

# **ASEAN-Korea Environmental Cooperation Project (AKECOP) Agroforestry regional research**

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## **Abstract**

AKECOP showcases creative regional collaboration in research and development initiatives for forest restoration and rehabilitation in the ASEAN region. Through action-research participatory agroforestry was found to be a promising strategy for enhancing the productivity and sustainability of degraded forest ecosystems as well as the economic well being of forest dependent local communities in the region. Sustainability of agroforestry systems can be enhanced through the participation of local people and the provision of land tenure security and other incentives, as shown by the experiences in Indonesia and in the Philippines. Preliminary results of agroforestry field experiments in the Philippines and Vietnam tend to validate the protective value of agroforestry systems, in that they enhance the condition of degraded forest soils. Depending on the objectives of agroforestry system design, farmers should take tree species and spacing as critical decision criteria.

## **Introduction: Environmental Crisis and the AKECOP Challenge**

Several years of global assessments have shown that the area of the world's forests is shrinking. Global forest area is almost 30 percent of the total land area. The United Nations Food and Agriculture Organization (FAO) estimated that 0.38 percent of the world's forests were converted to other land uses every year in the 1990s. Large areas have also been reverted to forest, but still there is a net annual forest loss of 0.23 percent per year (FAO 2003). Showing the highest rates of deforestation among the tropical regions was Southeast Asia with 1.04 percent or an average of 23,260 km<sup>2</sup> of forests destroyed per year from 1990 to 2000 (Table 1). This is more than four times faster than the global average of 0.23 percent per year (UNEP, 2003).

A primary reason identified by FAO for the current situation of the world's forests is agricultural expansion due to increasing population and growing per capita consumption. Preliminary studies showed that agricultural land is expanding in

about 70 percent of the countries of the world, declining in 25 percent and with generally no change in 5 percent. Increasing food production to address the rising global population has been at the expense of hundreds of millions of hectares of forest. Agricultural expansion in two-thirds of the countries has shown a decrease in forest area with only one-third of the countries showing an expanding forest area. And more land will be cleared in the future (FAO, 2003).

Adverse ecological and social conditions in several parts of the world particularly tropical Asia, have also contributed to deforestation and forest degradation. Low rainfall, shifting cultivation, uncontrolled livestock grazing and indiscriminate gathering of fuel wood have slowed down regeneration and reforestation. Forest productivity and biological diversity in natural and planted forests in developing countries are likewise being threatened by poor rural communities who depend entirely on these forests for their livelihood and way of life. The unregulated hunting of wildlife for meat and other products and the consequences of forest fires are also alarming, particularly in tropical forests (FAO, 2003).

Southeast Asia is considered one of earth's most diverse areas, with Indonesia, Malaysia and the Philippines among the world's 17 megadiversity countries. However, several socioeconomic and biophysical factors mentioned above had contributed to the fast rate of deforestation and forest degradation in these countries that could result to habitat loss and disappearance of plant and animal life (UNEP, 2003). In the face of this environmental crisis that threatens tropical biological and social systems integrity and sustainability including that of Southeast Asia, there is a need for a concerted effort at the regional level to develop programs that could address this problem. The ASEAN-Korea Environmental Cooperation Project (AKECOP) is a timely and fitting respond to this need.

Table 1. *Forest area and area change in Southeast Asia. Source::FAO, 2003*

COUNTRY	LAND AREA ('000 HA)	FOREST AREA, 2000		FOREST COVER CHANGE 1990 - 2000	
		TOTAL FOREST ('000 HA)	% OF LAND AREA	ANNUAL CHANGE ('000 HA)	ANNUAL RATE OF CHANGE (%)
Brunei Darussalam	527	442	83.9	-1	-0.2
Cambodia	17652	9335	52.9	-56	-0.6
Indonesia	181157	104986	58.0	-1312	-1.2
Lao PDR	23080	12561	54.4	-53	-0.4
Malaysia	32855	19292	58.7	-237	-1.2
Myanmar	65755	34419	52.3	-517	-1.4
Philippines	29817	5789	19.4	-89	-1.4
Thailand	51089	14762	28.9	-112	-0.7
Vietnam	32550	9819	30.2	52	0.5

*What is ASEAN-Korea Environmental Cooperation Project (AKECOP) ?*

The ASEAN-Korea Environmental Cooperation Project (AKECOP) is a regional initiative responding to the challenge of restoring degraded tropical forest ecosystems particularly in Southeast Asia. It was launched in July 2000 as an off-shoot of the ASEAN-Korea Summit Meeting in 1997 in Bali, Indonesia where environmental challenges were identified as a priority area of collaboration between ASEAN member countries and Korea.

