the Sacred Forest

There was no a significant relationship between ecological indices and distance from the fallow plots to the sacred forests in seedlings and all woody plants species. This agrees with other studies that found no relationship between the distances to the primary forest on trees, seedling, sapling richness, abundance, or species composition [26]. In these studies it was suggested that it might be that colonizing species were specialists to disturbed habitats rather than primary forest [30]. Some studies shown that the distances from sacred forests to the forest reserves had a weak influence on trees diversity and had little influence on their similarity with forest reserve sites [49]. However, one study [48] reported that seeds input to the successional areas declined with distance from seed source habitat. Another study [26] also confirmed that the abundance and diversity of seeds dispersed from tropical forests into open old fields is inversely related to the distance. Dispersal is much reduced at distances greater than 5–10 m from forest edges, but in some cases, small seeds of wind and animal dispersed species can travel greater distance [50-51].

4.3 Plant Regeneration Characteristic in Fallow Plots

In early stages of succession of rotational shifting cultivation or fallow fields, the important factors for maintenance of plant diversity and species richness are sprouts or coppicing [23]. Total number of sprouts decreased with advancement of successional stage. Our results agree with the study of Nzunda [24]. Plants originated from seeds may come from the soil seed bank or from surrounding forests that have mature trees that can produce seeds. Our results show that the most abundant trees species in 1–3 years old fallow plots originated from sprouts rather than seeds, but those in older fallow more than 5-years old, the proportion of plants originated from seeds more often than from sprouts. These results agree with the study of Vieira and Proctor [27]. In tropical forests one ecological advantage of sprouting over establishment from seeds is rapid regrowth and a greater capacity for exploitation of limited resources [24]. Most of the plants in young fallow plots were coppices. The remainder came from mature trees that the villagers left in the plot, or from adjacent vegetation in secondary forest surrounding them. When we compared similarity of seedling species and all woody plant species within their fallow plot and sacred forest, we found that seedling species were the same as

all mature woody plant species within their plot and , some of them were the same as the mature tree species in the sacred forest, and some species came neither from sacred forests nor the fallows. This result may explain that species richness of young fallow plots is limited by the potential species capable to producing seeds in the surrounding areas. In our study starting with the 3-4 years plots there are many species that can grow to mature trees and act as seed donors for their plot such as Aporosa villosa, Diospyros glandulosa, Lithocarpus. elegans, L. polystachyus, Quercus kerrii, Tristaniopsis burmanica var. rufescens, etc. The total number of mother trees that can act as seed donors were high when the age of fallow plots increased. The presence of mother trees within fallow sites and in surrounding primary forest patches greatly enhance the regeneration process [42], being sources of seedlings that promote colonization during succession stage. However, the one potential limitation for the establishment of seedlings is the extensive invasion of shrubs into fallow site. Shrub encroachment is always found in the early successional stage at our study sites in the 1–2 years fallows as well as in the 3–4 years fallows in both villages.

5. Conclusions

The sacred forest are of value for a variety of reasons, such as ecological function as a reservoir of biodiversity for preserving plant species in this region. We observed the highest of species richness and calculated the highest values for the diversity indices in both sacred forests. We conclude that the two sacred forests of the Karen and the Lawa do not act as sources of seedling for pioneer species for the early succession stage. Because the species in the sacred forest are evergreen forest species or climax species while, species composition in the fallow plots of this study almost are pioneer species. Natural succession of rotational shifting cultivation fields to secondary forest is a process by which plant species grow in habitats due to environmental factors and time. The succession takes a long time to recover a vegetation structure that is the same as the primary forests. However, the forest management of indigenous people in remote areas is an important key to successful local biodiversity conservation and highly effective forest management. Some sacred forests in Thailand have recently been developed into community forest networks which are currently being implemented by the local communities [14]. Thus, the Thai government should pay attention and give priority to these networks in their policy formulation for the purpose of conserving and increasing forest areas of the country.

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References

[1] Sponsel L.E, Natadecha-Sponsel P., Dhamma S.P. and Sivaraksa S. Why a

tree is more than a tree? Reflections on the spiritual ecology of sacred trees in Thailand. Bangkok, Thailand., 2001.

[2] Hughes J.D., Sacred groves and community power. Capilalism Nature Socialism., 1997; **8(4)**: 99-105.

[3] Byers B.A., Cunliffe R.N. and Hudak A.T. Linking the conservation of culture and nature: A case study of sacred forests in Zimbabwe, Hum Ecol., 2001; **29(2)**: 187–218.

[4] Mgumia F.H. and Oba G. Potential role of sacred groves in biodiversity conservation in Tanzania. Environmental Conservation., 2003; **30(3)**: 259-265.

[5] Liu A., Pei S. and Chen S. Yi Nationality's sacred groves and biodiversity conservation in Chuxiong, Yunnan, Chinese. Journal of Applied Ecology., 2000; **11**: 489-492.

[6] Ormsby A.A. and Bhagwat S.A. Sacred forests of India: A strong tradition of community-based natural resource management. Environmental Conservation., 2010; **37**: 320-326.

[7] Wadley R.L. and Colfer C.J.P. Sacred forest, hunting, and conservation in west Kalimantan, Indonesia. Hum Ecol., 2004; **32(3)**: 313–338.

[8] Dafni A. The Supernatural characters and powers of sacred trees in the holy Land. Journal of Ethnobiology and Ethnomedicine., 2007; **3(10)**: no page number.

[9] Anh H. and et al. Link between spirit forest and biodiversity conservation case study at Son la province. 2003. www.rcfee.org.vn/en/images/stories/.../hva_spirit_forest.pdf . Accessed 10 August 2010.

[10] International Union for Conservation of Nature (IUCN)., World Commission on protected areas task force on protected areas categories, One of a series of papers for the IUCN categories summit, Andalusia, Spain, 2007.

[11] Sponsel L.E., Natadecha-Sponsel P., Ruttanadakul N. and Junadach S. Sacred and/or secular approaches to biodiversity and conservation in Thailand. Worldviews., 1998, **2**: 155-167.

[12] Ganjanapan A. Local control of land and forest: Cultural dimension of resources management in northern Thailand. Thailand; Regional Center for Social Science and Sustainable Development (RCSD), 2000.

[13] Fufuang M. and et al. Hill tribes; Understanding with different culture. Thailand: Hill tribes Research Institute, 1995.

[14] Schmidt-Vogt D., Swidden farming and fallow vegetation in northern Thailand. Germany., Stuttgart, 1999.

[15] Smittinand T. and et al. Farmer in the forest: Economic development and marginal agricultural in northern Thailand. University Press of Hawaii for the East-West Center., The United States of America, 1978.

[16] Rarkasem K., Lawrence D., Padoch C., Schmidth-Vogt D., Ziegler A.D. and Bruum T.B. Consequences of swidden transitions for crop and fallow biodiversity in southeast Asia. Hum Ecol., 2009; **37**: 347-360.

[17] Howlett B.E. and Davidson D.W. Effects of seed availability, site conditions and herbivory on pioneer recruitment after logging in Sabah, Malaysia. For Ecol Manage., 2003; **184**: 369–383

[18] Miller P.M. and Kauffman J.B. Seedling and sprout response to slash-and-burn agriculture in a tropical deciduous forest. Biotropica., 1998; **30(4)**: 538-546.

[19] Whitmore T.C. Secondary succession from seed in tropical rain forests. For Abstr., 1983; **44**: 767–779.

[20] Abdulhadi R., Kartawinata K. and Sukristijono S. Effects of mechanized logging in the lowland dipterocarp forest at Lempake, East Kalimantan. Malays Forest., 1981; **44**: 407–415.

[21] Uhl C., Clark H., Maquirino P., Clark K. and Maquirino P. Successional patterns associated with slashand-burn agriculture in the upper Rio Negro region of the Amazon basin. Biotropica., 1982; **14**: 249–254.

[22] de Rouw A. Regeneration by sprouting in slash and burn rice cultivation, Taý¨ rain forest, Coˆted'Ivoire. J Tropical Ecol., 1993; **9**: 387–408

[23] Fukushima M., Kanzaki M., Ohkubo T., Thein H.T. and Minn Y. Recovery process of fallow vegetation in the traditional Karen swidden cultivation system on the Bago mountain range, Myanmar. Southeast Asian Studies., 2007; **45(3)**: 316-333

[24] Nzunda E.F. Sprouting, succession and tree species diversity in a south African coastal dune forest. J Trop Ecol., 2011; **27**: 195-203.

[25] Kammesheidt L. The roles of tree sprouts in the restoration of stanstructure and species diversity in tropical moist forest after slash-and-burnagriculture in Eastern Paraguay. Plant Ecol., 1998; **139:** 155–165

[26] Cubina A., and Mitchell A.T. The effect of distance from forest edge on seed rain and soil seed bank in tropical pasture. Biotropica., 2001; **33(2)**: 260-267.

[27] Vieira I.C.G. and Proctor J. Mechanisms of plant regeneration during succession after shifting cultivation in eastern Amazonia. Plant Ecol., 2007; **192**: 303-315.

[28] Toky O.P. and Ramakrishnan P.S. Secondary succession following slash and burn agriculture in north-Eastern India: I. Biomass, Litter Fall and Productivity. J Ecol., 1983; **71**: 735-745.

[29] Wangpakapattanawong P., Kavinchan N., Vaidhayakarn C., Schmidt-Vogt D. and Elliott S. Fallow to forest: Applying indigenous and scientific knowledge of swidden cultivation to tropical forest restoration. Forest Ecol Manag., 2010; **260**: 1399–1406.

[30] Suvo, Tigabu M., Savadogo P., Odén P.C. and Xayvongsa L. Recovery of secondary forests on swidden cultivation fallows in Laos. Forest Ecol Manag., 2009; **258(12)**: 2666-2675.

[31] Tran V.D., Osawa A. and Nguyen T.T. Recovery of a mountain forest after shifting cultivation in northwestern Vietnam. Forest Ecol Manag., 2010; **259(8)**: 1650-1659.

[32] Jinto P. Trees and ground flora diversity of framework species plantation plots and Dong Seng forest, Mae Rim district, Chiang Mai province. M. Thesis, Chiang Mai University, Thailand, 2009.

[33] Santisuk T. and Larsen K. Flora of Thailand, Prachachon Co. LTD., Bankok, Thailand. 2008.

[34] Magurran A. Measuring biological diversity. Blackwell Publishing Company., The United Stated of America, 2004.

[35] Simpson E.H. Measurement of diversity. Nature., 1949; **163**: 688.

[36] Misra R. Ecology work book. Oxford and IBH puplishing Company., India, 1986.

[37] Kershaw K.A. Quantitative and dynamics plant ecology. Edward Arnold., London, 1973.

[38] McCune B., Grace BJ. and Urban L.D. Analysis of ecological communities. MjM Software Design., The United Stated of America, 2002.

[39] Jamir S.A. and Pandey H.N. Vascular plant diversity in the sacred groves of Jaintia Hills in northeast India. Biodivers Conserv., 2003; **12**: 1497-1510.

[40] Khumbongmayum A.D., Khan M.L. and Tripathi R.S. Biodiversity conservation in sacred groves of Manipur, northeast India: Population structure and regeneration status of woody species. Biodiver Conserv., 2006; **15**: 2439-2456.

[41] Gupta A.K. Shifting cultivation and conservation of biological diversity in Tripura, northeast India. Hum Ecol., 2000; **28(4)**: 605-629.

[42] Chazdon R.L. Tropical forest recovery: Legacies of human impact and natural disturbance. Perspective Plant Ecology., 2003; **6**: 51-71.

[43] Swaine M.D. and Whitemore T.C. On the definition of ecological species groups in tropical rain forest. Vegetatio., 1988; **75**: 81-86.

[44] Letcher S.G. and Chazdon. Rapid recovery of biomass, species richness, and species composition in a forest chronosequence in northeastern Costa Rica. Biotropica., 2009; **41(5)**: 608-617.

[45] Holl K.D., Loik M.E., Eleanor H.V.L. and Samuels I.A. Tropical montane forest restoration in Costa Rica: Overcoming barriers to dispersal and establishment. Restor Ecol., 2000; **8(4)**: 339-349.

[46] Seidler T.G. and Plotkin J.B. Seed dispersal and spatial pattern in tropical trees. Plos Biology., 2006; **4(11)**: 2132-2137.

[47] Datta A. and Rawat G.S. Dispersal modes and spatial patterns of tree species in a tropical forest in Arunachal Pradesh, northeast India. Tropical Conservation Science., 2008; **1(3)**: 163-185.

[48] Ingle R.N. Seed dispersal by wind, birds, and bats between Philippine montane rainforest and successional vegetation. Oecologia., 2003; **134**: 251-256.

[49] Galanes I.T. and Thomlinson J.R. Relationships between spatial configuration of tropical forest patches and woody plant diversity in northeastern Puerto Rico. Plant Ecol., 2009; **201**: 101-113.

[50] Günter S., Weber M., Erreis R. and Aguirre N. Influence of distance to forest edges on natural regeneration of abandoned pasture: A case study in the tropical mountain rain forest of southern Ecuador. European Journal Forest Research., 2007; **126**: 67-75.

[51] Corlett R.T. Seed dispersal distances and plant migration potential in tropical east Asia. Biotropica., 2009; **41(5)**: 592-598.

[52] World Agroforestry Centre (ICRAF), Scenarios Development in Mae Cheam Watershed, Northern Thailand. Field Guide; ASB MA Scenarios Training Workshop., Chiang Mai, Thailand, 2004.

[53] Tran V.D. et al. Population changes of early successional forest Species after shifting cultivation in northwestern Vietnam. New Forests., 2011; **41(2)**: 247-262.

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Research Paper

Ethnobotanical study of medicinal plants used by Tai Yai in Northern Thailand

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ABSTRACT

Ethnopharmacological relevance: We studied traditional knowledge of medicinal plants used by Tai Yai people in Northern Thailand. We documented traditional medical practices and determined importance among the Tai Yai. This paper reports on knowledge in usage of medicinal plants of the Tai Yai people in Northern Thailand.

Materials and methods: Interviews were conducted in 4 Tai Yai villages in Mae Hong Son and Chiang Mai provinces whose inhabitants immigrated from Myanmar at different times. Discussions and interviews were held with 126 key-informants (56 males and 70 females) ranging in age from 16 to 80 years in three age groups (age 16–40, 41–60, and 61–80). We calculated the informant consensus factor (ICF) for use category, use value index (UV) for use report of plant. We tested differences between the knowledge of different age groups and locations using principal component analysis (PCA).

Results: These Tai Yai people used of 141 medicinal plants belonging to 59 families. Of the medicinal plant species, the highest percentage was in the family Euphorbiaceae: *Croton acutifolius* and *Croton roxburghii*. The highest number of Informant consensus factor was for metabolic system disorders. Overall, Tai Yai people use medicinal plants to cure many sicknesses such as hypertension, lumbago, wounds, puerperium, kidney disorders, kidney stones, coughs, fevers, hemorrhoids, flatulence and malaria. There were no significant differences in knowledge of plants usage among villages of different ages. In addition, the knowledge of the plants was not significantly different between men and women. However, we found that the younger had less experience with and knowledge of medicinal plants than older people.

Conclusions: The result indicates loss of accumulated knowledge of medicinal plants and traditional use. Although, the medicinal plant knowledge was passed from one generation to the next by word of mouth, the detailed documentation of medicinal plants and their use may effectively prevent the knowledge-loss through time.

1. Introduction

Northern Thailand has many ethnic groups such as Karen, Lahu, Hmong, Lisu, Akha, Mien, Lawa and Tai Yai (Srisawat, 2004). They possess knowledge about plant utilization for food, medicine, housing materials, fuel, dyes and fiber (Suksri, 2003; Trisonthi and Trisonthi, 2009). There have been many ethnobotanical studies of various ethnic groups such as Mien or Yao (Tovaranonte, 1998; Srithi et al., 2009); Akha (Inta et al., 2008), Tai Lue (Tovaranonte, 1998; Tovaranonte and Chukeatirote, 2005), Karen (Winijchaiyanan, 1995), Lahu, Hmong (Tovaranonte, 1998), Lisu and Lawa (Tangtragoon, 1998; Yaso, 2000; Santasombat, 2001), and H'tin (Yaso, 2000).

Ethnobotany is the local traditional knowledge of utilizing indigenous plants, such as for food, medicine and tools, that local people have been practicing for a long time. The utilization of plant species found in nature varies in each region. Local folk wisdom on botanical uses has been applied in nature to the advantage of ethnic groups for a long time (Santasombat, 2001).

Ethnobotanical studies have shown great variation in traditional uses of herbal medicines among different cultural and social groups (Lee et al., 2008). The study of medicinal plant is one of the methods of examining the interaction and relationships between

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biological and cultural components of the environment (Bye, 1986). Since ancient times, people have resorted primarily to nature for food and medicine. The ethnic groups of Northern Thailand rely mostly on plants for subsistence and medical cures (Tene et al., 2007). Ethnobotany also attracts interest from different industries, thus it is predominantly linked to economic botany (Upho, 2004).

The Tai Yai (Shan, Tai, Ngio and Tai Luang) is an ethnic group with a population of about 6 million in western Assam, northern of Yunnan, Laos, Vietnam and Thailand (Vejjajiva, 1996; Wittinayasak, 2001; Conway, 2006; Taoprasert and Taoprasert, 2006). They speak a language of the Tai Kadai language family (Aummatayakul, 1994; Conway, 2006). It is estimated that there are 3–4 millions Tai Yai in the Shan State of Myanmar, and about 100,000 scattered all around northern Thailand, particularly in the provinces of Mae Hong Son, Chiang Mai and Chiang Rai (Ramitanon et al., 1998; Mesatan, 2001; Wittinayasak, 2001; Srisawat, 2004; Conway, 2006).

