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Bamboo for Thailand and Southeast Asia

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Tracing the History, Scanning the Technology and Initiatives on Bamboo Production and Conservation in the Philippines

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Abstract

Enhancement of bamboo production and conservation aimed at supplying enough quantity of high quality materials for the bamboo-based industries had been and still is being given so much attention so that the country becomes globally competitive as far as bamboo products are concerned. One of the approaches done is through research, development and extension not only on bamboo production and conservation but also utilization. This particular paper attempts to trace the history of research, development and extension and to scan the technology and initiatives on bamboo production and conservation in the Philippines. Specifically, the initiatives of different sectors/stakeholders on bamboo production and conservation are presented and discussed.

The country's research, development and extension initiatives on bamboo production have a very long history. Based on records, it is more than a century already. The country, however, continuously develops, packages and transfers bamboo production technologies including nursery propagation and plantation development and management. A number of government and non-government agencies/institutions including individuals and groups were and still are involved in either nationally or internationally funded research, development and extension on bamboo production.

Voluminous materials are available not only as reference for further scientific work but also for information, education and communication programs designed to promote bamboo production and conservation ot only as important commodity for livelihood development but also for biological conservation, environmental services and landscape aesthetics. A Master Plan for Sustainable Bamboo Development crafted a decade ago awaits review, rehash and repackaging for possible funding of its implementation. Renewed interests and initiatives on bamboo are due to its roles in providing livelihood options and at the same time increasing the capacity of the communities to adapt to climate change. Other recent research, development and extension initiatives and relevant recommendations for the sustainable development of the bamboo industry through scientific bamboo production approaches are enumerated.

Keywords: sustainable development, bamboo production, stakeholders

Introduction

Relevance of bamboo to human living especially in the social, cultural, economic and environmental aspects of life cannot be over-emphasized. Many agricultural or farming activities, fishery, construction, tourism, landscaping and gardening, handicraft and furniture and food industries utilize bamboo materials. The bamboo's traditional sobriquet as poor man's timber has diminished through time because of the many commercial uses that considerably compete with the traditional ones. Such condition remarkably increased the market demand for bamboo while supply was not improving due to the limited establishment of plantation. This made the price of bamboo unaffordable to local people.

During the past, supply of bamboo was very much dependent on the natural bamboo stands either in the forests or those scattered in the villages. To systematically and scientifically improve the supply of quality bamboos to support the growing bamboo-based and bamboo using industries, the need for research, development and extension on bamboo production was felt by both the government and private sectors.

It is the intention of this paper to trace the history and scan the technology on bamboo in the country by looking at research, development and extension initiatives of various stakeholders on bamboo production through the years. For almost a century, works on bamboo production have involved quite a number of research, development and extension agencies/institutions including private individuals and institutions and non-government organizations.

Research, Development And Extension Initiatives

Among the leading institutions in research, development and extension on bamboo include some state universities and colleges notably, the University of the Philippines Los Banos (UPLB); the research arms of the Department of Environment and Natural Resources (DENR) namely, the Ecosystems Research and Development Bureau (ERDB) based in Los Banos and Ecosystem Research and Development Services (ERDS) in various regions of the Philippines; the Forest Products and Research Development Institute (FPRDI) of the Department of Science and Technology (DOST) and the research arms of the Department of Agriculture (DA) such as the Bureau of Agricultural Research (BAR) and the Bureau of Plant Industry (BPI).

Some state universities and colleges like the Mariano Marcos State University (MMSU), Don Mariano Marcos State University (DMMSU), Isabela State University (ISU), Nueva Viscaya State University (NVSU), Benguet State University (BSU), Bulacan State University (BuSU), Visayas State University (VSU), Central Mindanao University (CMU), Bataan Peninsula State University (BPSU), Tarlac College of Agriculture (TCA), Pampanga Agricultural College (PAC) and others have their own research, development and extension programs on bamboo production and conservation. Some of them have collaborative works with other government and private institutions in the country and international agencies.