The goal of AKECOP is to contribute to the sustainable and equitable forest management and rehabilitation of deforested areas in the tropical forest ecosystems of ASEAN member countries through creative partnership between Korea and ASEAN member countries.

*The first ever collaboration between the Republic of Korea and ASEAN, the project is aimed towards the following specific objectives:*

To provide ASEAN countries with the opportunity to share in Korea's practical knowledge and experiences on addressing deforestation;

To establish partnership between Korea and the ASEAN in the conduct of basic and applied researches on biodiversity, sustainable forest management, and agroforestry in the tropics;

To develop and implement technologies for the restoration of degraded forest ecosystems and for sustainable forest management in selected areas within the ASEAN member countries;

To help advanced professional and technical expertise of the ASEAN member countries to deal with forest degradation problems;

To enable Korean scientists to better understand tropical forest ecosystems and enhance their capacity to undertake field researches in such areas;

To achieve the above goal and objectives AKECOP adopts three complementary strategies. These are research, advanced education and training, and information exchange.

## **Research**

The conduct of research is the primary vehicle in operationalizing the cooperative endeavor. The sustainable management of the ASEAN forests and the various resources within these ecologically diverse and important ecosystems will never be a reality unless a scientific understanding of the various processes and functions that occur in them exists.

Appropriate interventions to address the urgent need to restore degraded tropical forests and stop the further decimation of biodiversity in the region need to be developed, tested and validated through time and varying ecological conditions.

AKECOP conducts two types of research in the context of cooperation -- the on-site research by Korean scientist and the regional researches of the ASEAN scientists in their respective countries. On-site experiments on forest restoration, agroforestry and biodiversity conservation and management are carried out by the Korean scientists in the Philippines. These experiments are designed to generate information on the fundamental changes in structure and functions of tropical forest ecosystems as affected by various disturbance factors. The basic information obtained will be used in developing technologies for the ecological restoration of degraded tropical forests and the sustainable management of biodiversity.

The regional researches are undertaken by the participating ASEAN countries on the issues and concerns on forest restoration, agroforestry and biodiversity that are existing in their respective countries. Research topics in the individual countries are harmonized with the research themes espoused by the AKECOP, which also provides the funds for the implementation of these researches.

Major findings of these researches would provide sound scientific bases for improved management of forests, and contribute to effective restoration and rehabilitation of highly degraded forest environments in ASEAN countries. All technical information and experiences would be shared between ASEAN and Korean researchers for further improvement of techniques.

#### *Advanced Education and Training*

AKECOP also provides opportunities for post graduate scholarships and fellowships for short term trainings on fields of studies relevant to its mandate. The Project offers scholarships at the Seoul National University to qualified professional staff and researchers of the ASEAN participating countries to enable them to obtain a masteral or doctoral degree in forestry, agriculture, environmental sciences and any other related fields. The success of the AKECOP also rests on its capacity to provide short term training in research methods and operational techniques related to forest restoration, agroforestry and biodiversity conservation and management. A highlight of the short training programs is the opportunity for ASEAN researchers and scientists to acquire skills in the operation of modern equipment for environmental research and obtain learning experiences and practical knowledge on forest restoration and management from Korea.

#### *Information Exchange*

The great Swiss zoologist and geologist, Louis Agassiz once proclaimed, "Time has come when scientific truth must cease to be the property of the few, when it must be woven into the common life of the world; for we have reached the point when the results of science touch the very problem of existence." AKECOP recognizes the wisdom in these very elegant and powerful words of the Swiss scientist. In the context of the AKECOP cooperation, the forest crisis in the ASEAN region is best addressed when scientists, researchers and professional staff working on forest restoration, agroforestry and biodiversity conservation and management engage in a free exchange of research results and information, when data and hard facts of research findings and observations are made known and questions on them debated in open and frank discussions. This is one best way for the sciences of forest restoration, agroforestry and biodiversity conservation and management to advance.