They inhabit upland valleys and practice wetland rice cultivation (Conway, 2006), with a few livestock (Mesatan, 2001). Their villages are surrounded by mountains and are near rivers. They have used a variety of plants from nature to their advantage for a long time (Santasombat, 2001). Some plants were used to make money for people in the community. Their knowledge of traditional medicines is based on oral tradition or medico-spiritual manuscripts (Pankhurst, 1990; Teklehaymanot et al., 2007). It has been generally accepted that medicinal plants are important for drug development (Singh and Singh, 2009). Since they have no written record about their traditional ethnobotanical knowledge, previous studies suggested the existence of a gradual process of loss of transmission of traditional knowledge and a risk of erosion of accumulated knowledge. It is, therefore, necessary to document the use of medicinal plants by the Tai Yai people before this knowledge becomes extinct. This study focused on possible changes of traditional ethnobotanical knowledge of Tai Yai immigrants who came to Thailand during different time periods. This traditional knowledge can be useful for establishing priorities, planning effective use of resources and conservation of biodiversity and cultural knowledge (Ibrar et al., 2007).

2. Materials and methods

2.1. Study area

Between May 2011 and July 2012, four Tai Yai villages, Pratoo Muang, and Ban Luang in Khun Yuam district (18° 50′ 22″ N, 97° 57′ 5″ E), Mae Hong Son province, and Pang Kwai and Ban Jong in Wiang Hang district (19° 33′ 34″ N, 98° 38′ 8″ E), Chiang Mai province (Fig. 1) were studied. All the villages are located near the border with Myanmar. They are believed to have migrated into northern Thailand at different times (Thaitambon, 2000).

2.2. Data collection

One hundred and twenty-six key informants (57 males and 69 females, aged 16–39, 40–60, and 60–80 years (Teklehaymanot, 2009)) (Table 1) were randomly selected for semi-structured interviews (Martin, 1995; Gomez-Beloz, 2002; Huai and Pei, 2004). They were shown plant specimens and photographs, and were asked for their vernacular names, used parts, modes of preparation, dosages, notable characteristics (e.g. pigmentation and scent), and ecological data (abundance, elevation, and habitats). The plant specimens were deposited (with voucher numbers) at the Department of Biology, Faculty of Science, Chiang Mai University and Queen Sirikit Botanic Garden Herbarium (QBG), Chiang Mai, Thailand. Plant identification was done by a taxonomist, J.F. Maxwell (CMU Herbarium), based on taxonomic literature such as Flora of Thailand (Santisuk and Larsen 1999, 2000), Flora of Northern Thailand (Gardner et al., 2006), and on comparison with existing specimens in the herbarium. The information gathered from the key informants established the domain of a

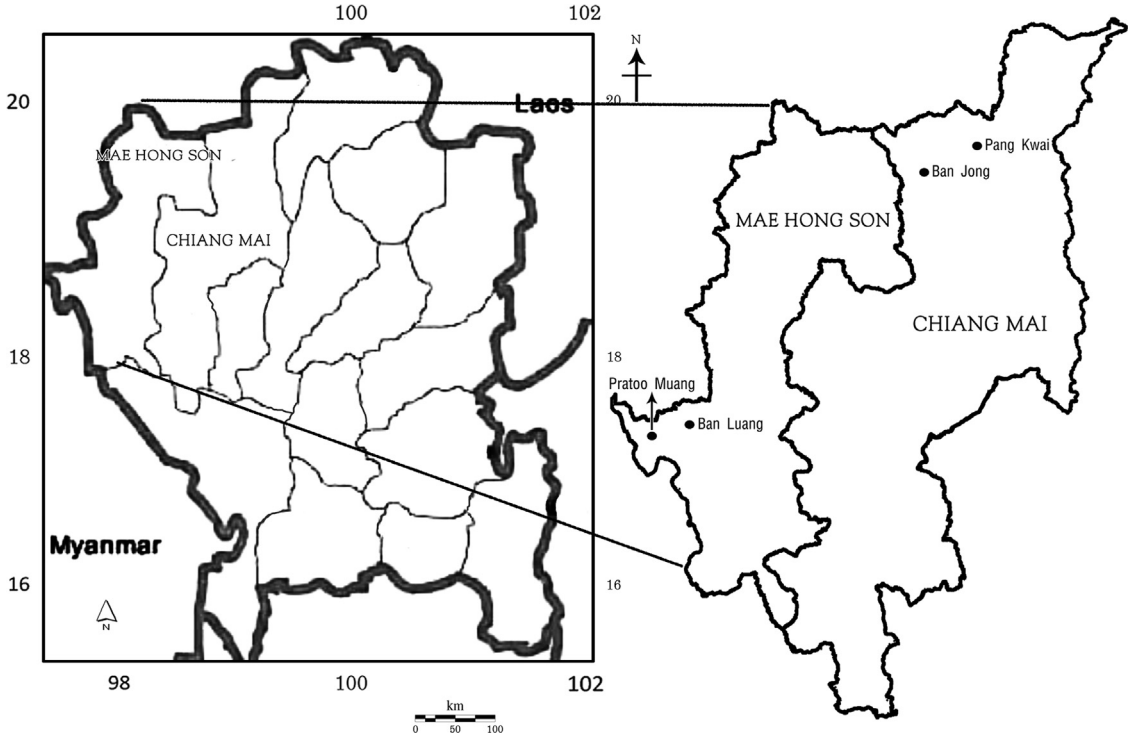

Fig. 1. Four studied Tai Yai villages (Trek Thailand Team, 2012).

Table 1
Basic information of the four Tai Yai villages

Villages	Total house holds	Total inhabitants	Year since settlement (Wittinayasak, 2001)	Total number of key informants (male/female)	Number of informants for each age group		
					16–40	41–60	61–80
Pang Kwai	79	313	17	32 (14/18)	10	12	10
Pratoo Muang	75	303	70	30 (12/18)	11	10	9
Ban Jong	409	1,006	100	34 (17/17)	11	13	10
Ban Luang	86	349	107	30 (13/17)	10	11	9
Total				126 (56/70)	42	46	38

questionnaire used in semi-structured interviews with non-specialist informants.

2.3. Data analysis

2.3.1. Informant consensus factor (ICF)

ICF was used to test homogeneity of knowledge (Trotter and Logan, 1986; Heinrich et al., 1998)

$$\mathrm{ICF} = \frac{Nur - Nt}{(Nur - 1)}$$

Where *Nur* refers to the number of use reports and *Nt* refers to the number of taxa in each usage category. ICF values range from 0 to 1. A value near one (1) indicates a high degree of consensus among the informants for medicinal plants in a particular use category where as values near zero (0) infer that there is a low degree of consensus or when plants used for such use category are chosen randomly. The categories of diseases of the Informant Consensus Factor were followed Cook (1995).

2.3.2. Use value (UV)

The relative importance was calculated employing the use value (Phillips et al., 1994), a quantitative measure for the relative importance of species known locally

$$\mathrm{UV} = \frac{\Sigma Ui}{n}$$

where *Ui* is the use numbers of plants by each informant for a given species and *n* is the total number of informants. Use values are high when there are many use-reports for a plant, implying that the plant is important, and approach zero (0) when there are few reports related to its use.

2.3.3. Statistical analyses

Statistical tests were performed to test differences between the knowledge of different age groups and locations. The data of village age, gender, informant age, and numbers of medicinal plants known by the informants were analyzed using Principal Component Analysis (PCA) using Q-mode PCA. The data of informant age and numbers of medicinal plants known by the informant were also analyzed using a linear regression in R Programming Language version 2.15.3 (R Core Team 2013). The calculation was done by a singular value decomposition of data matrix (R Core Team 2013). Furthermore, the numbers of medicinal plants known by the informants and the continuous variable of informant age were analyzed using a linear regression. The knowledge of medicinal plants between females and males were compared using Chi-square statistics, *t*-test and analysis of variance (Teklehaymanot, 2009).

3. Results

3.1. Medicinal plants

There were 141 medicinal plant species belong to 59 families (Table 2). The most utilized plant families were 9.8% (13 species) each in Leguminosae–Papilionoideae and Euphorbiaceae, 6.0% (8 species) in Rubiaceae, 5.3% (7 species) in Asteraceae, 4.5% (6 species) in Zingiberaceae, 3.8% (5 species) in Lamiaceae and 3.0% (4 species) in Acanthaceae, Poaceae and Moraceae (Fig. 2.) The dominant plant parts used in preparations both in single and multiple treatments are: whole plants 44 species, leaves 39 species, stems 36 species, roots 15 species, bark 13 species, fruits 10 species, water from roots 3 species, flowers 2 species and seeds 1 species. The local people employed a variety of methods in preparation of medicinal plants: boiling 108 species (76.60%), fresh 25 species (17.73%), fresh or boiling 7 species (4.96%) and baking 1 species (0.71%). Ways of administration of medicinal plants included bath 84 species (59.57%), oral 39 species (27.66%), paint 5 species (3.55%), mouth 5 species (3.55%), smoke 1 species (0.71%), bath or oral 6 species (4.25%) and ear 1 species (0.71%).

3.2. Informant consensus factor

Table 3 shows 19 Informant consensus factor numbers for categories of diseases. The use categories with most use-reports were the categories of plants used for metabolic system disorder (3 use reports, 1 species, e.g. hyperlipidaemia) had the highest degree of consensus with the informant consensus factor value of 1.000. This category had a less use report and species, so it had high degree of consensus with ICF values. The other use categories also had high degrees of consensus with ICF values greater than 0.8 include sensory system disorders (9 use-reports, 2 species e.g. otorrhea and astigmatism), digestive system disorders (325 use-reports, 61 species, e.g. flatulence, laxative, diarrhea, colic, sore teeth, hemorrhoids, gastric ulcers, purgative and vomiting), pregnancy/birth/puerperium disorders (202 use-reports, 40 species e.g. puerperium and metrorrhagia as well as skin/subcutaneous cellular tissue disorders (149 use-reports, 30 species e.g. itching, wounds, warts and acne) (Table 3). and these use categories all had a high degree of consensus with ICF values greater than 0.80.

3.3. Use values

The use values were high for plants with many use-reports. Widely used medicinal plants included for example *Chromolaena odoratum* (0.73), *Croton roxburghii* (0.65), *Cassia fistula* (0.64), *Phyllanthus emblica* (0.55), *Croton acutifolius* (0.49), *Aegle marmelos* (0.40), *Clerodendrum paniculatum* (0.38), *Adiantum flabellulatum* (0.38), *Crotalaria sessiliflora* (0.36), *Paederia linearis and Zingiber montanum* (0.35) and *Clerodendrum serratum* (0.32) etc. Medicinal plants were used for treating otorrhea, anemia, puerperium, wart, wounds, malaria, cough, hypertension, detoxification, hemorrhoid,

Table 2
Medicinal plants used by Tai Yai in Northern Thailand.

Family	Scientific names	Tai Yai name	Parts used	Preparation	Way of administration	Medicinal efficacies	UV	Voucher No.
Acanthaceae	*Asystasia salicifalia* Craib	–	Whole plants	Boil	Bath	Puerperium	0.008	Sn001
	Barleria strigosa Willd.	Dipakang	Root	Boil	Bath	Tonic	0.040	Sn004
	Justicia procumbens L.	Hangsaue	Whole plants	Boil	Bath	Lumago, itching	0.016	Sn005
	Strobilanthes auriculata Nees.	Peopongfa	Whole plants	Boil	Bath	Malnutrition	0.024	Sn006
	Thunbergia laurifolia Lindl.	Namnae	Whole plants	Boil	Bath	Detoxificant	0.183	Sn010
	Thunbergia similis Craib	Takai	Fruit	Fresh	Oral	Tonic	0.016	Sn011
Anacardiaceae	*Lannea coromandelica* (Houtt.) Merr.	Kokmok	Whole plants	Boil	Bath	Dizziness	0.008	Sn014
	Spondias pinnata Kurz	Makkok	Fruit	Fresh	Oral	Flatulence	0.008	Sn015
Apocynaceae	*Holarrhena pubescens* Wall.	Maiyangkhao	Stem, bark	Boil	Oral	Diarrhea, weight loss	0.087	Sn020
Araceae	*Amorphophallus corrugatus* N.E. Br.	Buk	Rhizome	Fresh	Paint	Bruises	0.008	Sn021
	Rhaphidophora peepla Schott	-	Whole plants	Boil	Bath	Oedemas	0.008	Sn023
Araliaceae	*Heteropanax flagrans* Seem.	Aochang	Bark	Boil	Bath	Metrorrhagia	0.040	Sn024
Aristolochiaceae	*Aristolochia pierrei* Lec.	Hampai	Stem, leaves	Boil	Bath	Flatulence	0.016	Sn025
Asclepiadaceae	*Streptocaulon juventas* (Lour.) Merr.	Khueakhon	Stem, leaves	Boil	Bath	Tonic	0.008	Sn028
Asteraceae	*Inula cappa* DC.	Nad	Whole plants	Boil	Bath	Lumbago, anemia	0.024	Sn030
	Inula indica L.	Nad	Whole plants	Boil	Bath	Weight loss, paralysis	0.071	Sn036
	Vernonia cinerea Less.	Phamsamwan	Whole plants	Boil	Bath	Ulcers	0.079	Sn032
	Vernonia parishii Hook.f	Nadkham	Whole plants	Boil	Bath	Puerperium, tonic	0.222	Sn034
	Chromolaena odoratum (L.) R.M. King & H. Rob.	Langphang	Stem,leaves	Fresh,boil	Bath	Lumbago, wounds	0.730	Sn037
	Blumeopsis flava (DC.) Gagnep.	Phakkaddoi	Stem,leaves	Fresh,boil	Bath	Lumbago	0.032	Sn038
	Blumea lacera DC.	Mokngok	Leaves	Fresh	Paint	Wounds	0.016	Sn039
Bignoniaceae	*Markhamia stipulate* (Wall.) Seem.ex Sch. var. *stipulate*	Kae	Stem	Boil	Bath	Oedemas	0.040	Sn041
	Oroxylum indicum Kurz	Makdinchang	Stem	Boil	Bath	Metrorrhagia	0.063	Sn042
Burseraceae	*Canarium subulatum* Guill.	Makoem	Whole plants	Boil	Bath	Itching	0.008	Sn048
	Garuga pinnata Roxb.	-	Leaves	Boil	Bath	Laxative	0.008	Sn049
Caprifoliaceae	*Viburnum sambucinum* Blume var. *tomentosum* Hallier f.	Aun	Leaves, flower	Boil	Bath	Puerperium, dizziness	0.016	Sn051
Clusiaceae	*Cratoxylum formosum* Prun. Flolum.	Maiki	Root	Boil	Oral	Sore teeth	0.024	Sn053
Combretaceae	*Terminalia alata* Heyne ex. Roth	Hokfa	Bark	Fresh	Mouth	Sore teeth	0.032	Sn055
	Terminalia chebula Retz. var chebula	Makna	Fruit	Fresh	Oral	Cough	0.056	Sn056
	Terminalia mucronata Craib & Hutch.	Laenhai	Bark	Fresh	Mouth	Sore teeth	0.016	Sn057
Commelinaceae	*Commelina diffusa* Burm. f.	Phakkhap	Whole plants	Boil	Oral	Sprains	0.032	Sn060
	Murdannia edulis (Stokes) Faden.	Phakkhap	Whole plants	Boil	Oral	Hypertension	0.087	Sn062
Costaceae	*Costus speciosus* Smith.	Ueang	Whole plants	Bake	Smoke	Otorrhea	0.175	Sn064
Cucurbitaceae	*Gynostemma pentaphyllum* (Thunb.) Mak.	Chiaokulan	Whole plants	Boil	Oral	Ulcers	0.024	Sn065
Cyperaceae	*Fimbristylis thomsonii* Boeck.	Hauchom	Whole plants	Boil	Bath	Acne, fever	0.111	Sn070
Dilleniaceae	*Dillenia parviflora* Griff.	Maksanhing	Bark, leaves	Boil	Bath	Protein deficiency	0.087	Sn072
Dioscoreaceae	*Dioscorea bulbifera* Linn.	Manyang	Fruit	Fresh	Paint	Wart	0.087	Sn075
	Dioscorea grabra Roxb.	Yasamkip	Stem	Fresh	Paint	Wounds	0.087	Sn076
Dipterocarpaceae	*Hopea odorata* Roxb.	Sakkhian	Bark	Fresh	Mouth	Sore teeth	0.024	Sn082
	Shorea obtuse Wall. ex Blume	Ngae	Bark	Boil	Oral	Diarrhea	0.016	Sn083
	Shorea siamensis Miq.	Pau	Leaves	Boil	Bath	Dizziness	0.008	Sn085

Table 2 (*continued*)