Funding for the many research, development and extension activities on bamboo production in the country came from national funding institutions like the Philippine Council for Agriculture and Natural Resources Research and Development (PCARRD) of the Department of Science and Technology (DOST), the National Research

Council of the Philippines (NRCP), Department of Agriculture (DA), Development Bank of the Philippines (DBP), Technology and Livelihood Resource Center (TLRC), Department of Technology and Industry (DTI), Local Government Units (LGU), congressional allocations or from Community Development Fund of politicians via their own personal prerogative. Most lucrative source of funding is from international institutions like the European Commission (EC), United Nations Development Fund- Food and Agricultural Organization (UNDP-FAO), Japan International Cooperating Agency (JICA), Japan Society for the Promotion of Science (JSPS), International Tropical Timber Trade Organization (ITTO), Asian Development Bank (ADB), International Network for Bamboo and Rattan (INBAR), World Bank (WB), World Agroforestry Center (WAC), South East Asia Regional Center for Agriculture (SEARCA) and many others.

Recently, the trend in research development and extension is regional in scope or it is collaborative work with a network of several countries in Asia or ASEAN or Asia Pacific Region and sometimes includes countries in Europe or United States of America (USA) to be able to get the necessary international funding support.

Research, Development and Extension Activities

On taxonomy and bambusetum establishment

The first report on Philippine bamboos was Bulletin 1 written by Brown and Fisher in 1918 that was published by the Bureau of Printing. Subsequently, this formed part as a one of the Chapters of the Brown and Fisher's book on Minor Forest Products of the Philippines published in 1920.

Earliest initiative related to bamboo production was the study done by the College of Forestry-UPLB and Forest Products Research Institute (FPRDI) on taxonomy. This dealt with variations in morphological characters (Quimbo, 1957) and review of the various erect bamboo species (Lindayen et. al., 1969) of the Philippines. Study on the growth and characteristics of *Schizostachyum lumampao* was done in the Makiling Forest in 1961 (Zamuco, 1961 as cited by Bumarlong, 1980). In 1971, a bibliography on minor forest products came out. This included, among others, some studies done on the propagation and utilization of Philippine bamboos.

In 1986, a book "Guide to Philippine Flora and Fauna" published by the Natural Resources Management Center (NRMC), Ministry of Natural Resources (MNR) now known as Department of Environment and Natural Resources (DENR) and the University of the Philippines includes chapters on bamboos and grasses (Vera Santos, 1986). In 1995, a book on Bamboos- Plant Resources of South-East Asia (PROSEA) was published in which Philippine Bamboo Species are included. All these provided information on the important bamboo species that have potential for commercial utilization and as basis for natural and artificial regeneration.

The establishment of bambusetum was first reported by Tamolang in 1954 presumably initiated by the Forest Products Research and Development Institute (FPRDI). The College of Agriculture and the Institute of Plan Breeding of UPLB have their own living collection of bamboo. Accordingly, through the ERDB-DENR-UNDP/FAO project, bambuseta (living collection of different native and exotic bamboo species) were established in the country in 1987. These were in Mt Makiling, Los Banos, Laguna, Loakan, Baguio City and in Nabunturan, Compostela Province. Private individuals mostly bamboo enthusiasts also established their own collection. Example of which is Carolina Farm in Antipolo Rizal. ERDS-DENR specifically in Butuan City, Caraga region also started the establishment of bambusetum. Recently, importation of various species of semi-temperate and temperate species of bamboos from China was made. These bamboo species are being acclimatized and being used for scientific investigation at Benguet State Uninversity (BSU) in La Trinindad, Benguet. This importation presumably passed the plant quarantine policies and regulations of the country.

On bamboo inventory

Forest inventory conducted in 1988 by the RP-German Forest Resources Inventory Project included rattan and bamboo. The natural bamboo stands included in the inventory were mostly *Schizostachyum lumampao*, *Schizostachyum lima* for the erect types and also *Schizostachyum spp.* for the climbing types, being the naturally growing bamboo species in the forests. This was the first and the last inventory of bamboo stands in the forests when the Philippines still have vast forest areas. Provincial-wide inventory of erect bamboo stands mostly in the villages of some selected provinces in the country was undertaken in 1981 to 1984 (Virtucio et.al., 1983). Relevant to bamboo inventory was the study conducted on the mensurational attributes of five bamboo species in different parts of the country (Tandug, 1979). Based on FAO publication entitled, "Bamboo Resources of the World" (FAO, 2005), the Philippines has 127,000 hectares. This, accordingly, increased to 156,000 has in 2000 and 172,000 has in 2005. Figure 1 shows the bamboo production areas including the plantations established by government institutions and private individuals, groups and organizations.