Along this line of thought, AKECOP has organized and will continue to hold conferences, workshops, symposia and similar gatherings to foster and/or encourage active interactions among scientists and researchers participating in the project. By design, these activities are held annually in both Korea and the ASEAN countries. Results of both the on-site and regional researches are presented, and constructive discussions are made on the implications of the findings and observations of the studies made. The same gatherings also make possible the learning and/or further improvement of specific research skills and the discovery of more in-depth knowledge of the tropical forests.

### *Collaborating Countries and Institutions*

With Korea as main proponent and lead implementer, AKECOP originally started with only six participating countries, Indonesia, Philippines, Vietnam, Malaysia, Laos and Cambodia. In view of the demand for a wider Project coverage in the ASEAN region the number of participating countries has now increased from six to nine with the recent addition of Thailand, Myanmar, and Brunei Darussalam. The collaborating institutions in Korea and in the nine participating countries are as follows:

Korea; Department of Forest Resources and Forest Products and the National Instrumentation Center for Environmental Management, The College of Agriculture and Life Sciences, Seoul National University; The National Institute of Environmental Research; and Korea Forest Research Institute;  
Brunei; The University Brunei Darussalam; and the Forestry Department;  
Cambodia; Department of Forestry and Wildlife, Ministry of Agriculture, Forestry and Fisheries; and Nature Conservation and Protection Department, Ministry of Environment;  
Indonesia; Institute Pertanian Bogor (Bogor Agricultural University);  
Lao PDR; Forestry Research Center, National Agriculture and Forestry Research Institute;  
Malaysia; Forest Research Institute of Malaysia;  
Myanmar; Forest Research Institute;  
Thailand; Faculty of Forestry, Kasetsart University;  
Philippines; College of Forestry and Natural Resources, University of the Philippines, Los Banos; and Bantay Kalikasan, ABS-CBN Foundation, Inc.;  
Vietnam; Forest Science Institute of Vietnam.

### *AKECOP Agroforestry Research*

Agroforestry has over the years been considered a suitable approach towards reversing the forestland degradation process. As a land-use, it is a dynamic ecologically-based, natural resources management system that diversifies and sustains smallholder production for increased social, economic and environmental benefits through the integration of trees into farm and rangeland (Leakey, 1996). Having been known as an ancient practice worldwide, particularly by most farmers in the tropics, agroforestry has gained recognition as a land use system because of its potential in improving the productivity and sustainability of a given piece of land. Nair (1993) classified four types of agroforestry systems based on composition:

Agrosilvicultural system - combination of agricultural crops with woody perennials.

Silvipastoral system - combination of woody perennials with livestock production.

Agrosilvipastoral system - combination of agricultural crops, woody perennials and livestock.

Integrated or complex agroforestry systems- could include all the above and other complementing elements.

Among the nine ASEAN member countries that are participating in AKECOP only Indonesia, Lao PDR, Philippines, and Vietnam are conducting research in agroforestry. In addition to the regional agro-forestry research being conducted by Filipino scientists, Korean scientists also conduct an on-site agro-forestry research in the Philippines. Basically, there are two types of agroforestry research being conducted; experimental research in the Philippines, Lao PDR and Vietnam and action-research or development-oriented research in Indonesia and in the Philippines.

### Goals and Objectives

The goals and objectives of agroforestry vary in the four participating countries (Table 2). The bottom line however, is that all of these researches hopefully would redound to the development of agroforestry technology or system that is most appropriate in the respective countries, site specific-wise (AKECU 2003; AKECU 2004; OACP 2005)