Euphorbiaceae	*Antidesma acidum* Retz.	Kampang	Fruit	Fresh	Oral	Tonic	0.024	Sn091
	Aporosa villosa Baill.	Moedlong	Stem, leaves	Boil	Bath	Vomiting	0.056	Sn094
	Bridelia retusa L.	Paonam	Stem, leaves	Boil	Bath	Lumbago	0.127	Sn097
	Bridelia stipularis (L.) Bl.	Paonam	Stem, leaves	Boil	Bath	Lumbago	0.032	Sn099
	Cleidion spiciflorum Merr.	Dimi	Bark	Boil	Bath	Itching	0.135	Sn100
	Croton roxburghii N.P. Balakr.	Hayoeng	Whole plants	Boil	Bath	Fever, puerperium	0.651	Sn101
	Croton acutifolius Ess.	Hayoeng hom	Whole plants	Boil	Bath	Fever, puerperium	0.484	Sn102
	Flueggea virosa (Roxb.ex Willd) Voigt.	Kangpa	Stem,leaves	Boil	Bath	Itching	0.270	Sn103
	Mallotus philippensis Mull. Arg.	Pidpiodaeng	Root	Boil	Oral	Leukorrhoea, allergic asthma	0.024	Sn107
	Phyllanthus emblica Linn.	Makkhampom	Fruit	Fresh	Oral	Cough, sore throat	0.548	Sn108
	Phyllanthus roseus Beille	Manpa	Whole plants	Boil	Bath	Oedemas	0.008	Sn109
	Phyllanthus urinaria L.	Makhamna	Whole plants	Boil	Bath	Malaria	0.262	Sn110
	Sauropus bicolor Craib	Mayomtuean	Whole plants	Boil	Oral	Fever	0.016	Sn111
Fagaceae	*Lithocarpus polystachyus* Rehd.	Komaed	Whole plants	Boil	Bath	Puerperium	0.024	Sn113
	Quercus aliena Bl.	Koe	Fruit	Fresh	Oral	Heart disease	0.008	Sn118
	Quercus kerrii Craib	Kotapiad	Whole plants	Boil	Bath	Puerperium	0.016	Sn119
Flacourtiaceae	*Flacourtia indica* Merr.	Makkaen	Leaves	Boil	Oral	Diarrhea	0.008	Sn122
Hypoxidaceae	*Curculigo latifolia* Dry. ex W.T.Ait.var *latifolia*	Khakhae	Whole plants	Boil	Bath	Hypertension	0.024	Sn125
Juglandaceae	*Engelhardtia spicata* Bl.	Doksoi	Bark	Boil	Mouth	Mouth ulcer	0.032	Sn129
Lamiaceae	*Clerodendrum paniculatum* L.	Pingdaeng	Flower, leaves	Fresh,boil	Oral	Hemorrhoids	0.381	Sn131
	Clerodendrum serratum (L.) Moon var. *wallichii* Clarke	Phakhasuai	Whole plants	Boil	Bath	Puerperium	0.317	Sn132
	Premna tomentosa Willd.	Sakkai	Stem, leaves	Boil	Bath	Lumbago	0.008	Sn135
	Vitex canescens Kurz.	Tinnok	Whole plants	Boil	Bath	Puerperium	0.008	Sn138
	Vitex limoniifolia Wall. ex Schauer	Kesai	Stem, leaves	Boil	Bath	Cough, kidney disorders	0.167	Sn139
Lecythidaceae	*Careya sphaerica* Roxb.	Maipui	Leaves	Boil	Bath	Hypertension	0.008	Sn144
Leeaceae	*Leea indica* (Burm.f.) Merr	Choengkhoeng	Root, stem	Boil	Oral	Colic	0.214	Sn145
	Leea macrophylla Roxb. ex Hornem	Choengkhoeng	Root, stem	Boil	Oral	Colic, hemorrhoids	0.063	Sn146
Leguminosae -Caesalpinioideae	*Cassia fistula* Linn.	Lomlaeng	Fruit	Fresh	Oral	Laxative	0.635	Sn148
Leguminosae-Papilionoideae	*Crotalaria albida* Hey. ex Roth	Mahingnu	Root	Boil	Oral	Urination, kidney stone	0.333	Sn160
	Crotalaria pallida Ait.	Mahingnu	Root	Boil	Oral	Urination, kidney stone	0.317	Sn163
	Crotalaria sessiliflora L.	Mahingnu	Root	Boil	Oral	Urination, kidney stone	0.357	Sn164
	Dalbergia oliveri Gamble	Pi	Stem, leaves	Boil	Bath	Protein deficiency	0.032	Sn166
	Desmodium heterocarpon (L.) DC.	Khangna	Whole plants	Boil	Bath	Oedemas	0.056	Sn173
	Desmodium oblongum Benth.	Haklueang	Root	Boil	Oral	Tonic, lumbago	0.175	Sn174
	Desmodium velutinum (Willd.) DC.	Doklid	Stem, leaves	Boil	Bath	Hypertension	0.024	Sn176
	Flemingia strobilifera (L.) Roxb.ex Ait	Khoklib	Whole plants	Boil	Bath	Oedemas, lumbago	0.230	Sn178
	Millettia auriculata Bak. var. *extensa* Benth.	Kwaokhuea	Stem, leaves	Boil	Bath	Tonic	0.032	Sn180
	Mucuna bracteata DC. ex Kurz.	Maknim	Seed	Fresh	Paint	Ulcers	0.087	Sn181
	Phyllodium pulchellum (L.) Desv.	Khoklib	Whole plants	Boil	Bath	Oedemas, lumbago	0.262	Sn183
	Pterocarpus macrocarpus Kurz.	Kaetok	Bark	Fresh	Mouth	Sore teeth	0.111	Sn184
	Spatholobus parviflorus Ktze.	Kwao	Stem, leaves	Boil	Bath	Oedemas, lumbago	0.040	Sn186
Liliaceae	*Disporum calcaratum* D. Don	Mokkhadin	Root	Boil	Bath	Bruised	0.008	Sn190
Lythraceae	*Lagerstroemia macrocarpa* Kurz var. *macrocarpa*	Siphung	Bark	Boil	Bath	Hypnotic	0.087	Sn192

Table 2 (*continued*)

Malvaceae	*Thespesia lampas* Dalz. & Gibs	Kuituean	Root	Boil	Oral	Tonic	0.024	Sn199
Melastomataceae	*Osbeckia stellata* Buch- Ham. ex ker-Gawl var. *rostrala*(D.Don.) C.Han	-	Whole plants	Boil	Bath	Protein deficiency, dizziness	0.032	Sn204
Menispermaceae	*Stephania japonica* (Thunb.) Miers var. *discolor* (Bl.) forman	Khueakon	Whole plants	Boil	Bath	Tonic	0.071	Sn206
Moraceae	*Ficus hirta* Vahl var. herta	Makdoepong	Water from root	Fresh	Oral	Dementia	0.056	Sn211
	Ficus hispida L.f.	Makdoepong	Water from root	Fresh	Oral	Dementia	0.063	Sn212
	Ficus semicordata J.E. Smith	Makdoepong	Water from root	Fresh	Oral	Dementia	0.079	Sn213
Myrtaceae	*Syzygium cumini* (L.) Skeels	Maisape	Stem, leaves	Boil	Bath	Hemorrhoids	0.016	Sn219
	Tristaniopsis merguensis Peter	Maisisaen	Stem, leaves	Boil	Bath	Puerperium	0.016	Sn221
Ochnaceae	*Ochna integerrima* (lour.) Merr	Niangdin	Whole plants	Boil	Bath	Mouth ulcer, jaundice	0.063	Sn223
Oxalidaceae	*Biophytum sensitivum* (L.) DC.	Lammuen	Whole plants	Boil	Bath	Tonic	0.024	Sn226
Parkeriaceae	*Adiantum flabellulatum* L.	Hukhwak	Stem	Fresh	Ear	Ulcers	0.373	Sn227
	Anisocpium cumingianum Presl.	Kuddoi	Root	Boil	Oral	Dizziness	0.016	Sn230
Passifloraceae	*Adenia pinnatisecta* (Craib) Craib var. *pinnatisecta*	Khueakwua	Whole plants	Boil	Bath,oral	Dizziness	0.016	Sn233
Pinaceae	*Pinus kesiya* Royle ex Gordon	Paek	Stem, leaves	Boil	Bath	Dizziness	0.103	Sn235
	Pinus merkusii Jungh. & de Vriese	Paek	Stem, leaves	Boil	Bath	Dizziness	0.103	Sn236
Poaceae	*Imperata cylindrica* Beauv.	Yakha	Whole plants	Boil	Bath	Tonic	0.048	Sn241
	Cyrtococcum oxyphyllum (Steud.) Stapf.	Kawnok	Whole plants	Boil	Oral	Urination	0.008	Sn242
	Digitaria violascens Link.	Pakkwai	Whole plants	Boil	Bath	Fever	0.024	Sn244
	Themeda triandra Forssk.	Tachang	Whole plants	Boil	Oral	Diarrhea	0.008	Sn251
Polygalaceae	*Polygala chinensis* L.	Mamaekam	Whole plants	Boil	Bath	Tonic	0.103	Sn252
Rabiaceae	*Meyna pubescens* (Kurz.) Roby	Namnuea	Whole plants	Boil	Bath	Lumbago	0.079	Sn255
Rubiaceae	*Aphaenandra uniflora* (Wall. ex G. Don)	Khaotaektuean	Whole plants	Boil	Oral	Colic, fever	0.016	Sn261
	Gardenia erythroclada Kurz.	Naknen	Stem, leaves	Boil	Bath	Paralysis	0.063	Sn264
	Gardenia obtusifolia Roxb. ex Kurz	Khaimok	Stem, leaves	Boil	Bath	Puerperium	0.016	Sn265
	Hedyotis tenelliflora Bl.var.*kerrii*	Linngu	Whole plants	Boil	Bath	Lumbago	0.032	Sn267
	Hymenodictyon orixense (Roxb.) Mabb.	Somheb	Stem, leaves	Boil	Bath	Pruritus	0.056	Sn268
	Knoxia corymbosa Willd.	Khemtuean	Whole plants	Boil	Bath	Lumbago	0.016	Sn270
	Mitragyna rotundifolia Kuntze	Talong	Stem, leaves	Boil	Bath	Lumbago, fractures	0.079	Sn272
	Paederia linearis Hook. f.	Todma	Whole plants	Fresh, boil	Bath, oral	Flatulence, hemorrhoid	0.349	Sn274
	Wendlandia tinctoria A. DC.	Khaengkwang	Stem, leaves	Boil	Bath	Fractures	0.024	Sn278
Rutaceae	*Aegle marmelos* L.	Makpin	Fruit	Boil	Oral	Mouth ulcer	0.397	Sn279
Sabiaceae	*Meliosma simplicifolia* Roxb.	Hakmu	Bark	Boil	Bath	Fever, lumbago	0.016	Sn281
Schzaeaceae	*Lygodium polystachyum* Wall.ex Moore.	Kudkong	Root	Fresh, boil	Oral	Diarrhea	0.063	Sn286
Selaginellaceae	*Selaginella ostenfeldii* Hier.	Paakkhodkhaed	Stem, leaves	Boil	Oral	Flatulence	0.008	Sn287
Simaroubaceae	*Harrisonia perforate* Merr.	Maigi	Stem, leaves, fruit	Boil	Bath	Candidiasis	0.095	Sn288
	Brucea javanica (L.) Merr.	Peiyphan	Whole plants	Boil	Bath	Itching	0.008	Sn289
Smilacaceae	*Smilax verticalis* Gagnep.	Nampao	Whole plants	Boil	Bath, oral	Oedemas, lumbago	0.016	Sn290

Table 2 (*continued*)

	Smilax ovalifolia Roxb.	Nampao	Whole plants	Boil	Bath, oral	Lumbago	0.016	Sn291
Sterculiaceae	*Sterculia balanghas* Linn.	Pofan	Root	Boil	Bath	Lumbago	0.008	Sn296
	Sterculia villosa Roxb.	Kuituean	Root	Boil	Oral	Female infertility	0.008	Sn297
Strychnaceae	*Strychnos nux-vomica* Linn.	Maktueng	Bark, leaves	Boil	Bath	Oedemas, puerperium	0.095	Sn300
Theaceae	*Anneslea fragrans* Wall.	Mupi	Stem, leaves	Boil	Bath	Appetite stimulant	0.071	Sn303
	Ardisia sanguinolenta Bl. var *sanguinolenta*	Takai	Fruit	Fresh	Oral	Heart disease	0.008	Sn305
	Schima wallichii Korth.	Chongkai	Leaves	Boil	Bath	Tonic	0.008	Sn306
Tiliaceae	*Grewia acuminata* Juss.	Potaeng	Stem, leaves	Boil	Bath	Ulcers, oedemas	0.040	Sn313
	Grewia eriocarpa Juss.	Poe	Stem, leaves	Boil	Bath	Ulcers, oedemas	0.024	Sn314
	Grewia hissuta Vahl.	Toyo	Bark	Fresh, boil	Bath	Protein deficiency	0.024	Sn315
	Microcos paniculata Linn.	Khaohaeng	Whole plants	Boil	Bath	Lumbago	0.024	Sn317
Urticaceae	*Pouzolia hirta* Hassk.	Pharuesi	Leaves	Boil	Bath	Puerperium	0.008	Sn321
Vitaceae	*Ampelocissus martinii* Planch.	Haukhaoyang	Stem, leaves	Boil	Bath	Lumbago	0.024	Sn322
	Cissus repens Lamk.	Somkhobchaeb	Whole plants	Boil	Bath	Laxative	0.008	Sn323
Zingiberaceae	*Alpinia galanga* (L.)Willd. var. *galanga*	Kha	Rhizome	Fresh, boil	Oral, bath	Flatulence	0.310	Sn324
	Boesenbergia rutunda L.	Hausipu	Rhizome	Fresh	Oral	Flatulence	0.317	Sn325
	Zingiber kerrii Craib	Khingtuean	Rhizome	Fresh	Oral	Flatulence	0.048	Sn330
	Zingiber montanum (Koenig)	Mincharang	Stem, rhizome	Boil	Bath	Puerperium	0.349	Sn331
	Zingiber smilesianum (Roxb.) O.K. Craib.	Pokkaraek	Rhizome	Fresh	Oral	Flatulence	0.048	Sn332
	Zingiber zerumbet Rosc.Smith.	Laaen	Rhizome	Fresh	Oral	Flatulence	0.048	Sn333

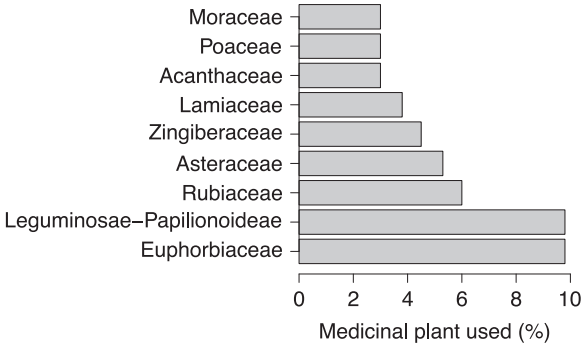

Fig. 2. Percentages of medicinal plants used by plant family.

colic, eodemas, tonic, lumbago, kidney disorders, kidney stone, flatulence, sore teeth, malnutrition, diarrhea, metrorrhagia, weight loss, respiratory tract problem etc. (Table 2).

3.4. Medicinal plant knowledge

Four Tai Yai villages are estimated to have immigrated into Thailand at different times. We found no differences in knowledge of the plants between the villages. On the age basis, the oldest age group knew more medicinal plants (average 19.70 species) than did the middle-age group (average 14.38 species). The youngest group knew the fewest (average 6.57 species). We found a relationship between age and numbers of medicinal plants known by the Tai Yai informants. Medicinal plant used increases with age. The older people use more medicinal species than the younger. In total the first two principal components (PC) explained 67% of the total variation. Along the PC1 axis, the change in the number of medicinal plants known by the informants had the same direction as the age of the informants, and the gender slightly changed in the opposite direction. The gender did not change in a significant way (Fig. 3). For the PC2 axis, the gender and the village age were changed in the different direction. Overall, the PCA analysis suggested that the number of species known by the informant was more likely to associate with the informant age. Furthermore, the linear regression between the data of number of plants known by the informants and their age showed a significant positive relationship ($R^2=37.64$, $F_{(1,124)}=74.86$, $P<0.001$; Fig. 3). This suggested that the older informants knew more medicinal plants

Table 3
Number of Informant Consensus Factor (ICF) recorded among Tai Yai communities per use followed Cook (1995).

No.	Category (Cook, 1995)	Use citations	Species	ICF
1	Metabolic system disorders	3	1	1.000
2	Sensory system disorders	9	2	0.875
3	Digestive system disorders	325	61	0.815
4	Pregnancy/Birth/Puerperium disorders	202	40	0.806
5	Skin/subcutaneous cellular tissue disorders	149	30	0.804
6	Injuries	133	29	0.788
7	Endocrine system disorders	14	4	0.769
8	Poisonings	17	5	0.750
9	Abnormalities	73	20	0.736
10	Mental disorders	24	8	0.696
11	Nutritional disorders	160	51	0.686
12	Respiratory system disorders	120	40	0.672
13	Muscular-skeletal system disorders	155	55	0.649
14	Genitourinary system disorders	72	26	0.648
15	III-Defined symptom	83	31	0.634
16	Blood system disorders	14	6	0.615
17	Infections/infestations	69	31	0.559
18	Nervous system disorders	24	13	0.478
19	Circulatory system disorders	34	20	0.424

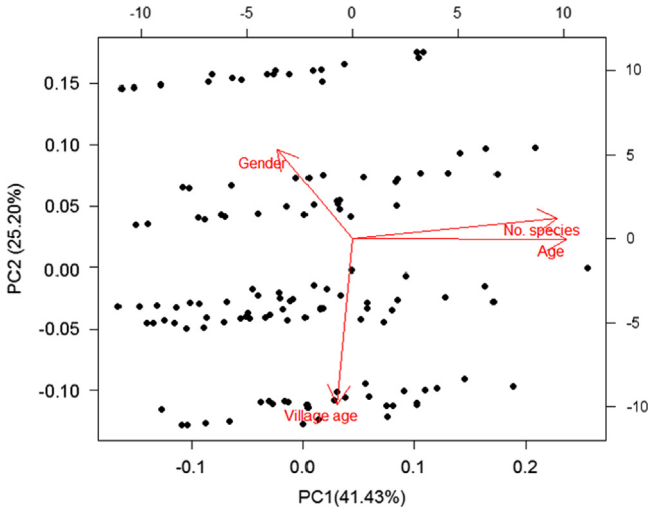

Fig. 3. Biplot of the data. The horizontal axis shows projections on to the first principal component (PC1), the vertical axis the second component (PC2). Red arrows show the projections of the original features on to the principal components.