On propagation and field performance

1. Sexual propagation (use of seeds)- ERDB (formerly Forest Research Institute) started bamboo propagation research as early as 1976 when the clumps of *Schizostachyum lumampao* in UPLB campus produced flowers and bore fruits. The fruits which are the seeds themselves were collected and used for germination and seedling culture including fertilizer application study (Lapis, 1976).

2. Macro-vegetative materials: Direct Planting of Cuttings-

a. Traditional method of bamboo propagation include the use of culms cut into 3 to 4 nodes or even longer and planted directly in the field with hole immediately below the node for watering. Use of rhizomes or division was also commonly practiced.

b. The earliest recorded studies on the propagation of Philippine bamboos dealt mainly on using culm cuttings that were directly planted in the field: For example, Curran and Foxworthy in 1912 studied directly planted cuttings of *Bambusa blumeana*, *B. vulgaris* and *Gigantochloa levis* but found to have very dismal survival percentage of 34%, 32% and 6%, respectively. Another study done by Foxworthy in 1917 in a 2 hectare plot directly planted with stump cuttings and culm cuttings had survival percentage of 59% and 40%, respectively. Mabayag in 1937 studied the propagation of *B. blumeana* culm cuttings and found that cuttings from basal portion of culms performed well under sunlight than under shade. Subsequently, Cabanday in 1957 and Agleam in 1960 studied the propagation of bamboos by various forms of cuttings and layerage. The former found 60% survival of unsplit *B. blumeana* culm cuttings while the latter found better results using unsplit culm cuttings of bolo taken from the middle and top portions of the culm.

c. In a study conducted by Baja-Lapis, Bumarlong, Tandug and Moldes in 1980 on direct planting of culm cuttings, it was reported that out of a total of 720 two-node unsplit culm cuttings taken from about 1 to 2 year old culms of *B. blumeana*, *B. vulgaris* and *Dendrocalamus merrilianus* directly planted in cogonal area had a survival rates of only 25%, 51%, and 35%,respectively, after six months. Subsequent to the above study was a project in Ilocos Norte and Bukidnon on the survival and growth of *G. levis* and *D. merrilianus* as affected by site preparation and fertilizer application, the results of which were reported by Baja-Lapis et. al., in 1984.

3. Nursery propagation using culm cuttings

a. Instead of direct planting of cuttings, nursery propagation of culm cuttings was undertaken to be able to supply quality planting stocks to plantation developers so that higher survival in the field can be assured.

b. Through trial and error method, the Caasi family in Mindanao was able to develop vegetative propagation of *Bambusa philippinensis*. At first, the Caasi's tried the rhizomes or division but found to be laborious and costly since only few propagules can be extracted from a clump. Subsequently, the Caasi's tried culm cuttings and found that is more efficient and effective if culm cuttings from 15 to 24 month old culms are used. This species and its propagation were popularized by the Caasi's in Mindanao since such bamboo species is the main propping material for banana.

c. The desire to further improve the propagation technology, graduate students in UPLB used bamboos for propagation studies in the late 1970's and early 1980's: Propagation of culm cuttings in the nursery was conducted by Bumarlong (1977); Propagation using branch cuttings was done by Palijon (1983) and Soriano (1984).

d. Use of rooting hormones in bamboo propagation: Uchimura in 1977 used rooting hormones and found that soaking of cuttings of *B. vulgaris* to 100 ppm Indole butyric acid (IBA) solution for 24 hours before planting had better rooting rates and had longer roots than stocks soaked in same concentration of alpha-naphthalene acetic acid (ANAA) and IBA; Bumarlong also in 1977studied IBA, Indole acetic acid (IAA) and ANAA in rooting cuttings of *B. blumeana* and found that 600 ppm ANAA gave the highest total dry weight and mean length of roots while the 200 ppm ANAA gave the highest mean number of roots; Palijon in 1983 found 100 ppm IBA and 100 ppm IAA were much better treatments in enhancing rooting in the nursery and survival in the field of *B. blumeana* branch cuttings. Palijon's study included the field performance of branch cuttings, the results of which was published in Philippine Agricultural Scientist, an International Journal. .