Table 2. *Agroforestry Research in Indonesia, Lao PDR, Philippines, and Vietnam*

Country	Research Title	Research Objectives
Indonesia	Restoration of degraded forests through establishment of sustainable agroforestry system with high ecological and economic values using people's participation in Gunung Walat, Indonesia	<ul style="list-style-type: none"> <li>-Development of agroforestry system</li> <li>-To maintain agroforestry systems with appropriate technology and practices.</li> <li>-To evaluate and strengthen extension technology and practices.</li> <li>-To evaluate and strengthen local farming institutions and income generating activities.</li> <li>-Research on agroforestry</li> <li>-To conduct research on the socioeconomics of agroforestry.</li> <li>-To conduct biological studies towards the improvement of agroforestry system</li> </ul>
Lao PDR	Study of an agroforestry in degraded forest land after shifting cultivation in northern Lao PDR	<ul style="list-style-type: none"> <li>-To determine agroforestry techniques suitable for geographical zone, local and socio-economic conditions.</li> <li>-To identify suitable species of commercial timber trees, fruit trees and crop species</li> </ul>
Philippines	Rehabilitation of degraded lands through forest tree-based agroforestry system	<ul style="list-style-type: none"> <li>-To determine growth performance of 2 forest tree species (Gmelina arborea or yemane; and Swietenia macrophylla or large-leaf mahogany) planted under 3 different initial spacings (2 x</li> </ul>

		<p>2m; 2 x 3m; and 2 x 4m)</p> <ul style="list-style-type: none"> <li>-To determine the effect of spacing on growth and yield of intercropped corn and mungbeans;</li> <li>-To determine the soil and light dynamics under different spacings of each forest tree species and their correlation to growth and yield of intercrops.</li> <li>-To determine the best initial spacing for each forest tree species.</li> </ul>
	Rehabilitation of degraded lands through nurse tree-climax species (NTCS) strategy	<ul style="list-style-type: none"> <li>-To evaluate the effect of planting nurse species on the growth and development of climax species in a degraded area. Specifically it aims to:</li> <li>-Determine the growth performance of two trees (<i>Gliricidia sepium</i> or kakawate and <i>Erythrina orientalis</i> or dapdap) serving as nurse trees;</li> <li>-Evaluate the survival and growth of two climax species (<i>Parashorea malaanonan</i> or bagtikan and <i>Durio zibethinus</i> or durian) planted under dapdap and kakawate nurse trees; and assess the cost-effectiveness of the nurse tree-climax species approach.</li> </ul>
	Studies on the development of tropical agroforestry system based on local people's participation: The case of Mt. Makiling in the Philippines	<ul style="list-style-type: none"> <li>-To diagnose problems and constraints of the present land-use systems and agroforestry technologies;</li> <li>-To propose improved land-use system and agroforestry technology based on local people's participation.</li> <li>-To undertake experiments that could improve agroforestry systems based on locally identified problems.</li> </ul>
Vietnam	Restoration of degraded forest by agroforestry system in the northern mountainous region of Vietnam	-To determine the best agroforestry practices for restoration of degraded natural forests.

Source: AKECU 2003, AKECU 2004, OACP 2005

### **Preliminary results**

The preliminary results of the agroforestry researches conducted in the Indonesia, Philippines and Vietnam are reported below. Research results in Lao PDR are not available.



*Indonesia (Darusman and Sundawati 2005; Darusman 2003)*

Three agroforestry system designs based on initial forest stand condition and people's interest was recommended. First is a combination of *Agathis lorathifolia* and *Paraserianthes falcataria* as tree components with banana, pineapple, chili and rice/corn/peanuts as agriculture crop components in areas where almost no trees were present. Second, is the same tree and agricultural crop combination but established in area where about 25 until 100 trees per hectare were present. And third, is a combination of *Agathis lorathifolia* (tree crop) and banana, cardamon and coffee (agricultural crops) in area where more than 100 trees per hectare were present.

Local people's participation has been integrated into the agroforestry system development. Total number of local people participants to the AKECOP project were 22 farmer groups in five forest blocks with total membership of 213 households covering a total occupied/encroached area of 74 778 hectares. Through participatory rural appraisal techniques (PRA) regular meetings, local interests and plant species preferences were discussed.

Security of tenure has been provided to the farmer project participants through a legal contract entered into between them and Gunung Walat Educational Forest (GWEF) Manager on behalf of the Institut Pertanian Bogor (IPB). The farmer participants are allowed to cultivate the forest land according to the planned agroforestry design for about ten (10) years. The farmers are secured to get all the agricultural crops, with 50 percent of the wood volume from *Paraserianthes falcataria* and resin from *Agathis lorathifolia*.