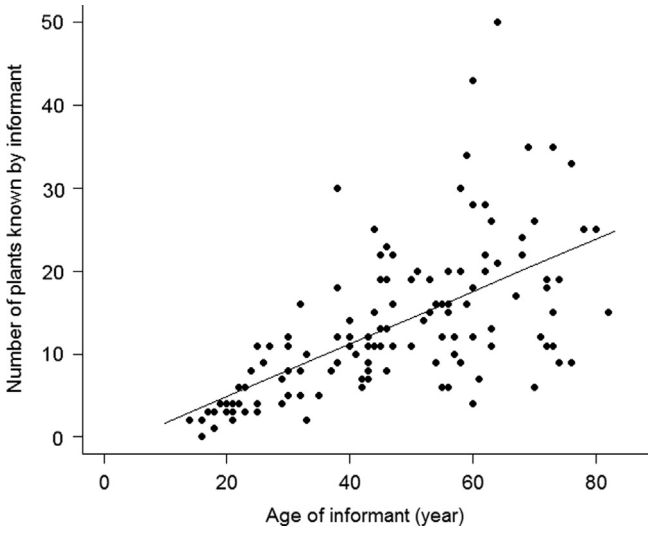

Fig. 4. The relationship between the age of informants and the number of medicinal plants known by the informants ($Y=0.32X$, $F_{(1,124)}=74.85$, $R^2=37.64$, $P<0.001$).

than younger ones. When comparing the knowledge of medicinal plants between female (70) and male (56) by chi-square statistics, *t*-test and analysis of variance. We found no differences in knowledge of the plants between the two. The knowledge of medicinal plants between females and males has no significance Fig. 4.

4. Discussion

The Tai Yai is a social group with characteristic culture and language transmitted from their ancestors. They have applied plants around themselves in their livelihood, and for well-being. Tai Yai is an example of interdependence between humans and the nature. The wisdom and knowledge become their identity. Local traditional plant knowledge is the combined knowledge based on the lifestyle, beliefs and trial and error practices of the communities which is passed on from generation to generation. It is being increasingly felt that, this indigenous knowledge not only needs to be preserved but also documented (Tetali et al., 2009). In addition, some plants are used as important herbs and to make money for people in the community. The medicinal plant species, the highest percentage, use value were cause of these plants used for, birth-related conditions or after birth or birth. They are most important species used to treat Tai Yai women's health conditions, including postnatal and for treatment after birth (Taoprasert and Taoprasert, 2006; Khuankaew et al., 2013). The highest number of Informant consensus factor was for metabolic system disorders. This category had fewer citations and species compared to the other categories. Some plants were used in more than 1 ailment category various parts were used for preparation. Other ethnobotanical studies have been reported in Northern Thailand (e.g. Taoprasert and Taoprasert (2006), Khuankaew et al. (2013)). Some plants are also used by the Lahu, Lawa, Karen and other ethnic groups.

We found that most the knowledge about the total number of medicinal plants known and used by the informants positively correlated with the age group. Old people use more medicinal species than younger ones. This ancient knowledge is disappearing in the younger generations (Estomba et al., 2006). We interviewed a range of ages. The younger had less knowledge of medicinal plants than old people in all the villages. This may be because of lack of experience with traditional herbal medicine, which is very important to transfer of knowledge. Medical advances and treatment in hospitals reduces exposure to traditional medicine. In this respect, in face of globalization, education and in spite of increasing socio-economic welfare, well-developed roads and medical facilities, the tradition of using plants for the treatment of some diseases still continues (Long and Li, 2004). In addition, living conditions of these aboriginal communities at present seem to endanger the transmission of traditional knowledge, including wild plant use, to future generations. For example, Ladio and Lozada (2001, 2003) documented that in Mapuche communities, wild plant knowledge decreases with age. Estomba et al. (2006) showed that native medicinal plant use increases with age, i.e. older people use more medicinal species than younger ones (also Dovie et al., 2008). Srithi et al. (2009) found an absence of knowledge in the new generation. This knowledge in the use of plants is being lost in various ethnic groups. The younger generations have not learned enough about the herbal tradition to keep the practice going (Long and Li, 2004). Knowledge of using plants as remedies is apparently the result of transmission from the old to the younger. Most inherited knowledge is passed down from ancestors to parents to the next generation. They only remember how to use them. They do not take notes or write a treatise on them. All of these are causing new generations to neglect traditional knowledge.

In regard to the influence of age of the villages on individuals' knowledge about medicinal plants, this study found no differences in knowledge of the used plants in the 4 Tai Yai villages estimated to have immigrated into Thailand at the different times. Period of immigration did not affect the knowledge of the ethnic groups. It is possible that the knowledge of Tai Yai have brought with them a strong culture (cultural coherence). A similar same ethnobotanical study reported (Inta et al.,2008). Because all the 4 villages are under the similar societal influences and somewhat similar ecological conditions, most of the traditional knowledge in usage of medicinal plants of the Tai Yai is similar among the 4 villages.

There was no difference in the knowledge of the men and the women in this study because the medicinal plants is the combined knowledge based on the lifestyle and practiced of their livelihood which is passed on from parents. Moreover, there was no division of tasks and both sexes participated in the activity of collecting medicinal plants (Sa' e Silva et al., 2009).

However, this study also demonstrated the wider relationship between people and the traditional knowledge of plants. To take

advantage for development of scholarly and economic value and for applications in the medical industry, traditional plant uses should be conserved. It is possible that in the future the knowledge will be lost or changed. Therefore, collected research about the knowledge of plants will prevent the loss of ethnobotanical knowledge.

5. Conclusions

The research has enabled us to document the traditional knowledge in usage of medicinal plants by Tai Yai in Northern Thailand, still today, a certain wealth of ethnobotanical information, especially that obtained by interviewing the elderly. The medicinal plant in this study might be helpful in other studies likewise developing new medicines or other products. In addition to medicinal plant usage, our study provided insight into the transmission of medical plant knowledge. Regardless of time since immigration and gender, we found that younger people had less knowledge of medicinal plants than older ones. This result indicates a loss of accumulated knowledge, which is likely due to development and modernization that may increase modern medical practices. To improve the knowledge of medicinal plants and prevent the knowledge-loss, future work documenting medicinal plant identification and treatment preparation are needed.

Acknowledgments

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References

Aummatayakul, P., 1994. The Migration of Shan People into Chiang Mai Province. Chiang Mai University, Chiang Mai, Thai.
Bye, R.A., 1986. Medicinal plant of Sierra Madre: Comparative study of Tarahumara and Mexican market plants. Econ. Bot. 40 (1), 103–124.
Cook, F.E.M., 1995. Economic Botany Data Collection Standard. Royal Botanic Gardens, Kew, United Kingdom.
Conway, S., 2006. The Shan Culture. Art and Crafts. River Books Co., Ltd, Bangkok, pp. 11–13.
Dovie, B.K.D., Witkowski, T.F.E., Shackleton, M.C., 2008. Knowledge of plant resource use based on location, gender and generation. Appl. Geogr. 28, 311–322.
Estomba, D., Ladio, A., Lozada, M., 2006. Medicinal wild plant knowledge and gathering patterns in a Mapuche community from North-western Patagonia. J. Ethnopharmacol. 103, 109–119.
Gardner, C., Sitthisoonton, P., Anusansoonton, W., 2006. Flora of Northern Thailand. Department Of Biology, Faculty of Science, Chiang Mai University, Chiang Mai (in Thai).
Gomez-Beloz, A., 2002. Plant use knowledge of the Winikina Warao: the case for questionnaires in ethnobotany. Econ. Bot. 56, 231–241.
Heinrich, M., Ankli, A., Frei, B., Weimann, C., Sticher, O., 1998. Medicinal plants in Mexico: healers' consensus and cultural importance. Soc. Sci. Med. 47, 1859–1871.
Huai, H., Pei, S., 2004. Medicinal plant resources of the lahu: a case study from Yunnan Province, China. Hum. Ecol. 32 (3), 385–388.
Ibrar, M., Hussain, F., Sultan, A., 2007. Ethnobotanical studies on plant resources of Ranyal Hills, District Shangla, Pakistan. Pak. J. Bot. 39 (2), 329–337.
Inta, A., Pei., S., Balslev, H., Wangpakapattanawong, P., Trisonthi, C., 2008. A comparative study on medicinal plants used in Akha's traditional medicine in China and Thailand cultural coherence or ecological divergence? J. Ethnopharmacol. 116, 508–517.
Khuankaew, S., Wangpakapattanawong, P., Jampeetong, A., 2013. Relationship of Tai Yai Livelihood and Biodiversity to traditional knowledge. Khon Kaen University Sci. J. 41 (2), 298–308.
Ladio, A.H., Lozada, M., 2001. Nontimber forest product use in two human populations from northwest Patagonia: a quantitative approach. Hum. Ecol. 29, 367–380.
Ladio, A.H., Lozada, M., 2003. Comparison of wild edible plant diversity and foraging strategies in two aboriginal communities of northwestern Patagonia. Biodivers. Conservation 12, 937–951.
Lee, S., Xiao, C., Pei, S., 2008. Ethnobotanical survey of medicinal plants at periodic markets of Honghe Prefecture in Yunnan Province, SW China. J. Ethnopharmacol. 117, 362–377.
Long, C., Li, R., 2004. Ethnobotanical studies on medicinal plants used by the Red-headed Yao People in Jinping, Yunnan Province, China. J. Ethnopharmacol. 90, 389–395.
Martin, G.J., 1995. Ethnobotany: A Methods Manual. Chapman & Hall, London.
Mesatan, W., 2001. Encyclopedia ethnic Tai Yai. Mahidol University, Bangkok, pp. 16–21. (in Thai).
Pankhurst, R., 1990. An Introduction to the Medical History of Ethiopia. The Red Sea Press Inc., Trenton, NJ.
Phillips, O., Gentry, A.H., Reynel, C., Wilkin, P., Galvez Durand, B.C., 1994. Quantitative ethnobotany and Amazonian conservation. Conservation Biol. 8, 225–248.
Ramitanon, C., Somsawat, W., Wichasil, R., 1998. Tai: TAI, Women's Studies Center, Faculty of Social Sciences. Chiang Mai University, Chiang Mai (in Thai).
Sa′ e Silva, I.M.M., Marangon, L.C., Hanazaki, N., Albuquerque, U.P., 2009. Use and Knowledge of fuelwood in three rural caatinga dryland communities in NE Brazil. Environ., Dev. Sustainability 11, 833–852.
Santasombat, Y., 2001. Biodiversity and Indigenous Knowledge for Sustainable Development. Chiang Mai University, Chiang Mai (in Thai).
Santisuk, T., Larsen, K., 1999. Flora of Thailand. The Forest Herbarium, Royal Forest Department, vol. 7, part 1. Diamond printing, Bangkok.
Santisuk, T., Larsen, K., 2000. Flora of Thailand. The Forest Herbarium, Royal Forest Department, vol. 7, part 2. Diamond printing, Bangkok.
Singh, A.K., Singh, K.P., 2009. An ethnobotanical study of medicinal plants in Chandauli District of Uttar Pradesh, India. J. Ethnopharmacol. 121, 324–329.
Srisawat, B., 2004. 30 Ethnic Groups in Chiang Rai. Siam, Bangkok p. 53. (in Thai).
Srithi, K., Balslev, H., Wangpakapattanawong, P., Srisanga, P., Trisonthi, C., 2009. Medicinal plant knowledge and its erosion among the Mien (Yao) in northern Thailand. J. Ethnopharmacol. 123, 335–342.
Suksri, S., 2003. Ethnobotany in Bung Khong Long Non-Hunting area, Changwat Nong Khai (M.Sc. thesis). Kasetsart University, Bangkok (in Thai).
Tangtragoon, T., 1998. Ethnobotany of the Khamu, Lawa and H'tin in Some Areas of Nan Province (M.Sc. thesis). Chiang Mai University, Chaing Mai (in Thai).
Taoprasert, Y., Taoprasert, K., 2006. Medical Texts and Tai Yai's Herbal Tribes (Shan). Chiang Rai Rajabhat University, Chiang Rai (in Thai), pp. 6–8.
Teklehaymanot, T., Giday, M., Medhin, G., Mekonnen, Y., 2007. Knowledge and use of medicinal plants by people around Debre Libanos monastery in Ethiopia. J. Ethnopharmacol. 124, 69–78.
Teklehaymanot, T., 2009. Ethnobotanical study of knowledge and medicinal plants use by the people in Dek Island in Ethiopia. J. Ethnopharmacol. 124, 69–78.
Tene, V., Malag´on, O., Finzi, P.V., Vidari, G., Armijos, C., Zaragoza, T., 2007. An ethnobotanicalsurvey of medicinal plants used in Loja and Zamora-Chinchipe, Ecuador. J. Ethnopharmacol. 111, 63–81.
Tetali, P., Waghchaure, C., Daswani, P.G., Antia, N.H., Birdi, T.J., 2009. Ethnobotanical survey of antidiarrhoeal plants of Parinche valley, Pune district, Maharashtra. India J. Ethnopharmacol. 123, 229–236.
Tovaranonte, J., 1998. Ethnobotanical study of the Tai Lue, Hmong and Yao in Some Areas Nan Province (M.Sc. thesis). Chiang Mai University, Chiang Mai (in Thai).
Tovaranonte, J., Chukeatirote, E., 2005. Ethnobotanical survey of indigenous plants used by Tai Lue community at Wiang Kaen, Chiang Rai. Congress on Science and Technology of Thailand at Suranaree University of Technology, 18–20 October (in Thai).
Trek Thailand Team. 2012. Thailand Northern Provinces (Online). Available from: ⟨http://www.trek⟩ Thailand.net/p1/ (accessed 10.12.12).
Trisonthi, C., Trisonthi, P., 2009. Ethnobotanical study in Thailand, a case study in Khun Yuam District Maehongson Province. Thai J. Bot. 1 (1), 1–23.
Trotter, R.T., Logan, M.H., 1986. Informant consensus: a new approach for identifying potentially effective medicinal plants. In: Etkin, N.L. (Ed.), Plants in

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Payments for biodiversity conservation in the context of weak institutions: Comparison of three programs from Cambodia ☆

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ABSTRACT

Implementing any conservation intervention, including Payments for Ecosystem Services (PES), in the context of weak institutions is challenging. The majority of PES programs have been implemented in situations where the institutional framework and property rights are strong and target the behaviours of private landowners. By contrast, this paper compares three PES programs from a forest landscape in Cambodia, where land and resource rights are poorly defined, governance is poor, species populations are low and threats are high. The programs vary in the extent to which payments are made directly to individuals or to villages and the degree of involvement of local management institutions. The programs were evaluated against three criteria: the institutional arrangements, distribution of costs and benefits, and the conservation results observed. The most direct individual contracts had the simplest institutional arrangements, the lowest administrative costs, disbursed significant payments to individual villagers making a substantial contribution to local livelihoods, and rapidly protected globally significant species. However, this program also failed to build local management organisations or understanding of conservation goals. By contrast the programs that were managed by local organisations were slower to become established but crucially were widely understood and supported by local people, and were more institutionally effective. PES programs may therefore be more sustainable when they act to empower local institutions and reinforce intrinsic motivations.

1. Introduction

Although the global benefits of conservation and ecosystem services are well recognised (Balmford et al., 2002; Daily, 1997; Stern, 2006), these benefits are often valued differently at the local level (Kremen et al., 2000), and there may be local costs associated with conservation. Payments for ecosystem services (PES) have been proposed as a mechanism for changing incentives for local people and Governments to more accurately reflect global benefits (Ferraro, 2001; Ferraro and Kiss, 2002; Wunder, 2007). PES have been described as voluntary transactions where a well-defined environmental service is bought by a buyer (i.e. someone who is willing to pay for it), if and only if the provider secures the provision of such service (Wunder, 2005). This view of PES is based in Coasean economics, where transaction costs are assumed to be low and property rights clearly defined. The largest global PES programs are government programs in developed countries, such as conservation easements in the USA or the Common Agricultural Policy in Europe (Ferraro and Kiss, 2002). These programs conform to the Coasean view: land ownership or resource tenure is clearly defined, these rights are protected by law, enforcement agencies are well funded, and there are credible external monitoring systems. Within the past 10–15 years a number of government-financed PES programs have been established in developing countries with similarly well-defined institutional frameworks (Engel et al., 2008), including the Costa Rican payments for environmental services program (Pagiola 2008; Zbinden and Lee, 2004) and Mexico's payments for hydrological environmental services program (Muñoz-Piña et al., 2008). In addition, there are a growing number of user-financed programs, such as payments for watershed services between downstream users and upstream forest owners in Ecuador (Wunder and Albán, 2008) and Bolivia (Asquith et al., 2008), and contracts brokered between organisations and private landowners, communities or governments (Milne and Niesten, 2009). In the vast majority of cases, but not all, these PES programs have been established in situations where property rights

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are clearly defined, although other aspects of the institutional framework may be weaker.

Wunder (2007) suggested that effective implementation of PES may be considerably more difficult where institutions are weak. In many countries land ownership and resource tenure are unclear, with land and resources technically still owned and managed by the state (Agrawal et al., 2008); natural resources have high rents thereby attracting resource grabs and corruption; powerful individuals can often act with impunity; and government agencies have poor capacity and may receive little political support. These are also the conditions known to lead to high rates of habitat destruction and over-exploitation of natural resources (Chomitz et al., 2007; Geist and Lambin, 2003). The high level of threat to species and habitats means that some of these areas are of the highest urgency for conservation. Institutional failure is problematic for implementation of a PES program to protect biodiversity for a number of reasons: poorly defined property rights makes it challenging to determine who to pay, contracts cannot be legally enforced, elite capture is common, and enforcement of laws (e.g. prohibiting land clearance) may be weak. However, institutional failure makes it challenging for any conservation intervention to succeed (Barrett et al., 2001), hence a critical area for research is to understand which approach is most effective given these circumstances.