e. Use of branch marcot (marcotting) culm cuttings was introduced by an Engineer, Mr Domingo Alfonso in the early 1980's. This propagation method was one of the highlights in his Kawayan (Bamboo) Farm in Pillilla, Rizal.

f. Pre-rhizomed, pre-rooted branch cuttings were also tried. Results show great potential for use in commercial propagation of selected species of bamboos (Palijon, undated).

g. The use of mist (Palijon, 1983; Mindanao Baptist Rural Life Center in Mindanao- MBRLC, 1980's) and non-mist system or sometimes referred to as "incubation method" (Caasi, 1988; MBRLC; Philippine Rural

Reconstruction Movement-PRRM)\ in Cavite and DENR-ERDB and DENR-ERDS) in propagating culm cuttings and branch cuttings was tried, popularized and commercialized.

h. Airponic Technology in propagation- Maravilla in Iloilo City introduced the use of “airponic” that requires a million peso oxygen-rich greenhouse in the propagation not only of bamboo branch cuttings but also high value horticultural crops. This technology shows how it can effectively enhance rooting of cuttings and accelerate the growth in a very short period of time. The root zone of the cuttings is suspended in a growing chamber and intermittently pulse-misted with a nutrient solution.

i. Micro-propagation: *Tissue culture and mini-clump division*- genetically superior bamboo planting stocks, accordingly, can be mass produced throughout the year using this method (Zamora, 1994). This bio-technology was tried in the Philippines using excised embryo of S. lumampao, G*igantochloa levis* and *S. lima*. Field performance of tissue cultured planting materials done in Bataan, Zambales and Laguna were successful (Zamora and Gruezo, 1999). A sequel to this study was the use of tissue cultured materials for further multiplication into planting stocks with similar genetic quality through mini-clump division. This method involves separation of 3 to 4 month old plantlets from tissue-cultured materials into individual stems or small clumps of 2 to 3 stems. The separations can be done further at 2 to 3 month intervals.

On plantation establishment and management

1. It was in the 1915 that the first initiative on bamboo planting was done at the College of Agriculture was recorded (Villamil, 1915). In 1965, bamboo plantation development was initiated in Mindanao (Chinte, 1965).

2. From 1981 to December 1983, a project on the production and utilization of bamboos at barangay level, in Pangasinan and Quezon was implemented (Virtucio et.al., 1983). Simultaneously, a project on the development of pilot scale plantation of selected bamboo species in Rizal and Quezon provinces for cottage industries was similarly undertaken from 1981 to 1987 (Lapis, et.al., 1987). A follow through to the above project was the bamboo expansion program within the ‘Lungsod Silangan” communities which was implemented from 1988 to 1989 (Virtucio et. al., 1989).

3. In 1985, the basic site requirements for some of the commercially important bamboo species and the locations in the country where the particular species may be suitable where provided by Lantican, Palijon and Saludo (1985). Such information can still be useful when plantation establishment is to be carried out. This was published in the proceedings of the International Bamboo Workshop held in Hangzhou, People’s Republic of China (PROC).

5. On pests and diseases: In one of PCARRD’s (1984) technical bulletin as cited by Lantican et. al., (1985), some of the pests that were observed on bamboos include termites, cottony cushion mealy bug, bamboo scale oriental migratory locust, leaf roller, tussock moth and mites. Diseases, on the other hand, include physiological and fungal diseases. It was however, mentioned that none of these pests and diseases have been reported as serious problems in nurseries, plantations and natural stands.

4. Intermediate silvicultural treatment: In 1984, Robilllos disclosed his findings on removal of spiny thickets in and around the lower portion of clumps of *B. blumeana* and decongestion of the clumps by removing high stumps from previous harvesting and cutting of deformed and overmature culms. He found that such treatment resulted to higher production and better quality of culms.