Eleven (11) research support activities, four socioeconomic and 7 biophysical are being conducted. The socioeconomic research includes agroforestry products marketing, agroforestry labour allocation and income effect, socioeconomic assessment of GWEF communities and factors affecting farmers' participation in forest rehabilitation project. The biophysical studies include diversity of plant species in local people's garden, seed yield of *Agathis lorathifolia* in agroforestry stand, pest and diseases commonly found in agroforestry system, vertical and horizontal space allocation of intensive and less intensive agroforestry systems in relation to yields, mykorrhiza field inoculation and production techniques, and erosion rates and slope variation and vegetation composition in agroforestry site

After four years researchers observed the following at the research site.

- No more occurrence of illegal cutting.
- No further encroachment by local people
- Increased farmers' cash income
- Agroforestry has given a certain level of staple food security in the area
- Farmers expect to get more/additional income when the trees (*Paraserianthes falcataria*) are harvested
- Agroforestry in the degraded forest area of GWEF has increased the diversity of plant species in the areas

Based on the experience of Indonesia, development of appropriate agroforestry systems through people's participation and provision of land tenure security can be an effective strategy for promoting forest rehabilitation and people's welfare. Community-based forest management appears to be the better approach to forest establishment or rehabilitation especially where there is high population pressure on the forest for agricultural land.

### *Philippines*

On-site action-research (Lee, 2005 and Lee & Kim, 2003)

Using the diagnosis and design (D & D) methodology, a participatory action research approach, on-site research on agroforestry being conducted by Korean scientists in collaboration with Filipino academic researchers have so far achieved the following results.

Three broad categories of farming/agroforestry systems were found in the Mt. Makiling Forest Reserve: kaingin (slash and burn), home gardens, and plantation-based. The most dominant farming system is the plantation-based type consisting of farms planted with agricultural crops in combination with fruit or plantation crops and tree crops.

Within the forest reserve, formerly citrus orchard monoculture and coconut-based multi-storey system were generally found. However, virus infestation of citrus in 1990 resulted to abandonment of most of the citrus farmlands. Today only coconut-based multi-storey systems (with fruit tree or coffee) are cultivated inside the forest reserve.

In the study area in Sitio Jordan, San Vicente, Sto. Tomas, Batangas, coconut-based multi-storey system along with fruit tree or coffee is commonly practiced. However, many farmers prefer mahogany planting along the boundary and within their farm lots.

There are several reasons why farmers prefer mahogany (*Swietenia macrophylla*) as a tree component in their agroforestry system. Primarily, mahogany is perceived as a source of raw material for house construction in the future. Other reasons are its potential for erosion control, income source, and as farm boundary. More specifically, farmers prefer mahogany + coconut + fruit trees as the best combination of crops in terms of income generation as well as environmental protection. In addition, farmers also claimed that mahogany + fruit trees + annuals combination of planting is also profitable and is environmentally protective. Many farmers are shifting to mahogany-coconut-mixed multi-storey system from the coconut, fruit-tree or coffee-based multi-storey system due to the decreasing price of agricultural products in the long run. However, change is so slow and mahogany plantations are not well maintained. Limited investments on mahogany plantation was also observed because of uncertainty of mahogany timber market, lack of farmers skill in growing and managing mahogany, no guarantee of seed quality, and labor difficulty due to competing new jobs in the industry.

The socioeconomic conditions in the project site are generally characterized as follows:

Economy is dominated by commercial and medium scale agriculture and agroforestry operations. Main products are coconut (including copra), timber (coconut and mahogany), ginger, taro, coffee, and other fruits. The household income level ranges from US\$70 to US\$1000 per month. Farm size lies generally between 1.5 to 8 hectares. Land ownership pattern indicate that 80 percent of the farmers claimed to have security over their land. Age classes (reflecting manpower availability) range from 51 to 70 years old.