Muradian et al. (2010-this issue) have proposed a continuum of types of PES as an alternative to Wunder's and Ferraro's original descriptions, ranging from direct payments that conform to the Coase theorem, to collective action problems where property rights may be poorly defined and benefit distribution is unclear. This paper compares three PES programs for biodiversity conservation that were implemented within a weak institutional setting in Cambodia, for wildlife populations and their habitats that were either under open-access or common property regimes. The three programs vary in the extent to which payments were made at the individual or collective level, ranging from direct payments to individuals for bird nest protection; a hybrid program that combines agri-environment payments to farmers with local management by a village authority; and a community-based tourism enterprise based on collective action. All were designed in response to a high level of threat where conservation opportunity costs, at least for conversion of forest lands, were also moderately high. The comparison focuses on the institutional effectiveness of the programs: the institutional arrangements, the distribution of costs and benefits, and the conservation results observed. A full evaluation of program impacts on wildlife or habitats (c.f. Ferraro and Pattanayak, 2006) is beyond the scope of this paper; the programs were initiated only recently and as yet insufficient data exist for comparison of implementation sites with controls.

2. Description of the PES Programs

2.1. Background

Cambodia lies within the Indo–Burma hotspot (Myers et al., 2000) and contains four of the Global 200 Ecoregions (Olson and Dinerstein, 1998). The country is of global conservation importance due to the largest remaining examples of habitats that previously spread across much of Indochina and Thailand, which still contain nearly intact species assemblages, albeit at heavily reduced densities (Loucks et al., 2009). These include the deciduous dipterocarp forests that once supported the greatest aggregation of large mammals and waterbirds outside the African savannas (Wharton, 1966). Many of these species are listed on the IUCN (International Conservation Union) Red List (WCS, 2009), including 45 mammals (7 Critically Endangered or Endangered), 46 birds (12 Critically Endangered or Endangered, including the Giant and White-shouldered Ibises, *Pseudibis gigantea* and *P. davisonii*) and 17 reptiles (9 Critically Endangered or Endangered). Conservation strategies are therefore frequently focused on remnant populations of highly threatened species where there is little room for error. Hunting, habitat destruction and human disturbance–both by residents and immigrants–are the major and urgent threats to biodiversity conservation. National annual deforestation rates were 0.7% during 1973–1997 (DFW, 1998) and 0.5% during 2000–2005 (Forestry Administration, 2008), despite the fact that since 2002 most forest clearance has been illegal. Based on these statistics Cambodia has one of the highest rates of land-use change globally. Deforestation is driven by a variety of processes, including large-scale development projects such as agro-industrial concessions, improved road access, population growth, and smallholder encroachment both by landless in-migrants and established communities (Forestry Administration, 2009). Encroachment is attractive to local people because land is an easily available secure form of wealth which is viewed as an open-access resource and enforcement of laws is rare. Many plots are claimed but not cleared, forcing new farmers to move further into the forest (An, 2008).

Initial conservation strategies in Cambodia focused on protected area (PA) management. The PAs were established from 1993 and have a small number of poorly paid staff with limited capacity or infrastructure, i.e. they are 'paper parks' (Wilkie et al., 2001). PAs usually contain existing human settlements with unclear property rights, as is often observed in other countries (Bruner et al., 2001). The Cambodian PA system was also declared based on relatively little information and consequently excludes many areas of importance for biodiversity conservation, again not an uncommon situation (Brooks et al., 2004), emphasising the importance of working both inside and outside PAs. Under these conditions PA management is not sufficient to achieve biodiversity conservation goals.

The Ministry of Environment and Ministry of Agriculture, Forestry and Fisheries, with the support of the Wildlife Conservation Society (WCS), an international Non-Governmental Organisation (NGO), instituted a series of pilot PES programs as a complement to protected area management in 2002. This paper compares three different programs which were initiated in the same villages within two PAs in the Northern Plains landscape; the 4025 km^2 Kulen Promtep Wildlife Sanctuary, which was established in 1993 and is managed by the Ministry of Environment, and the 1900 km^2 Preah Vihear Protected Forest, declared in 2002 and managed by the Forestry Administration of the Ministry of Agriculture, Forestry and Fisheries. Both PAs contain or are used by long-established communities that practice either lowland rain-fed paddy rice cultivation or upland shifting cultivation for rice and other crops, collection of forest products and fishing (McKenney and Prom, 2002; McKenney et al., 2004). Forest resources are a crucial livelihood safety net, and provide cash income particularly from the sale of liquid resins from dipterocarp trees (McKenney and Prom, 2002; McKenney et al., 2004).

For the two village-managed programs, payments were initiated following an initial two-year participatory land-use planning process, which established forest management zones and clarified ownership over land and natural resources (Rock, 2001). The land-use plan is approved by the relevant Government authorities and is managed by an elected village committee of nine people. It specifically sets out which areas can be used for agriculture and residential land, including expansion areas that are currently forest. The village organisations and approved land-use plans provided the necessary institutional foundation for subsequent initiation of the PES programs.

2.2. Community-based Ecotourism

The community-based ecotourism program was initiated in 2004 in the village of Tmatboey in Kulen Promtep Wildlife Sanctuary, following initial awareness-raising in 2002–2003, and has since been replicated in other villages in the landscape. We focus here on Tmatboey, although the program operates in a similar manner at the other village sites. Tmatboey is a small village of 236 families, located in a large mosaic of

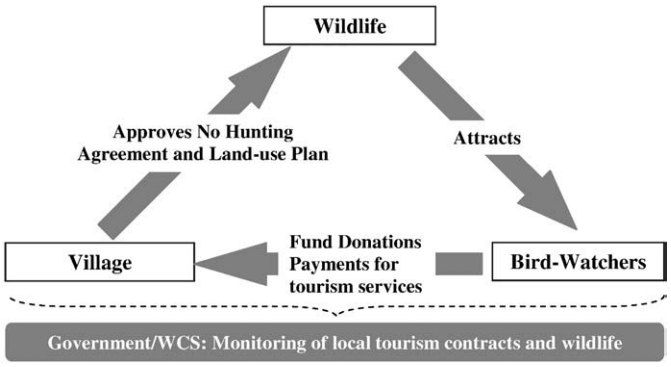

Fig. 1. Design of the community-based ecotourism program.

deciduous dipterocarp forest, seasonally flooded grasslands and wetlands. The total village area is about 25,780 ha, of which only a small proportion (620 ha) is currently used for agriculture. The site fulfils many of the criteria for a successful ecotourism location (Wilkie and Carpenter, 1999): it contains rare species that are high profile targets for international birdwatchers (e.g. the Giant Ibis); sightings are reliable year-round; access is relatively easy from the major tourism centre at Siem Reap, which receives more than 2 million visitors annually and has an international airport; accommodation standards have improved as village capacity has increased; and prices are moderately inexpensive. The ecotourism program aims to conserve the globally threatened wildlife through establishing local village-level tourism enterprises that directly link revenue received to long-term species conservation (Fig. 1). This link is provided by the agreement between the PA authorities, WCS and the village, which stipulates that tourism revenue is subject to the villagers stopping hunting of key species and abiding by the land-use plan. This is reinforced by fees that are paid by all visitors: $30 per person if all key species are seen and $15 if only a subset are. A detailed description is given in Clements et al. (2008).

Institutionally, the program relies on four parties, each of whom plays a key role:

- Elected village committees: site management of tourism services, management of income received and fund disbursements, local enforcement following no-hunting agreements and land-use plans, report serious violations to PA authorities;
- PA authorities: legally approve tourism agreements and local land rights, law enforcement;
- Sam Veasna Center: a local civil society partner based in Siem Reap that is responsible for marketing, site promotions, tourism bookings management and monitoring on behalf of the village-level enterprises;
- Private sector: tourist bookings provide revenue.

WCS plays a general support role to all parties, and monitors the agreements.

2.3. Agri-environment Payments: Wildlife-Friendly Products

Tourism has limited potential for replication because all villages support a similar species mix, and the international birdwatching market is of restricted size. The agri-environmental payment program was therefore initiated in 2007 as an alternative community-based payment program that could be replicated widely. Under the program, farmers that keep to the land-use plan and no-hunting rules are allowed to sell their rice through the village committee responsible for management of the land-use plan to a marketing association (Fig. 2). The association offers preferential prices to the farmers, which are supported by directly selling the rice to national market centres, bypassing middlemen who previously monopolised village trade, and through selling to tourist hotels under the 'Wildlife-Friendly' certification system, a new global brand. The association also provides start-up capital and training in new agricultural techniques. All profits are shared between the farmers and the village organisations, after deducting the costs of the association. Payments to individual farmers are linked to monitoring by the village committee of their compliance with the land-use plan and no-hunting rules and external verification by the marketing association. The payment value was set based on the market premium available for the products, not based on assessment of the opportunity costs to farmers of further encroachment. For farmers with sufficient labour or access to machinery these opportunity costs are likely to be high, since alternative forms of employment are limited. The committee also receives a share of the profits, which provides added motivation (and income) for their work.

2.4. Direct Contracts for Bird Nest Protection

The globally threatened large birds found in the Northern Plains are heavily threatened by human disturbance and particularly the collection of nests for eggs and chicks, some of which can fetch prices of >US$100 in the national and international wildlife trade. The collection is mostly done by local communities, who then re-sell the eggs and chicks to middlemen. The Bird Nest Protection program was initiated in 2002 in order to locate, monitor and protect the remaining nesting sites. Under the program, local people are offered a reward of up to US$5 for reporting nests, and are then employed to monitor and protect the birds until the chicks successfully fledge. Protectors receive $1/day for their work and an extra $1/day worked upon completion if the chicks successfully fledge. The full payment is made if it can be verified that nests failed due to natural causes, including predation. The total payment of $2/day was judged an acceptable daily wage based on initial village consultations. The protection teams are regularly visited every 1–2 weeks by village rangers employed by WCS and by WCS monitoring staff to check on the status of the nests and for the purposes of research and data collection. The program operates year-round, as some species nest in the dry season and others during the wet season. It started in four pilot villages in 2002 in Kulen Promtep Wildlife Sanctuary and was extended to Preah Vihear Protected Forest in 2004. By 2007 it

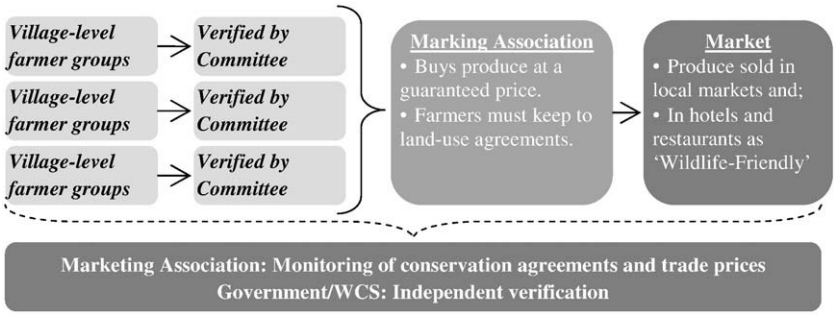

Fig. 2. Design of the agri-environment program.

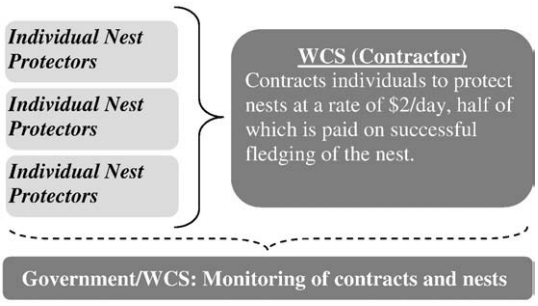

Fig. 3. Design of bird nest payments.

was operating in >15 villages. Unlike the previous two examples the bird nest protection program works entirely through individual contracts; it is not community-based (Fig. 3).

3. Outcomes of the PES Programs

3.1. Community-based Ecotourism

Table 1 shows the growth of the ecotourism program in Tmatboey. At the village scale the ecotourism program has helped to educate the local people about the importance of the bird species and their potential value. Villages have developed and locally enforce their own rules about which species are protected and have agreements about the conservation of nesting and feeding sites (A. John, pers. obs.). Substantial increases in wildlife numbers have been seen at the first village site, Tmatboey. For example the population of White-shouldered Ibis, one of the rarest birds in the world (Hirschfeld, 2009), has increased from one nest and a single pair in 2002 to at least six nests and 23 individuals in August 2008 (Fig. 4). In addition, local people have begun to enforce the land-use plan regulations, for example by refusing to accept in-migrants and controlling where new forest is cleared (A. John, unpublished data). Tmatboey, for example, refused 69 in-migrant families that tried to settle in 2007 alone. Self-enforcement is usually based on local verbal or written contracts between individuals and the committee to stop illegal activities or relocate agricultural plots within land-use plans, rather than levying strong punishments. Significant challenges remain, particularly as escalating national land prices have dramatically increased incentives for land-grabbing both by villagers and in-migrants.

Tourism numbers at Tmatboey have increased by an average of 36% annually since 2005 (Table 1). Revenue, however, increased by an average of 100%/annum over the same period, as the villagers have improved service quality, allowing them to raise prices, and diversified the range of services provided so that they capture a greater proportion of the value chain. As a consequence the average per tourist payment for services increased from $10 in 2004 to $67 in 2008 and the percentage of tourism revenue spent locally has risen from 11% to 24%. Costs not captured by the village include transportation, hotel bookings before and after the visit and English-speaking tour leaders. By the 2007–2008 season the village received >$12,000 in revenue, of which >$3500 was contributions to the village fund and nearly $8500 used to pay for services provided by villagers. Not all service payments are retained locally, since the villagers have to import goods not available in the village. In 2007–2008 25 individuals (from 236 families) were employed on a part-time permanent basis as guides, cooks and guesthouse managers, receiving on average $20–40/month each during the tourism season (average of $160/year, maximum $400). These sums are significant for families that depend on subsistence agriculture and forest products, where average cash incomes per family are $350–$500/year. A further 65 individuals benefited in some manner through temporary employment (e.g. occasional guides, guesthouse maintenance, carrying water), or through local trade within the village mainly for food. In total, therefore, around 40% of families were involved to some extent in the program. Donations to the village fund have been used to help pay for a new school, building a road, fish ponds, repairing waterpumps and digging of new wells. Some of the profits were used by the committee to pay villagers for local patrols and guarding of nesting birds.

3.2. Agri-environment Payments

Table 2 shows the results from the first full year of the agri-environment payment program in 2008. Farmers were offered an average price of $0.25/kg of rice plus profit-sharing, representing an initial premium of 200% over the standard price offered by the middlemen. However, in response to the competition the middlemen raised their price to $0.22/kg and in addition offered to use the village's scales, since the middlemen's was widely suspected to be biased. Despite this the villagers still preferred to sell through the village committee. Farmer interviews indicated that they preferred to sell to 'their own people' rather than outside middlemen, because they trusted the village committee, were treated with respect, the process was transparent, they had control over their own future, and they liked the idea that profits would come back to the village in the future (A. John, unpublished data). There was considerable variation between farmers, since some had more rice of appropriate quality than others, so the median payment was $160, with one farmer earning $908. The actual premium in all cases was much lower, given that the middlemen had raised their prices to be competitive. In total, the villages captured about 55–65% of the total revenue from the rice sale, with the remainder being transport, processing, marketing and certification costs. A very large number of families expressed interest in joining the program, but only 38 had rice of the appropriate type to sell through the program; this is expected to increase rapidly in future years as farmers adopt standardised techniques.

Local enforcement of land-use plan regulations has also been observed in the four agri-environment program villages. The percentage of families that have been recorded breaking land-use plans in each village is <8%, whilst three of the four villages have refused to accept in-migrants (the fourth is remote and no in-migrants tried to settle there). The effect of the agri-environment program in protecting species is unclear, but the program has only been in operation since late 2007 and it is probably too early to draw conclusions. As with the ecotourism program, local self-enforcement is based on verbal or written contracts

Table 1
Tourism revenue in Tmatboey, 2003–2008.

Year	Visitors	Total	Fund	Services	% of overall revenue captured by the village	Average service payment/tourist	Payments to villagers	Regular employees	Total beneficiaries
2003–4	13	$498	$370	$128	11.4%	$10	$128	n/a	n/a
2004–5	51	$2588	$1530	$1058	14.1%	$21	$ 820	n/a	n/a
2005–6	72	$3553	$2100	$1453	14.1%	$21	$1158	12	35
2006–7	78	$5521	$2220	$3301	19.9%	$42	$1997	13	51
2007–8	125	$12,807	$4295[a]	$8512	23.9%	$68	$5846	25	90

[a] Tmatboey also received the United Nations Development Programme Equator Prize in 2008, which contributed a further $5000 to the fund.

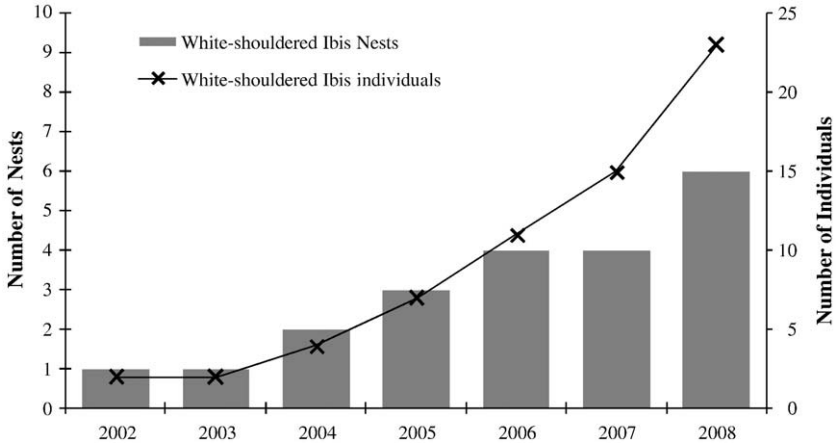

Fig. 4. White-shouldered Ibis populations at Tmatboey, 2002–2008.

between farmers and the committee to stop illegal activities or relocate ricefields within land-use plans, rather than strong punishments. At least eight families in two of the villages have relocated agricultural the agri-environment program contracts.