5. Study on the determination of optimum cutting and cutting age of some erect bamboo species in the different parts of the country was undertaken and the information generated was accordingly packaged and being used for dissemination. As outlined in the Master Plan for Development of Bamboo as a Renewable and Sustainable Resource (1997), the harvesting systems based on the various studies conducted in the Philippines include selective cutting and clear cutting or blanket method. The first one is conducted by cutting only selected culms or poles of the desired age while the other one requires cutting of all poles/culms, regardless of age and are totally cut leaving only the very young culms and shoots.

5. Recently, a POPEYE technology was developed by Malab (Personal Communication) which requires sustaining a 4:4:4:4 clump which is composed of 4-one-year old, 4- two year old, 4- three year old and 4- four year old culms in a clump to have continuous production.

6. On production of deformed bamboos for the furniture industry- The need to supply the furniture industry with the desired forms and shapes of bamboo materials that can make the products unique, a study on the response of erect bamboo species to artificial deformation was done in the Philippines (Pinol et.al., 1978). Encouraging results were achieved but adoption and commercialization did not pick up.

Bamboo plantation development and conservation initiative by Local Government Unit (LGU)

1. Foremost to this is the "Kawayan: Yaman Laguna" (translated in English as "Bamboo: Wealth of Laguna" project by no other than the Laguna Provincial Governor Joey Lina. The intention was to promote planting of bamboo for livelihood, conservation and environmental rehabilitation. Thousands and thousands of planting stocks of different species, with *B. philippinensis* as the most dominant, were raised and distributed to the different barangays and municipalities of Laguna and even in other provinces. The project was implemented with a consultant from Davao del Norte despite the fact that ERDB and UPLB are just stone throw away from the Office of the Provincial Governor in Sta Cruz. What exactly happens to this project, nobody knows. From personal communication with beneficiaries of the project, the species distributed to communities, which is *B. philippinensis*, was not very much acceptable.

Private initiatives on bamboo plantation development and conservation

1. One of the early users of culm cuttings for commercial production of planting materials was Engineer Domingo Alfonso. His 20 hectare farm in Pililla, Rizal mostly comprised of *B. blumeana* was established using culm cuttings. This farm used to be the source of culm cuttings utilized for propagating thousands and thousands of planting materials that were supplied to various clients coming from different parts of the country.

2. Another early plantation development initiative was in Mindanao where hundreds of bamboo planters/producers known as the Davao Bamboo Development Cooperative were organized by the Caasi to

systematize the supply of bamboo poles as banana props to banana plantations (Caasi, 1988). At first, the bamboo farms were established in La Union, Tagum, in Maco, Mabini, and in New Bataan covering a hundred hectares of idle cogonal lands, along river banks, hillsides, mountain sides and marshy areas. Then this enterprise grew and the plantation expanded several folds to meet the demands of the banana plantations. Mr. Caasi became popularly known as “Bamboo King” because of his success in promoting bamboo plantation as source of livelihood and for environmental improvement and sustainability.

List of the initiatives by other private individuals, groups and organizations on bamboo plantation development is shown in Table 1 (Virtucio and Rivera, 1995; Pastor, 1995; Alfonso, 1995; and, Caasi, 1994 as cited in Master Plan for the Development of Bamboo as a Renewable and Sustainable Resource, 1997).

From Table 1, the total bamboo plantation reported for the three major islands in the Philippines was 7,054 hectares. It will be noted that the bamboo species used in plantation for Luzon and Visayas is dominantly *B. blumeana* while *B. philippinensis* in Mindanao. If you take the percentage of the bamboo plantation established in these different islands, those in Luzon constitute only about 15 % (1,043 out of 7,054 hectares) while those in Visayas only less than 5% (312 out of 7,054 hectares) the rest, about 80% (5,699 out of 7,054 hectares) are in Mindanao. The species is dominantly *B. phlilippinensis* which is primarily intended for prop production for the banana industry. There was that *on and off use* of bamboo as props in recent years. The question is, are these plantations of *B. philippinensis* in Mindanao still exist?