In support of the agroforestry development activities in the individual farmer participants farms, three field experiments are being conducted, namely: 1) effects of thinning on the growth of eight year old mahogany and intercropped with gabi, edible fern, rattan and ubi; 2) effect of organic fertilizer and mulching treatments on growth of 3-year old mahogany plantation intercropped with gabi and papaya; and 3) effect of coconut frond pruning treatments on the growth and yield of interplanted mahogany. Perhaps because of the recency of the experiments, based on available data so far there has been no significant effect of the different treatments introduced in the three experiments.

During the last four years the research team was able to characterize the land use system in area, to investigate problems and constraints, to propose agroforestry development strategy at the farm level, and to undertake some field experiments. Based on the team's experience so far, the following conclusion can be drawn: Most farmers appear to prefer the mahogany-based agroforestry system because of economic and environmental reasons. However, investment in mahogany plantation based agroforestry system leaves much to be desired because of some socioeconomic constraints.

Based on the D & D approach, farmer participants were found to be good partners, good record keepers and "local scientists".

### *Experimental Research*

Rehabilitation of degraded lands through forest tree-based agroforestry system (OACP 2005)

Under this study two experiments were conducted. The first experiment is on the growth performance of yemane (*Gmelina arborea*) and mahogany (*Swietenia macrophylla*) under different tree spacing. Preliminary results showed that the mean height (261 cm) and diameter growth (47 mm) increment of yemane was comparatively higher than that of mahogany, respectively (72 cm and 13 mm height and diameter increment, respectively). For mahogany there were no significant differences observed in height and diameter growth under three different spacing treatments. However, for yemane, diameter growth was significantly lower at closer plant spacing (2 x 2m).

Another experiment was on the effects of tree species and spacing on the growth and yield of intercropped corn and mungbean. Preliminary results showed that the dry matter yield of mungbean was significantly affected by tree species and spacing. Mungbean intercropped with mahogany had higher dry biomass compared to those grown with yemane. This may be attributed to better light environment afforded by mahogany because of its relatively open canopy compared to yemane. In terms of tree spacing, dry matter production was highest for mungbean grown under trees planted at 2 x 4m spacing.

Grain yield of mungbean was not significantly different when intercropped with either yemane or mahogany. However, effect of spacing on grain yield was significant. Yield was significantly higher at 2 x 3m and 2 x 4m spacing. Mungbean mean yield (64 kg/ha) at 2 x 2m tree spacing is only half as much the mean yield (114 kg/ha) obtained across all treatments.

*The effect of tree species and spacing on biomass yield of corn was not significant*

Aside from the experiments on the effect of spacing on growth of two forest tree species in an agroforestry system and on the effect of trees and spacing on crop yields, the study also sought to assess the impact of the agroforestry system on soil properties. Results showed that the soil pH in all the plots sampled both at 0-15 cm and 15-20 cm depths generally increased or improved (from 4.97 to 5.33 for 0-15 cm depth and from 4.91 to 5.30 for 15-30 cm depth).

In topsoil, highest increase from 4.8 to 5.5 was recorded for plot planted with yemane and agricultural crops with 2 x 4m spacing. At 15-30 cm depth, highest increase was for plots with yemane and spacing of 2 x 2m. Across all plots however, there was greater increase in mean pH at the yemane than in the mahogany plots both at the two depths. Comparing the effect of spacing revealed higher increase in pH at 2 x 4m spacing for the topsoil and for both 2 x 2m and 2 x 3m spacing in the subsoil.

Based on the experiments and studies conducted on tree based agroforestry system the following conclusions can be drawn: Under experimental site conditions yemane appeared to grow faster apically (height) and laterally (diameter) than mahogany. Yemane's diameter growth is affected by spacing. Dry matter yield was significantly affected by tree species and spacing while grain yield was only affected by spacing. Tree-based agroforestry system improved soil condition as a result increasing pH in all sample plots.

*Rehabilitation of degraded lands through nurse tree-climax species (NTCS) strategy (OACP 2005)*

Data showed that both dapdap (*Erythrina orientalis*) and kakawate (*Gliricidia sepium*) are exhibiting relatively fast growth rate with mean height and diameter (across treatment combinations) of 3.46 m and 35 mm, respectively, after two years. But analysis revealed that there was no significant difference in the mean height of the nurse trees, dapdap (3.54 m) and kakawate (3.39 m). However,

kakawate had developed significantly smaller diameter (29 mm) compared to dapdap (42 mm). This could imply that the lateral growth rate of dapdap is faster than kakawate.