3.3. Bird Nest Protection Program

The bird nest program has been extremely successful at protecting nesting sites (Table 3), safeguarding over 1200 nests of globally threatened or near-threatened species since 2002, including 416 nests in 2007–2008. Very few protected nests have been collected by hunters, although it is not uncommon to find unprotected nests that have been collected. The numbers of nests monitored and protected has increased by 36% on average each year since 2004. Most of this increase is due to greater numbers of Sarus Crane *Grus antigone*, Vultures (*Sarcogyps calvus* and *Gyps bengalensis*), Oriental Darter *Anhinga melanogaster* and Lesser Adjutant *Leptoptilus javanicus* nests being found, suggesting that persecution and nest collection were the main factors limiting populations of these species. By contrast, Giant Ibis numbers have remained constant despite a high rate of breeding success (Keo et al., 2009), implying that other factors such as conversion of feeding habitats to agriculture and human disturbance are the primary threats to this species, as other studies have shown (An, 2008; Keo, 2008). The bird nest program does not directly target habitat protection, and interviews suggest that bird nest protectors are not able to protect breeding sites or feeding areas from other villagers or outsiders (A. John, pers. obs.). Villages with only the bird nest payments, but no ecotourism or agri-environment payments, regularly accept in-migrants who then contribute to deforestation and habitat loss. For example, in 2008 the nesting trees used by Greater Adjutant *Leptoptilus dubius* were cleared by in-migrants near the village of Antil. This is one of only two colonies recorded in Southeast Asia for this species.

A detailed breakdown of the bird nest payments made in the 2005–2006, 2006–2007 and 2007–2008 seasons is given in Table 4. The total cost to WCS of the program is around $25,000/year, with an average cost of $65–$120 per nest protected. The average cost has declined as the number of nests has increased, partly because monitoring costs can be shared between adjacent sites and also due to a greater number of nests at colonial sites. 71–78% of the spending went directly to local people, either protectors or village rangers, with the remaining expenditure being monitoring costs incurred by WCS. Average payments per family are around $100/year, with considerable variation depending upon how long people are employed. Some individuals are specialist protectors,

Table 2
Payments from agri-environment scheme 2008.

	Villages	Rice bought	Total rice payments	Profit-sharing	Total payments to village	% revenue captured by village	Families involved	Average (median) family payment
Total	4	35,534 kg	$8740	$1890	$10,631	55–69%	38	$255 ($160)
Village average	1	8884 kg	$2185	$473	$2658			

Table 3
Bird nest protection program: nests protected, 2002–2008. In some cases nests were protected but there is no data available. '–' indicates species that were probably present, but were not protected in that year. Initially the program started at one site and operated in two sites from 2004. Numbers found have grown by 36%/year since 2004.

Species	Global status	2002–3 (1 site only)	2003–4 (1 site only)	2004–5 (2 sites)	2005–6 (2 sites)	2006–7 (2 sites)	2007–8 (2 sites)
		Nests (colonies)	Nests (colonies)	Nests (colonies)	Nests (colonies)	Nests (colonies)	Nests (colonies)
Giant Ibis	Critical	–	5	27	28	28	29
Sarus Crane	Vulnerable	–	6	19	29	37	54
Vultures	Critical	–	–	1	4	5	5
Black-necked Stork[a]	Near-threatened	–	–	–	2	3	2
Oriental Darter	Near-threatened	13	–	–	-	26 (1)	33(1)
Greater Adjutant	Endangered	–	(Present)	21(2)	17(2)	18 (2)	10(2)
Lesser Adjutant	Vulnerable	–	34(5)	97(16)	134(15)	221(22)	277(27)
Totals		13	45+	164	216	338	410

[a] *Ephippiorhynchus asiaticus.*

Table 4
Bird nest protection program: costs, 2005–2008.

	2005–6	2006–7	2007–8
Local payments	$19,850	$19,119	$19,236
(%)	(78%)	(74%)	(71%)
Nest protection payments	$12,597	$11,248	$11,588
Community rangers	$7253	$7871	$7648
WCS monitoring	$5603	$6800	$7747
(%)	(22%)	(26%)	(29%)
Expenses	$2506	$3640	$4192
Salaries	$3098	$3160	$3555
Total	$25,453	$25,918	$26,986
Nests protected	216	342	416
Average cost/nest	$118	$77	$66
Villages	13	17	16
Average total payments/village	$1527	$1125	$1202
Maximum total payments/village[a]	$3713	$3775	$3449

[a] Antil village received the greatest total payments in each year.

switching species depending on the season and receiving continual employment for several months. The amounts paid, sometimes >$400/individual, are substantial in comparison with other cash income options. Payments per village average $1100–$1500, depending on the year, but some villages earn considerably more due to the presence of a large number of key species, or species with particularly long breeding periods. Antil village made the greatest amount, totalling nearly $11,000 of payments over the three seasons, mainly due to the presence of the Greater Adjutant colony which requires at least 6 months of protection each year.

4. Comparison of the Different PES Programs

4.1. Institutional Arrangements

Institutions are defined by North (1990) as: "the rules of the game in a society or, more formally, ... the humanly derived constraints that shape human interaction". Organisations are groupings of individuals that operate within the institutional framework. This framework includes property rights, monitoring, enforcement, governance and contracting arrangements (Table 5). Of the three PES programs described the bird nests program has the simplest institutional arrangements, since it relies on a direct contract between the individual and the conservation NGO to protect biodiversity. It is assumed that individuals can temporarily control a breeding site even if they do not own it. Regular monitoring by the conservation NGO ensures compliance. Simple contracting can fail however if not adequately supported by the institutional framework. For example, the Monarch Butterfly project in Mexico purchased logging rights from forest-dwellers to protect butterfly habitat; however most illegal logging was performed by powerful outsiders, which local people were incapable of preventing (Missrie and Nelson, 2005). Similarly, Cambodian bird nest protectors were unable to stop others from clearing breeding sites.

Both the ecotourism and agri-environment programs have more complex institutional arrangements. The ecotourism contract is made directly with a village organisation, which has been approved by the Government to develop local land-use regulations, whilst the agri-environment program is a hybrid program; the village organisation then sub-contracts to individual farmers. The village institutions–the local rules governing natural resource management–are nested in a multi-layered framework that includes:

- an external agency that provides rewards by connecting the villages to national and international markets, certifies compliance, and helps to mediate conflicts;
- PA authorities, who can enforce environmental and forestry laws, supporting village institutions to resolve cases they are unable to solve internally or to remove outsiders; and
- external organisations, including private sector companies and NGOs, that reinforce rules and can assist with resolving conflicts or other problems (such as talking to donors and higher Government authorities).

Monitoring of compliance (Keane et al., 2008) is conducted at all levels: local monitoring by village institutions, certification by the external agency, and enforcement of national laws by the PA.

Table 5
Summary comparison of the three direct payment programs.

	Community-based ecotourism	Agri-environment payments	Bird nest protection
Institutionality			
–Organisational arrangements	Four actors: Village: management PA: enforcement External agency: certification & marketing Private sector: sales	Four actors: Village: management PA: enforcement External agency: certification & marketing Private sector: sales	Two actors: Individuals: protection WCS: monitoring and making payments
–Property rights	Forest: common property co-managed by the village and the PA	Forest: common property co-managed by the village and PA; individually owned fields	Nests: *de facto* individual control
–Contracts	Tourists → village committee	Purchaser → village committee → villagers	NGO → villagers
–Local governance	Yes (local management)	Yes (local management)	No (NGO management)
–Monitoring	External agency (certification) and PA	External agency (certification) and PA	WCS
Distribution of costs and benefits			
–Initial investment	High ($50,000/village)	High ($50,000/village)	Low
–Income			
• Community funds	$1000/village (maximum $4000)	>$300/village	None
• Individuals	>$1200/village (maximum $6000) 10% of families employed, $160/year Many families receive some benefit	$2500/village 5–10% of families, median $160/year Potentially all farmers could benefit	$1200/village (maximum $4000) 5% of families employed, $120/year
–Efficiency (% of overall cost paid locally)	24% (increasing, as capacity improves)	55–60%	71–78%
–Financial sustainability?	Yes (both for community business & certification and marketing costs)	Yes (both for community business & certification and marketing costs)	No (WCS pays $25,000/year)
Conservation results			
–Conservation of			
• Key wildlife	20–100 individuals/village	20–100 individuals/village	>1000 individuals
• Habitat	10–50, ha (village area)	10–50,000 ha (village area)	0
–Targeting	Wildlife: yes Habitat: some	Wildlife: some Habitat: yes	Wildlife: yes Habitat: no

In summary, institutional arrangements under the most direct contracts program are considerably simpler than the other two examples, but this is not necessarily an advantage. The more complex institutional arrangements are multi-layered, with redundancy and reinforcement provided by different organisations (for example external monitoring by WCS, the PA and marketing or tourism agencies). These arrangements build resilience and checks in the system that ultimately may make the programs more effective and sustainable (Berkes, 2007).

4.2. Distribution of Costs and Benefits

The simplified institutional arrangements of the bird nest program lead to lower administrative costs: 71–79% of payments are disbursed at the local level (Table 5). This was predicted by Ferraro and Kiss (2002), who suggested that direct payment programs would have administrative costs of only 5–25%, far lower than indirect conservation interventions. The bird nest program was also inexpensive to establish. By contrast, the more complex ecotourism and agri-environment programs are much less efficient at disbursing revenue locally, mainly due to marketing and monitoring costs incurred by the external agencies. They are also expensive to establish, requiring substantial investments over approximately 2 years to build the capacity of the village organisations.

All three programs deliver approximately the same levels of individual income to villagers (Table 5): around $120–$160 per family participating, and an average of $1200 or a maximum of $4000–$6000 per village. Significant payments are made only to a minority of families under each program: the number of nest protectors and tourism employees is necessarily limited, and agri-environment payments are approximately proportional to the size of land holdings, meaning that wealthier individuals with larger fields will benefit the most (as suggested by Börner et al., 2010-this issue). However, in the village-managed programs decisions over who benefits are made locally rather than by an external NGO, and additional mechanisms ensure that benefits are shared more widely. For example, under the tourism a large number of villagers receive some income, whilst the agri-environment program will benefit more families as it grows. Communal development funds, managed by the village organisations, provide benefits to the entire village. These funds are extremely important because they are the only source of development assistance to the village that is entirely under local control; most other assistance is provided by NGOs or government authorities from outside the village and is driven by external priorities. All three programs are therefore inequitable to some extent, but the most direct (bird nests) benefits the least number of people and does not incorporate mechanisms for wider benefit-sharing. In Madagascar, a village-managed program was perceived to be fair by the majority of participants, despite apparent inequalities, and communal benefits were ranked highly (Sommerville et al., 2010-this issue). The same was found in the ecotourism and agri-environment payment examples described in this paper.

Direct payment programs for biodiversity conservation have been criticised as being unsustainable because they are reliant on continual funding (Swart, 2003). The bird nest program is entirely dependent on $25,000 made annually available by WCS. By contrast, both the ecotourism and agri-environment programs, once established, have the potential to be sustained through market sales.

4.3. Observed Conservation Results

All three programs target protection of wildlife, and the agri-environment and ecotourism programs also explicitly include habitat (Table 5). The bird nest program in particular provided very rapid protection for many species that were at risk of local extinction within the first few months of operation, and probably contributed to increases in these populations (Clements et al., 2009). By contrast, the village-based programs became institutionally effective only after a few years of operation and are more long-term and indirect in their conservation effect, aiming to reduce both habitat loss and over-harvesting of species. Understanding whether these programs are effective at delivering conservation will require a counterfactual comparison once they have been in operation for several years, as suggested by Ferraro and Pattanayak (2006). However, the substantial increases in species populations observed for both the bird nest and ecotourism programs are very promising, given the context of a general ongoing decline in species abundance in Cambodia (Loucks et al., 2009). The rejection of in-migrants by villages with the ecotourism and agri-environment programs is also significant, given that in-migration is known to lead to greater deforestation (An, 2008). Although rejected in-migrants might settle in other remote forest areas, displacing deforestation to another site, available information suggests that they have instead chosen to settle near major population centres outside the PAs.

Despite positive results in terms of species status, direct payments to individuals may fail to build broad local support for conservation. Villagers in Antil received $7488 during 2005–2007, much of it to protect two Greater Adjutant nesting sites. Over the same period, Tmatboey received $7475 in tourism payments, of which only $3155 was used to pay individual villagers. In both cases only a subset of the community benefited. During this period the population of White-shouldered Ibis doubled around Tmatboey due to a reduction in hunting pressure and improved protection of nesting and feeding areas, the village refused 69 families permission to settle, and undertook various other activities to curb land clearance. In Antil, however, forest encroachment and in-migration were widespread, culminating in the clearance of the Greater Adjutant colony in 2008. Villagers in Antil were not sufficiently motivated to protect this species, despite the high level of payments. Payments were widely perceived as being unfair, because only a few individuals benefited and no local institution existed to mediate conflicts.

The above example also illustrates the problem with highly targeted conservation interventions; a program's designer assumes the risk that the correct targets have been chosen to ensure success and that no perverse incentives will be created (Bowles, 2008). Under conditions of high uncertainty over threats and potential impacts of interventions, less specific payment programs that reward a set of outcomes (habitat protection and no-hunting agreements in the tourism and agri-environment cases) may be much more effective than a tightly targeted program (Kosoy and Corbera, 2010-this issue).

5. Conclusion

Institutional frameworks in tropical forest countries, many of which are undergoing a rapid rate of forest loss or erosion of biodiversity, are often weak and uncertain (Barrett et al., 2001). Designing PES programs in the context of weak institutions is challenging, particularly if property rights are not clearly defined. This comparison of three programs from Cambodia has highlighted two different approaches. The first is direct payments to individuals who can temporarily control a biodiversity resource, modelled on the approach proposed by Ferraro and Kiss (Ferraro, 2001; Ferraro and Kiss, 2002). The second approach is longer-term and requires investing in clarifying property rights and building local institutions for management of wildlife and habitats in addition to provision of incentives. The comparison suggests that the first approach can be very effective initially: the bird nest program rapidly protected several hundred pairs of globally threatened bird species, was inexpensive to implement and had low administrative costs with most money disbursed locally. However, this comparison has also suggested two significant problems with the approach.

Firstly, direct payments require strong institutional frameworks that support contracting, particularly enforcement of property rights (Börner et al., 2010-this issue; Muradian et al., 2010-this issue; Vatn, 2010-this issue). The Cambodian bird nest protectors had weak ownership rights over breeding sites, and were unable to protect them in the longer term from clearance by others. In the absence of strong existing institutional frameworks, payment programs need to invest in building appropriate institutions both at the village and higher levels. Increasing the diversity of institutions creates checks, improves resilience and sustainability in the system (Berkes, 2007) but imposes its own costs. In the two Cambodian cases (ecotourism and agri-environment programs) the increased institutional diversity led to a more sustainable outcome at the cost of reducing the proportion of payments that were made to local people, because revenue was also required to fund the other organisations for their monitoring, enforcement and supporting roles.

Secondly, direct payments to some individuals, but not to others, may fail to generate support for conservation, which is very necessary when the institutional framework is weak. Unlike the bird nest example, the two Cambodian village-managed programs successfully built local support for and understanding of rules and regulations for protected species and land-use plans. These rules and regulations were developed locally and approved by the entire village. This is an example of empowerment, defined by Chambers (1983) as "the process through which people, and especially poorer people, are enabled to take more control over their own lives, and secure a better livelihood, with ownership of productive assets as one key element". The importance of intrinsic motivation at determining behaviour has been recognised by psychologists since the 1980s (DeCaro and Stokes, 2008; Deci and Ryan, 1985). Endogenous rules are far more likely to be respected and understood by local people (Berkes, 2003; Ostrom, 1990), in comparison with externally-imposed rules (Cardenas et al., 2000), and would probably be sustained for a period if payments ceased. By contrast, bird nests are valued only because WCS chooses to pay for their protection, not through any particular recognition of the birds' importance, and if payments by WCS stopped, even temporarily, collection of bird nests would probably resume. Externally-imposed rules and incentives may even 'crowd-out' locally-developed rules and social norms (Bowles, 2008; Cardenas et al., 2000; Vatn, 2010-this issue), or lead to perceptions that incentives are unfair (Fehr and Falk, 2002), as may have occurred in the bird nests case. Payment programs that are structured to facilitate intrinsic motivations are therefore far more likely to be successful.

PES programs are best viewed as a tool in a broader process of strengthening institutions for conservation of biodiversity (Agrawal and Gibson, 1999; Barrett et al., 2001). The conditions under which institutions for collective management of common-pool resources are likely to be formed have been well articulated through several decades of research (Agrawal, 2001; National Research Council, 2002; Ostrom, 1990). However, few settings in the world are characterised by all these conditions (Dietz et al., 2003). The challenge therefore is to devise institutional arrangements that help to establish such conditions or meet the main challenges of governance in the absence of ideal conditions (Dietz et al., 2003). PES programs can address two critical constraints, firstly by providing an incentive to reform institutional arrangements (for example clarification of property rights), and secondly by increasing the financial returns from collective management through provision of additional payments under conditions where sustainable extraction alone would not be profitable. At the village-level, the combination of a stronger institutional framework and payments leads to a greater local incentive for collective action, i.e. the village moves closer towards fulfilling the design principles articulated by Ostrom and others (Agrawal, 2001). In the Cambodian cases the payments are critical for three main reasons. Firstly, they increase the value of the biodiversity resource to local people, both directly through individual payments and indirectly by providing funds for village development. Secondly, the payments fund the costs of management of common-pool resources by village institutions, a system which is itself a public good (Ostrom's 'second-order social dilemma' (1990)). Thirdly, the payments fund monitoring and sanctioning by the village institutions (Ostrom's 'third-order social dilemma'). The structure of the payments–providing revenue at both the individual and village-level scale–ensures that these outcomes are possible.