Department of Environment and Natural Resources' (DENR's) programs on bamboo plantation development

1. Bamboo being considered as reforestation species not only for socio-economic but also environmental benefits of the society, development of plantation of this crop in public lands was encouraged. Moreover, the DENR’s program on application and demonstration of bamboo production technology via pilot bamboo plantation in strategic areas in the country has contributed to the promotion of bamboo plantation establishment.

2. Effectiveness of bamboo demonstration plantation as a technology transfer scheme was tested from 1987 to 1990 in Region 5 where the Minor Forest Product Center of Ecosystem Research and Development Bureau (ERDB) (known that time as Forest Research Institute or FORI) was located. This project was assisted by the ERDB-USAID, and PCARRD. Table 2 shows the plantations that have been established under the DENR’s programs: regular planting program; contract reforestation program through the Forestry Sector Loan Program and research and pilot plantations (Malvas, 1995; National Forest Development Office (NFDO) DENR Report (1997); Region IV and Community Environment and Natural Resources Office’s (CENRO’s) updated reports as cited in Master Plan for the Development of Bamboo as a Renewable and Sustainable Resource, 1997). It can be noted that the area established by the government is only small compared to the size established by the private sectors. Moreover, the type of bamboo species in this government initiative on bamboo plantation establishment was not specified in the report. It is also important to determine whether these plantations still exist or whether they are producing and supplying the industry.

There is a need to determine whether there are some more plantations of bamboo that were established by both the government and the private sectors aside from the above initiatives.

Research, Development And Extension Initiatives Of Ecosystem Research Development Service (Erds) In The Various Regions Of The Country

The Ecosystem Research and Development Services (ERDS) of DENR in the regions likewise conduct studies that have some bearing on bamboo production. Table 3 shows the list of these RDE initiatives in the regions. These initiatives were mostly application and demonstration of production technologies and conservation activities.

Research Development And Extension Initiatives Of Various Institutions With International Funding Support

1. The National Bamboo Research and Development Project (NBRDP)- The efforts and initiatives on bamboo production were characteristically scattered and less comprehensive. The DENR through its research arm, the ERDB, felt the need to implement a more comprehensive national bamboo research and development project. Thus, in 1987 such project was launched with the funding support from UNDP-FAO. This project generated research outputs on the various aspects related to bamboo production from taxonomy, physiology, phenology, pest and diseases, propagation, harvesting and management including economics and marketing. Table 4 shows the list of the studies conducted under this NBRD project.

2. The European Commission Bamboo Project – Entitled "Sustainable management and quality improvement of bamboos," this project which was implemented from 1997 to 2001. It aimed to increase the knowledge on the sustainable supply, use and quality improvement of selected bamboo species in Southeast Asia. Specifically, it aimed to develop improved management and sustained use for bamboos in the region; determine the influence of management practices on basic culm properties; to optimize the processing and performance of higher technology bamboo products based on "improved" raw material; and, disseminate the information to user groups. The implementation of the project involved 3 countries in Southeast Asia (Philippines, Indonesia and Malaysia) and 3 countries in Europe (Germany, Belgium and United Kingdom). The Philippines was tasked to conduct study of the silviculture and management of 2 bamboo species, namely *Gigantochloa levis* and *Dendrocalamus asper*. The 2 hectare plantation was established at the UP Quezon Land Grant. The results of this study were published in Bamboo and Rattan International Journal published by INBAR in 2005.

3. Australian Council for International Research (ACIAR) Project (FST/2000/127) entitled "Improving and maintaining productivity of bamboo for quality timber and shoots in Australia and the Philippines" was implemented in Southeast Asia. Professor David Midmore has served as the Project Leader and Australians and Filipinos from different agencies and institutions were serving as investigators. It has the following objectives: First, to study and implement a process to rehabilitate existing aged/and or damaged bamboo stands for shoot and timber production; secondly, the project aims to develop management technologies for sustainable and high productivity of existing bamboo plantations for shoots and timber; and, third is to improve the efficiency and quality of the bamboo timber harvest.