The initial average height and diameter of climax species, bagtikan (*Parashorea malaanonan*) and durian (*Durio zibethinus*) were 0.63 m and 9 mm, respectively. Since the climax species have only been recently planted, statistical comparison between the different crop combinations cannot be conducted yet. Observations on the survival rate of the climax species 90 days after planting indicate that the survival of bagtikan and durian were relatively higher when planted either as pure crop or when interplanted under kakawate. This implies that kakawate can serve as good nurse trees for durian and bagtikan.

#### *Vietnam (AKECU 2004)*

In Tu Ne commune, *Cinamomum cassia* (a cash tree crop) has been tested in three different treatments: *C. cassia* plus cassava plus *Tephrosia candida*; *C. cassia* plus cassava; and *C. caasia* plus *Tephrosia candida*. Analysis of the height growth of *Cinamomum cassia* showed that there is no difference in its height growth in the three treatments. Average yield of cassava was 10 tons/ha (wet). *Tephrosia candida* could provide 3,500 kg of green manure equivalent to 50 kg  $(\text{NH}_4)_2\text{SO}_4$ .

Combination of N-fixing trees, agricultural crops and indigenous tree species for restoration of degraded land offers a great potential because of its multipurpose benefits.

#### *Agroforestry Research Implications*

##### Research strategy and research utilization

Either action-research or field experiments were used as agroforestry research strategies by the participating countries. As experienced in Indonesia and in the Philippines, action research provides the logic for an integrated research and development approach that enables researchers to directly deal with the environmental and social problems related to forest degradation and at the same time exploring the best technological solutions or most appropriate social interventions. Thus the application of technological and social innovations developed through action research is accelerated. On the other side, as applied in Lao PDR, Vietnam and also in the Philippines, experimental research is assumed to follow the traditional sequential model of research generation, research validation, and research utilization thus application of research results takes a longer time. In the context of the ASEAN region where the expected beneficiaries of agroforestry research are poor communities which can not afford the luxury of waiting too long for the results of long gestation research, action research seem to be the most appropriate strategy. But action research needs an interdisciplinary team of experts who can work together in a collaborative manner in addressing a common problem. This capability has yet to be developed in many if not most of the ASEAN countries.

The apparent advantage of action-research in the context of ASEAN does not all negate the importance and usefulness of experimental research by virtue of its longer research application and utilization pathway. In fact the speed at which the results of experimental research that follows the sequential model of research generation, validation, and application can also be accelerated through the active involvement of research clientele or expected beneficiaries in the research planning and development process as in action-research.

#### *Action-research results and the need for institutional change*

Based on the action-research experience in Indonesia and in the Philippines participatory agroforestry development with the active participation of local communities and provision of land tenure security appear to be an effective strategy for faster forest rehabilitation and restoration and social amelioration. However, for participatory agroforestry development or community-based forest management to be promoted and sustained in a wider scale beyond the action-research site some institutional changes are necessary. Policies legitimizing participatory or community-based agroforestry development and insuring land tenure security and other incentives for active local people participation must be formulated by national forestry development agencies. A bold step towards organizational re-structuring to enable forestry bureaucracies to more effectively respond to the challenges of participatory forest management must also be taken.

In the Philippines, much has been done towards these needed institutional changes. In Indonesia and other ASEAN countries the process of policy and organizational change are also underway.

#### *Experimental research results and agroforestry system design*

The result of these experiments provide empirical support or justification to farmers preference for agroforestry because of their protective value as observed in the on-site research area in Mt. Makiling in the Philippines.

In the design of agroforestry systems, if farmers are more interested in grain yield, they should take more consideration about spacing. On the other hand, if they are more interested in dry matter yield (biomass) they should take both species type and spacing serious consideration. Farmers can also consider kakauate as a possible shade tree when designing agroforestry system involving durian (a high value fruit tree) and bagtikan (a commercial tree species) which are light intolerant at their early stages of growth development.

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