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References

Agrawal, A., 2001. Common property regimes and sustainable governance of resources. World Dev. 29, 1649–1672.
Agrawal, A., Gibson, C.G., 1999. Enchantment and disenchantment: the role of community in natural resource conservation. World Dev. 27, 629–649.
Agrawal, A., Chhatre, A., Hardin, R., 2008. Changing governance of the world's forests. Science 320, 1460–1462.
An, D., 2008. Agricultural Expansion and its Effects on Breeding Habitat of Giant Ibis *Pseudibis gigantea* in Kulen Promtep Wildlife Sanctuary, Northern Cambodia. Department of International Environmental and Agricultural Science, Tokyo University of Agriculture and Technology, Tokyo.
Asquith, N.M., Vargasa, M.T., Wunder, S., 2008. Selling two environmental services: in-kind payments for bird habitat and watershed protection in Los Negros, Bolivia. Ecol. Econ. 65, 675–684.
Balmford, A., Bruner, A., Cooper, P., Costanza, R., Farber, S., Green, R.E., Jenkins, M., Jefferiss, P., Jessamy, V., Madden, J., Munro, K., Myers, N., Naeem, S., Paavola, J., Rayment, M., Rosendo, S., Roughgarden, J., Trumper, K., Turner, R.K., 2002. Economic reasons for conserving wild nature. Science 297, 950–953.
Barrett, C., Brandon, K., Gibson, C., Gjertsen, H., 2001. Conserving tropical biodiversity amid weak institutions. Bioscience 51, 497–502.
Berkes, F., 2003. Rethinking community-based conservation. Conserv. Biol. 18, 621–630.
Berkes, F., 2007. Community-based conservation in a globalized world. Proc. Natl. Acad. Sci. U. S. A. 104, 15188–15193.
Börner, J., Wunder, S., Wertz-Kanounnikoff, S., Tito, M.R., Pereira, L., Nascimento, N., 2010. Direct conservation payments in the Brazilian Amazon: scope and equity implications. Ecol. Econ. 69, 1272–1282 (this issue).
Bowles, S., 2008. Policies designed for self-interested citizens may undermine "the moral sentiments": evidence from economic experiments. Science 320, 1605–1609.
Brooks, T.M., Bakarr, M.I., Boucher, T., da Fonseca, G.A.B., Hilton-Taylor, C., Hoekstra, J.M., Moritz, T., Olivieri, S., Parrish, J., Pressey, R.L., Rodrigues, A.S.L., Sechrest, W., Stattersfield, A., Strahm, W., Stuart, S.N., 2004. Coverage provided by the global protected area system: is it enough? Bioscience 54, 1081–1091.
Bruner, A.G., Gullison, R.E., Rice, R.E., 2001. Effectiveness of parks in protecting tropical biodiversity. Science 291, 125–128.
Cardenas, J.C., Stranlund, J., Willis, C., 2000. Local environmental control and institutional crowding out. World Dev. 28, 1719–1733.
Chambers, R., 1983. Rural Development: Putting the Last First. Longman, London.
Chomitz, K.M., Buys, P., De Luca, G., Thomas, T.S., Wertz-Kanounnikoff, S., 2007. At Loggerheads? Agricultural Expansion, Poverty Reduction, and Environment in the Tropical Forests. World Bank, Washington, D.C.
Clements, T., John, A., Nielsen, K., Chea, V., Ear, S., Meas, P., 2008. Tmatboey Community-based Ecotourism Project, Cambodia. Wildlife Conservation Society, New York.
Clements, T.J., Garret, L., Kong, K.S., Pech, B., Rainey, H., Rours, V., Tan, S., Thong, S., 2009. Bird Nest Protection Program in the Northern Plains of Cambodia. Wildlife Conservation Society, Phnom Penh and New York.

Daily, G.C. (Ed.), 1997. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Washington, D.C.
DeCaro, D., Stokes, M., 2008. Social–psychological principles of community-based conservation and conservancy motivation: attaining goals within an autonomy-supportive environment. Conserv. Biol. 6, 1443–1451.
Deci, E.L., Ryan, R.M., 1985. The general causality orientations scale: self-determination in personality. J. Res. Pers. 19, 109–134.
DFW, 1998. Statistics of Area of Forest Concessions and Land Cover (in Cambodia). Department of Forestry and Wildlife (DFW), Phnom Penh.
Dietz, T., Ostrom, E., Stern, P.C., 2003. The struggle to govern the commons. Science 302, 1907–1912.
Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: an overview of the issues. Ecol. Econ. 65, 663–674.
Fehr, E., Falk, A., 2002. Psychological foundations of incentives. Eur. Econ. Rev. 46, 687–724.
Ferraro, P., 2001. Global habitat protection: limitations of development interventions and a role for conservation performance payments. Conserv. Biol. 15, 990–1000.
Ferraro, P.J., Kiss, A., 2002. Direct payments to conserve biodiversity. Science 298, 1718–1719.
Ferraro, P.J., Pattanayak, S.K., 2006. Money for nothing? A call for empirical evaluation of biodiversity conservation investments. PLoS Biol. 4, 482–488.
Forestry Administration, 2008. Forest Cover Map Change 2002–2006. Forestry Administration of the Ministry of Agriculture, Forestry and Fisheries, Phnom Penh.
Forestry Administration, 2009. Cambodia Readiness Project Idea Note (R-PIN) for the Forest Carbon Partnership Facility. Forestry Administration of the Ministry of Agriculture, Forestry and Fisheries, Phnom Penh.
Geist, H., Lambin, E., 2003. Is poverty the cause of tropical deforestation? Int. For. Rev. 5, 64–67.
Hirschfeld, E. (Ed.), 2009. Rare Birds Yearbook 2009. Birdlife International, Cambridge.
Keane, A., Jones, J.P.G., Edwards-Jones, G., Milner-Gulland, E.J., 2008. The sleeping policeman: understanding issues of enforcement and compliance in conservation. Animal Conservation 11, 75–82.
Keo, O., 2008. Ecology and Conservation of Giant Ibis in Cambodia. PhD Thesis. University of East Anglia, Norwich.
Keo, O., Collar, N.J., Sutherland, W.J., 2009. Nest protectors provide a cost-effective means of increasing breeding success in Giant Ibis *Thaumatibis gigantea*. Bird Conserv. Int. 19, 77–82.
Kosoy, N., Corbera, E., 2010. Payments for Ecosystem Services as commodity fetishism. Ecol. Econ. 69, 1228–1236 (this issue).
Kremen, C., Niles, J.O., Dalton, M.G., Daily, G.C., Ehrlich, P.R., Fay, J.P., Grewal, D., Guillery, R.P., 2000. Economic incentives for rain forest conservation across scales. Science 288, 1828–1832.
Loucks, C., Mascia, M., Maxwell, A., Huy, K., Duong, K., Chea, N., Long, B., Cox, N., Seng, T., 2009. Wildlife decline in Cambodia, 1953–2005: exploring the legacy of armed conflict. Conserv. Lett. 2, 82–92.
McKenney, B., Prom, T., 2002. Natural Resources and Rural Livelihoods in Cambodia: A Baseline Assessment — Working Paper 23. Cambodia Development Resource Institute, Phnom Penh.
McKenney, B., Yim, C., Prom, T., Evans, T., 2004. Focusing on Cambodia's High Value Forests: Livelihoods and Management. Cambodia Development Resource Institute and Wildlife Conservation Society, Phnom Penh.
Milne, S., Niesten, E., 2009. Direct payments for biodiversity conservation in developing countries: practical insights for design and implementation. Oryx. 43, 530–541.
Missrie, M., Nelson, K., 2005. Direct payments for conservation: lessons from the Monarch Butterfly Conservation Fund. Research Summary/Paper No. 8. College of Natural Resources, University of Minnesota.
Muñoz-Piña, C., Guevara, A., Torres, J.M., Braña, J., 2008. Paying for the hydrological services of Mexico's forests: analysis, negotiations and results. Ecol. Econ. 65, 725–736.
Muradian, R., Corbeta, E., Pascual, U., Kosoy, N., 2010. Reconciling theory and practice: An alternative conceptual framework for understanding payments for environmental services. Ecol. Econ. 69, 1202–1208 (this issue).
Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., Kent, J., 2000. Biodiversity hotspots for conservation priorities. Nature 403, 853–858.
National Research Council, 2002. The Drama of the Commons. Committee on Human Dimensions of Global Change. National Academy Press, Washington, DC.
North, D.C., 1990. Institutions, Institutional Change and Economic Performance. Cambridge University Press.
Olson, D.M., Dinerstein, E., 1998. The Global 200: a representation approach to conserving the Earth's most biologically valuable ecoregions. Conserv. Biol. 12, 502–515.
Ostrom, E., 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press.
Pagiola, S., 2008. Payments for environmental services in Costa Rica. Ecol. Econ. 65, 712–724.
Rock, F. (Ed.), 2001. Participatory Land-Use Planning (PLUP) in Rural Cambodia: Manual. Ministry of Land Management, Urban Planning and Construction, Phnom Penh.
Sommerville, M., Jones, J.P.G., Rahajaharison, M., Milner-Gulland, E.J., 2010. The role of fairness and benefit distribution in community-based Payment for Environmental Services interventions: A case study from Menabe, Madagascar. Ecol. Econ. 69, 1262–1271 (this issue).
Stern, N., 2006. The Economics of Climate Change: The Stern Review. HMG, London.
Swart, J., 2003. Will direct payments help biodiversity? Science 299, 1981.
Vatn, A., 2010. An Institutional Analysis of Payments for Environmental Services. Ecol. Econ. 69, 1245–1252 (this issue).
WCS, 2009. List of Animals on the IUCN Red List Found in Cambodia. Wildlife Conservation Society — Cambodia Program, Phnom Penh.
Wharton, C.H., 1966. Man, fire and wild cattle in North Cambodia. Proceedings of the 5th Annual Tall Timbers Fire Ecology Conference, pp. 23–65.
Wilkie, D., Carpenter, J.F., 1999. Can nature tourism help finance protected areas in the Congo Basin? Oryx 33, 332–338.
Wilkie, D.S., Carpenter, J.F., Zhang, Q., 2001. The under-financing of protected areas in the Congo Basin: so many parks and so little willingness-to-pay. Biodivers. Conserv. 10, 691–709.
Wunder, S., 2005. Payments for Environmental Services: Some Nuts and Bolts. CIFOR Occasional Paper No. 42. Center for International Forestry Research, Bogor.
Wunder, S., 2007. The efficiency of payments for environmental services in tropical conservation. Conserv. Biol. 21, 48–58.
Wunder, S., Albán, M., 2008. Decentralized payments for environmental services: the cases of Pimampiro and PROFAFOR in Ecuador. Ecol. Econ. 65, 685–698.
Zbinden, S., Lee, D.R., 2004. Paying for environmental services: an analysis of participation in Costa Rica's PSA program. World Dev. 33, 255–272.

FORESTLAND TENURE REFORM IN CHINA

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Introduction

This paper summarizes the key points contained in a soon-to-be-released publication which details the evolution of China's forestland tenure reform since the founding of the People's Republic of China in 1949. It provides an overview of forest resources in the country; identifies changes in and drivers of forestland tenure reform; describes current government policies and implementation in this area; outlines patterns and ownership with regard to forestland tenure; notes the impacts and consequences of change; and looks at future trends.

Forest resources in China

The 7th National Forest Inventory, published in 2010, reveals that forestland in China totals 303.78 million ha, 194.45 million ha of which is under forest cover. Stumpage is 14.91 billion m^3, with storage capacity of 13.72 billion m^3. In terms of forestland ownership, 123.32 million ha (roughly 40% of the total) belong to the state and 182.47 million ha (about 60%) belong to collectives.

Forests are mainly located in five regions: Northeast China and Inner Mongolia; mountainous areas in Southwest China; hilly areas in Southeast China; mountainous areas in Northwest China; and in tropical forest areas which account for 40% of China's territory and cover more than 70% of national forested land. In recent years, despite increases in forest cover and better quality of forest resources, the sector is unable to fill current demand to drive socio-economic development.

According to the Regulations for Implementation of the Forest Law of the People's Republic of China, forest resources consist of forests, stumpage, forestland, and wildlife and microorganisms in forested areas (SFA, 2001). In a broader sense, forest resources sometimes also include the eco-environmental and other commercial resources in forests (Huang, 2008).

In primitive society, when forests provided habitat not only for wildlife but for all humans, property rights did not exist because these resources were commonly owned. Later on, when individuals possessed, used, disposed of and benefited from forests, the notion of private ownership began to take hold. When rights and obligations over forests gained legal recognition and protection, forest tenure came into being.

Changes in and drivers of forestland tenure reform

Since the founding of the People's Republic of China in 1949, the forestland tenure system has undergone several changes (Table 1). After attempts over more than half a century, experiences gained and lessons learned laid a solid foundation for the current round of reforms. During the agrarian period (1950-1953) China's allocation of forestland and forests to households granted ownership to farmers. After agricultural cooperatives were established (1953-1956), they became the owners and managers of all forestland and forests, including those belonging to farmers. At the onset of the opening up period

(1980-2002), government attempted to implement the “Three Fixes” forestry policy which called for all forestland to be collectively owned. Collective forest management improved but tenure was still an intangible and unclear concept to local people. Farmers were not given secure rights nor were appropriate mechanisms put in place to share the proceeds from forest management - a key component of effective collective forest tenure reform (Lida and Huaiwei, 2009).

Table 1 History of China's Forestland Tenure Reform

Period	Changes in Tenure Systems	Effectiveness of Tenure Systems
1950~1953 Agrarian Reform: forests allotted to households	Ownership of farmers to land, including forestland and forests, was confirmed. They could harvest, trade, lease and give forestland as gifts. A number of large scale forest farms and forest enterprises were established under collective ownership.	Farmers became enthusiastic about forestry production as a result of their rights to own, manage and dispose of forestland and forests.
1953~1956 Agricultural cooperatives: collective forests to cooperatives	Ownership of forestland shifted from individual farmers to joint ownership by individuals and collectives. Farmers only retained ownership of allotted private forest plots and trees around their houses. Ownership of forestland and large forests was shifted to cooperatives.	Rural forest management shifted from decentralized to centralized. Community forestry took shape as individual members were no longer entitled to own or use the forestry assets assigned to cooperatives.
1957~1980 People’s Commune: collective ownership and management	From the onset of the Cultural Revolution, the community again took possession of the trees around members’ houses and on private forest plots to manage centrally. Collective ownership in rural areas became the norm, replacing all private ownership of land.	Thousands of rural forest farms were established nationwide under centralized management. Forest farmers destroyed many forests when they lost private ownership and use rights and became dissatisfied with how rights were distributed.
1980~2002 Reform and Opening up: forestry “Three Fixes” pilot for forest tenure reform	Farmers were given management rights over forestland and ownership of trees in regions previously under collectivities. Free markets were instituted and forests were allocated to individual households. The contracting period was extended to 70 years, allowing the transfer of both use and management rights. Management, administration and organization of resources became diversified.	Farmers were allocated private forest plots and contracted out responsibility for some of them. Tenure remained unclear and policies did not keep pace with changes. As a result, illegal logging and deforestation became severe in South China. In the wake of economic reform, forest property rights took various forms and forest products were traded in the market.
2003 to present: improving the market economy system and strengthening tenure reform	Farmers assumed a dominant position in forest management when tenure and ownership were clarified, management right diversified, deposition right identified, and usufruct guaranteed. Forest tenure reform was integrated into rural reform, including of taxes and fees, institutions, and social safety nets.	Reform was introduced in a systematic way. Tenure and property rights became more secure and the transfer of management and use rights easier. Owners under these new arrangements are diverse and they are taking a genuine interest in sustainable forest management. Forest productivity is now tied to the free market system.

Forest tenure reform in China is an outcome of the sector’s shift to a market economy. When the CPC Central Committee and State Council abolished government monopoly on the purchase, sale and distribution of timber in 1985, the timber market opened up and significantly raised the value of forestland. The price of timber soared from RMB37/m^3 to RMB300-400/m^3 and dramatically increased the income of forest farmers. From 2002 to 2008, the price of timber and other forest products increased by 84.06% and 50.75% respectively. Since 2002, the special tax on agricultural products and many charges on logs

and bamboo were eliminated in most parts of China. Specifically, timber taxes and charges in Jiangxi province decreased by more than 70%. In Shanxi province and Inner Mongolia, farmers do not pay a fee for logging but contribute to the afforestation fund. In Zhangping, Fujian province, profits from timber amount to 90 RMB per m^3. In Jiangxi province, farmers can make an extra 5 RMB for a single piece of bamboo and 150 RMB/m^3 more for timber.

Current government policies on forest land tenure and implementation

June 2003 marked the beginning of China's new round of forest tenure reform, following the CPC Central Committee and State Council Decision on Accelerating the Development of Forestry. This decision called for forestry institutions to be reformed; forest and forestland use rights to be transferred; forestry tax and charges to be unified; policies on resource utilization, investment and financing to be improved; and for non-public forests to be developed. It also stipulated the need to reform state owned forest farms, nurseries and enterprises, to manage forests by different categories, and to optimize forest management arrangements.

In 2004, the State Forestry Administration (SFA) authorized Yichun and Sanming to pilot tenure reform in state-owned and collective forests. By 2005, the central government began to develop rural areas, exploring new approaches to solve issues related to agriculture via the development of forestry. (Rural areas were faced with high poverty and an underdeveloped economy; agriculture yielded few returns; the level of industrialization was low; and the income disparity between urban and rural areas was wide.)

In 2007, the 17th Committee of the Communist Party of China put forward the Scientific Concept on Development which required altering approaches and accelerating implementation of forestland tenure.

Pattern of forestland tenure and ownership: collective-owned forests

In June 2008, the CPC Central Committee and State Council Guidelines on Fully Promoting Collective Forest Tenure Reform called for the management of collective forestland by households under contracting arrangements and advocated the liberalization and improvement of forest production - a provision which launched renewed efforts to bring change. The guidelines clarify the thrust of the reform, mainly in the following six areas.

Tenure clarification: Legal certificates are issued to firmly establish households under collective economic organizations as the holders of contractual management rights to forestland and ownership of trees. Tenure over forestland which is unsuitable for contract management must be settled by other methods such as equal distribution of shares and profits according to law and as agreed by the collectivity. Forestland and trees under disputed ownership should be settled according to law, after which time the principal management entities can be identified. Farmers use forest plots for private purposes free of charge and on a long-term basis - seventy years, with possibility of renewal. The collective organizations may retain a small amount of community forestland to manage and administer, under agreed contracting arrangements and according to law. Because contractual rights supersede ownership rights, owners of forestland can not arbitrarily rescind or adjust the contract, nor can they interfere with the contractor's entitlement to exclusive control of the land. Contractors are also protected from third-party grievances.

In addition, ownership will be clarified of collective forestland and of trees managed by authorities in nature reserves, forest parks, scenic spots, river courses and lakes as well as by state-owned forest (agriculture) farms and cultivation farms in order to maintain the stability of these areas and safeguard the legitimate interests of rightful holders.

Demarcation of boundaries and issuance of certificates: Previous reform efforts overlooked the importance of delineating boundaries and issuing certificates. As a result, many problems arose, such as people managing forests without certificates, and people with certificates either not having forests, or

managing forests not assigned to them. Therefore, this round of reform must first clarify contractual arrangements, delineate boundaries through on-site inspection, register eligible recipients, then issue forest certificates that contain detailed and accurate information. Forestry authorities at all levels should identify specific departments to administer forest tenure and undertake assigned tasks, including registration, issuance of certificates, archive management, transfer of property rights, arbitration of disagreements in contracted forestland, and investigation and mediation of disputes related to forest tenure.

Management rights: This area of tenure reform provides for commercial forests to be managed differently than ecological forests for public benefit. The former are defined as forests which grow under favourable site conditions and their harvest and utilization will not harm the ecological balance and biological diversity of the region. Farmers can select any management model and trade timber freely, according to law. The latter forests grow in important or ecologically fragile areas and, as long as their functions are not impaired, rational use of resources is permitted, including understory intercropping, poultry farming, and tourism.

Disposition rights: Without altering the use of forestland, contractors can subcontract, lease, transfer, exchange, or convert it into shares. This land can also be mortgaged or used as equity and in cooperative joint ventures for afforestation/reforestation and tree operations. If contractors choose to transfer their management rights, they can charge compensation but this transfer can not exceed the remaining period of the contract.

Usufruct: In the context of forest resources, usufruct refers to the right to contract forestland and easements to allow those who hold agreements to occupy, use and benefit from the area under contract. It further provides for farmers to be fully compensated if forestland is expropriated, be paid a resettlement subsidy, and be provided with social security funds to guarantee the same standard of living. If the forestland managed by a household under contract is expropriated legally, the contractor is entitled to compensation as well.

Responsibilities: Written contracts to manage community forestland promote sustainable forest management and are compulsory. They must clearly define responsibilities of the contractor and the contractee in terms of afforestation, tending, protection, fire prevention, and control of pests and diseases. Forestry authorities at the local level need to strengthen efforts to standardize the management of contracts.

In June 2009, the CPC held the first national forestry conference since the founding of New China to deploy a strategic plan to intensify forest tenure reform, drawing on the results of pilot tests. It announced that the development of the forest sector was key to implementing the Scientific Concept on Development and indicated that forestry was a priority for ecological integrity; a strategic choice to combat climate change; and an essential component for the advancement of rural areas. Subsequent to these statements, central government declared that collective forest tenure reform was complete and actively engaged in the further reform of state-owned forests.

Current reform aims to systematically and fully resolve tenure issues. Compared with past rounds, the objectives are clearer, concepts are better thought out, and procedures are more standardized. The process recognizes farmers as the main players and makes problems associated with unclear tenure a top priority for action. In this regard, the scope of the reform covers forests, trees and forestland where ownership of trees by rural community organizations is ambiguous and rights to use forestland have not been decided. It focuses on collective commercial forests and forestland as well as collective lands which county governments have deemed suitable for forestation. When ownership is confirmed, registration should be completed as soon as possible and certificates issued. Forests designated for public benefit by governments above the county level are temporarily excluded from the reform, as are trees and woodland where ownership is under dispute.

Pattern of forestland tenure and ownership: state-owned forests

According to China's Constitution, state-owned forests refer to all forest resources that belong to the state i.e. all citizens. On June 30, 1950, the Land Reform Law of People's Republic of China designated large forests, waste lands and hills as state owned and provided for the establishment of state-run forestry enterprises in northeastern China and Inner Mongolia where continuous tracts of forests were concentrated. In central and southern China, the state set aside a significant amount of forestland for afforestation, mainly to produce timber to meet the demands of a growing national economy and to respond to industry's need for infrastructure development. Currently, 135 key state forestry enterprises and 4482 state forest farms manage and operate state-owned forest resources in China. Forestry departments at all levels are responsible for forest management and the formulation of rules, regulations and policies in areas such as forest resources surveys, monitoring, statistics, logging quotas, and utilization of forest resources.

Since the establishment of New China, state-owned forests have provided more than one billion cubic meters of timber, a figure representing 50% of all national timber output. At present, state-owned forest farms produce most of the timber and timber products in the country, have the largest area of newly planted trees, support wildlife and biodiversity, and are an important component in the conservation of natural forests. However, with the transition to a modern economy in the mid 1980s, state-owned forestry enterprises and forest farms faced various difficulties, including having to deal with conflicting views over resource management and use.

State-owned forestry enterprises

The development of state-owned forestry enterprises took place in three stages.

1950s to 1970s: Forests were viewed as economic resources and the sector was considered an industry. Timber production was the sole concern of enterprises and little or no effort was made to replant after harvesting. It played a vital role in terms of national industry, construction, and military supply, in addition to helping to end the international blockade and reviving the economy. Although timber production was planned, enterprises were encouraged to exceed targets. Forest management, in principle, formed the foundation for logging, replanting, afforestation and integrated use but it was not applied conscientiously. Neither did the ecological and social benefits provided by state forests receive full recognition. Throughout this period, timber, steel and cement were considered the three most important materials.

1970s to 1990s: The second stage centered on promoting afforestation and forest conservation became as important as economic development. However, due to prolonged over harvesting, the forestry industry was in serious trouble by the end of the 1980s. In February 1990, a project was launched to manage the crisis. Enterprises began to adjust timber output in a planned manner and to restructure operations to also focus on integrated utilization and diversified management, in addition to timber production.

1998 to 2003: The rapid development of China's economy and increased demand for forest goods and services helped to increase state investment in the sector. In 1998, disastrous floods in river valleys, including the Yangtze River and Songhua River, placed environmental issues high on the government's agenda. A project to conserve natural forests was launched in key state-owned forest regions, including southwest and northwest China, and northeast Inner Mongolia. Timber production was reduced significantly and replaced with measures to protect the environment. A specific grant was allocated to tackle the economic issues which forestry enterprises faced as well as the social impacts resulting from the shift in focus. In 2003, the Central Party Committee and State Council promulgated the Decision on Accelerating Forestry Development which placed ecological considerations at the heart of sustainable forest management. Industry further reduced timber output and, through a national project to protect natural forests, it explored ways to address dwindling resources and the economic crisis the sector was experiencing.

State-owned forestry enterprises were established quickly to meet the urgent domestic need for timber. Due to time constraints and the large quantity of timber required, enterprises in forested regions were set up first, followed by government, then social services, hospitals and schools. Because few other industries established in these areas, government income almost exclusively depended on logging and transportation. Institutions which delivered social services relied on forestry enterprises for their survival as well. This situation led to an unclear assignment of responsibilities between government and state-owned enterprises since the latter was involved in both administrative and business activities - a system which had them overseeing logging operations as well as felling trees.

Under a planned economy, the management of enterprises, forest resources, and administration were well coordinated and promoted development of the sector to meet national demand for timber. However, with the establishment of a modern market economy and the gradual depletion of resources, this centralized approach led to overlapping functions between enterprises and governments. When profits and government revenue plummeted, social service agencies also struggled to survive. Hardship in forest regions brought drastic cuts in salaries and resulted in conflicts among the local population, the environment, the economy and resources. The arduous task of building a prosperous society, in harmony with the forest region, still lay ahead.

The following reforms in state-owned forest regions allowed them to move into a modern market economy:

- The new system separated management from supervision and regulatory functions.
- Government no longer was involved in the day-to-day operations of enterprises.
- Ownership of forest resources was distinct from management rights.
- The state relinquished their assets and reduced their capital.
- Enterprises were handed over to the private sector or joint-stock companies.
- Local government delivered social services.

State-owned forest farms

State-owned forest farms were public institutions set up to accelerate tree planting, conserve forest resources, and improve ecological conditions in fragile regions and in large areas of state-owned waste hills and land. When New China was founded, a large number were set up in remote and sparsely populated regions where the economy was undeveloped. Several more were subsequently built on state-owned forestland and in large areas of waste hills and land where communities were incapable of managing them. From the 1960s to 1970s, more state-owned forest farms were established in provinces (autonomous regions and municipalities), cities and counties.

By the end of 2007, after six decades of development, the number of these farms increased from the initial 50 to 4482, distributed in 31 provinces and 1600 counties. Employees number 660,000 - 470,000 of whom are in service and 190,000 retired. The management area totals 62 million hectares, more than 50 million of which is forestland. In addition to housing some 1300 wildlife nature reserves, state forest farms act as shelter belts in ecological regions of national importance and contribute significantly to economic development.

Although communities recognize the achievements of state-owned forest farms in terms of tree planting and forest conservation, ineffective systems of management and operations, insufficient capital, the slow pace of reform, and the absence of supporting policies, for example, have been problematic.

Lack of investment and weak infrastructure: State-owned forest farms operated on the principle of production first, livelihoods second. The limited capital at their disposal was invested mainly in afforestation while infrastructure development was all but ignored. When the state terminated grants in the 1980s, construction of roads and drinking water facilities was halted, as was the rebuilding of electric power facilities, old housing, and communications and cable TV networks, all of which made economic

and living conditions worse.

Unclear status and ineffective management: Although state-owned forest farms, as public institutions, managed operations as enterprises, they were not sufficiently funded or autonomous. The status of employees was also unclear, being neither workers nor farmers. Multiple management authorities led to ambiguity and marginalization, making it difficult to protect their rights and interests according to law. Such shortcomings seriously impeded forestry development both then and now. In recent years, the state invested heavily in forestry development but support for state-owned forest farms is insufficient, local financial investment is limited, and forest reform policies and measures are not in place.

Huge debt and a heavy socio-economic burden: A serious shortage of national investment in forestry means that people must depend on declining timber stocks as their main source of revenue. Due to harvesting quotas and the designation of some commercial forests as ecological forests for public benefit and nature reserves, logging was reduced, timber production dropped, and incomes decreased.

Heavy staff costs: With the decrease in logging and timber processing, the number of surplus forestry workers and retired staff grew, along with the heavy cost to continue to support them. With the decline in forest revenues, economic conditions deteriorated. Forest farms failed to pay retired workers their pensions and were unable to pay workers, retirees, and laid-off staff minimum living expenses on time and in full. Some farms could not even afford to disburse a few dozen Yuan per month to staff, a situation which left many destitute.

Impact and consequences of forestland tenure reform

By the end of 2009, 9 provinces (autonomous regions and municipalities) completed the tasks of clarifying forest tenure and contracting forestland to households. Work in 14 provinces is fully underway and another 8 are piloting the reform. Tenure for 101 million hectares of forestland was confirmed, accounting for 59.42% of total collective forestland area. Some 48,040,000 certificates covering 75,733,300 hectares (75% of total area) were issued to hundreds of millions of farmers and 570,000 forest tenure disputes (83.8%) were settled.

When forestland was contracted to individual households, farmers had genuine control and held valuable assets. They effectively restored ecosystems and became prosperous. After tenure reform, the average share of forestland distributed to each household reached 12.4 hectares or 558 cubic meters and the average value of assets amounted to 500,000 yuan.

Forest tenure reform extends beyond the rural household contract responsibility system and profoundly changed rural production methods. Other positive outcomes include:

- wider publicity, clarification of tenure and the provision of incentives awakened the enthusiasm of farmers to tend, protect and manage forests
- reform focused on revitalizing forestry, providing farmers with their own forestland, and reducing taxes and levies
- local authorities not only became more familiar with the situation of farmers and developed stronger ties with them, but the reform also heightened awareness of legislation, of democratic ways of doing business, and of the need to improve service delivery
- a new approach to forestry development is taking shape, with farmers taking the initiative to tend and manage most commercial forests - a situation which has reduced the fiscal expenditure of villages and increased farmer incomes
- new forestry economic cooperation organizations, social service organizations, and self-regulatory organizations were gradually established to facilitate the transformation of functions of forestry authorities and grassroots
- the market mechanism resulted in a better allocation of forestry production factors, more efficient utilization of forestland resources, and an increase in both the amount and quality of forest resources - all of which brought about enormous positive differences in farmer incomes, forestry and economic

development, and the health of the environment.

Because implementation of forest tenure reform in China requires different models and stages, it is a complex and tenuous process. Problems encountered include the following:

- Interest groups have shown resistance due to the way that shares have been reallocated.
- Contrary to reform policies, some property rights to forests and forestland are acquired illegally through political power.
- Vast tracts of forestland are contracted or transferred for too long a time and at unreasonably low prices, violating the principle of fairness on which reform is based.
- A number of farmers and workers who have been granted property rights fail to manage the forest resources due to factors which limit production potential.
- Property rights are not integrated and property management is not smooth because the forest resources management system has not been reformed and the market for forest products is not developed.

The system of forest tenure now in use was initiated under the planned economy and no longer fits current conditions. Outstanding issues from the previous system are impeding the rational allocation of forest resources, lowering the added value of forests, and dampening the enthusiasm of farmers to get involved in forest management, all of which ultimately constrain development of the sector.

1) Forest tenure is not properly defined, including ownership of forestland: Due to frequent changes in ownership over the years, it is not clear who owns some of China's forestland. In addition, ambiguous boundaries are being contested. In other cases, forest tenure certificates show the wrong demarcation, thus depriving people of exclusive access to forest resources, a situation which leads to improper management and deforestation.

2) Forest tenure rights are sometimes only partially granted: In such instances, government intervention in forest management can be excessive, administration unclear, and private rights infringed, for example, when authorities force farmers to develop and implement overly strict management plans; when owners are not given the right to dispose of wood; and when transfer rights are restricted in areas such as logging, transportation and the sale of forest products.

3) State and community ownership of forestland does not always benefit the citizens of China who are the real custodians: In practice, the State Council and village committees are entrusted with the management of forest resources on behalf of the people they serve. However, the state devolves this responsibility to various levels of government, some of which reap all the benefits from managing or contracting forestland, leaving the real owners in name only. Similarly, village committees control forest resources even though residents of the community are the ones who are entitled to possess, dispose of and benefit from them.

4) Current laws and regulations are out of date and incomplete: As a result, they do not effectively regulate forest management or protect forest tenure. For example, there are no provisions governing forest allocation, the issuance of forest management licenses, and the transfer of forest resources. Moreover, assessment procedures are mixed with those to approve licenses and some administrative procedures are inconsistent with the Law of Administrative Licensing and the Property Law.

Future trends

Forest tenure reform in China separates ownership of and access to trees, forests and forestland. Thus, rights and obligations vary, depending on the type of arrangements that different principals hold. A new system with incentives and binding responsibilities is taking shape. While the ongoing reform is not without problems, achievements and lessons learned so far could inform other countries as they undertake their own reforms.

The success of forest tenure reform in China lies in the development and implementation of policies which reflect its unique conditions: various types of forest resources, multiple stakeholders and benefits, and different degrees of socio-economic development throughout the country. Various models that take

into account diverse interests have been developed and pilot projects are testing approaches to protect the ecosystem, increase resources, improve livelihoods and establish businesses.

Balancing stakeholder interests in and demands on forests: Forest tenure reform involves empowering different stakeholders to benefit from the rights they possess. For example, farmers expect the forests they manage to yield maximum economic returns; forest enterprises try to obtain the most profit from sound forest management; villages or communes want to generate the most revenue from forests to support their administration; and government seeks to ensure the integrity of forest ecosystems and a secure timber supply.

Supplementing reform with complementary actions: Forest tenure reform in China requires progressive implementation because it involves multiple stakeholders and objectives. Elements include separating ownership of forestland with use rights; delineating the boundaries of forestland and forests and identifying their principals; and issuing certificates which clarify the obligations and rights of property holders. Complementary actions consist of strengthening the institutional framework for forest management and introducing innovative measures such as tax reductions and exemptions, subsidies for nurseries, mortgages and loans at discounted rates, and government insurance to reduce risks.

Adopting different models: The natural, historical and institutional environment varies from place to place in China, as do other factors such as the productivity of forestland, benefits gained from forest management, and the dependence of farmers on forest resources. Hence, different models have been adopted in the course of China's tenure reform in state-owned and collective forests.

Promoting wide participation: Forests are important means of production to farmers and important sources of income to staff and other workers of forest enterprises. Both groups are the driving force and beneficiaries of tenure reform. In this regard, protection of public interests in forests and forestry development is both the starting point and the ultimate goal of reform.

Concluding pilot projects before applying results more widely: The goals of forest tenure reform in China are to develop the forest sector, including forest enterprises, and improve livelihoods. They determine the way forest resources are used and how benefits are allocated. In the process, some people gain and some lose - a situation which inevitably raises obstacles and risks in carrying out the reform. Pilot projects are therefore implemented in a few select regions before results are applied on a larger scale.

REFERENCES

The Report of China's Forests Resources—the 7th National Forest Inventory, 2010.
Readers on Laws for Forestry Employees in China (V1). Office of Legal Knowledge Publicity, State Forestry Administration. Higher Education Press, 2001.11.
Liyan Huang. On the Reform of Property Rights of Forest Resources. The Website of China's Environmental Laws. 2008.3.
Zhang Lei, et al. Land Potential Productivity and Timber Supply in China. China Forestry Publishing House, 2009.
Han Lida and Xu Huaiwei. Review and Reflection on China's Collective Forest Tenure Reform [J]. Forest Resources Management, 2009(01)