As expected, project will contribute to the knowledge network in Australia and Southeast Asia and so, it will build on and foster the work of INBAR and other bamboo groups. Accordingly, project has been structured around a series of empirical experiments involving the management of bamboo spread around Australia and the Philippines. It includes formal and informal meetings designed to foster and promote associations between bamboo people and to formulate commercial arrangements.

Present National Project On Bamboo

The "Bamboo Industry Development Program: Mainstreaming Engineered-Bamboo

Products in the Philippine Raw Materials Market for Construction and Furniture," is the newly approved bamboo program being implemented by a number of collaborating institutions. The Program Leader is Dr. Ramon Razal of UPLB. It has 5 project components. The development and management of pilot bamboo plantations in selected areas in Laguna is one of the major components.

Packaged Bamboo Scientific Information And Technology

1. The Philippine Recommends for Bamboo Production published by PCARRD and the DENR National Program Coordinating Office was probably the first of a package of information on bamboo production and harvesting in the country. This was the product of the various researches conducted by the scientist and practitioners from ERDB, CFNR-UPLB, IPB-UPLB, Tarlac College of Agriculture (TCA), Kawayan Farms and PCARDD. This is being revised to include production and utilization of commercial bamboo species but also ornamental bamboos. The updated version will come out soon.

2. Agroforestry Technology Information Kit published by International Rural Reconstruction Movement (IRRM) in Cavite in which bamboo production is one of the main technology components.

3. Sustainable Livelihood Options for the Philippines: An Information Kit (Upland Ecosystem) –published by DENR where giant bamboo for propagule production, deformed bamboo production and bamboo utilization are included as alternative livelihood for the uplands.

4. Training Manual on Agroforestry published by KAPWA in collaboration with the Institute of Agroforestry, CFNR-UPLB. This manual serves as reference materials for trainors as well as for actual practitioners or users of technology.

5. Training documents on various courses namely: Reforestation, Nursery Establishment and Management, Community Enterprises, Social Forestry/Community Development and others include bamboo propagation, bamboo planting stock culture and bamboo plantation establishment and management. Compiled documents are available in CFNR-UPLB and these are used as materials for international as well as national training.

6. RISE or Research Information Series on Ecosystems (Reforestation Species) has specific volumes featuring bamboo species, their description, habitat, uses, propagation and cultural management procedures.

7. Techno-transfer series of DENR-ERDS: example is the Techno-Series,Bulletin No.1 published in 1988 entitled "Growing bamboo for livelihood and environmental protection" written in local visayan dialect side by side with English version. This features the Caasi Bamboo Technology.

8. Bamboo Farming in different language and dialects (English, Pilipino, Visaya and others) published by the DENR-ERDB/FAO-UNDP Bamboo Research and Development Project in 1995.

9. Philippine Erect Bamboos: A Field Identification Guide written by Rojo, Roxas, Pitargue,Jr. and Brinas and was published by the FPRDI-DOST which include both the native and exotic bamboo species. As a guide it provides key to the identification of each species.

10. Bamboo Production in the Philippines written by Virtucio and Roxas (2003) - the book provides a wealth of information on the bamboo industry, the bamboos and their habit, propagation methods, plantation establishment, maintenance and protection, shoot production, culm production and bambusetum development.

11. Bamboo, people, the environment: Propagation and Management, INBAR Technical Report. Volume 1 published by INBAR and Government of Netherlands.

Training On Bamboo Production

There are quite a lot of trainings related to bamboo production and utilization that have been conducted in the country. These trainings are mainly or secondarily offered by the following training providers:

1. Technology Resource and Livelihood Resource Center (TLRC) provides training on livelihood. Modules on bamboo production and utilization are included.

2. International Rural Reconstruction Movement (IRRM) and Philippine Rural Reconstruction Movement (PRRM)

3. South East Asia Research Center for Agriculture in the 1980's where I was tapped as resource person and am proud to say that many of the State Colleges and Universities that participated in bamboo training have adopted, even modified and improved the technology.

4. Institute of Agroforestry of the College of Forestry and Natural Resources and the Institute of Plant Breeding, both of UPLB.

5. Non-Government Organization (NGO)/Foundation (like Philippine Business for Social Progress- PBSP)); religious, civic and related organization (like Mindanao Baptist Rural Life Center- MBRLC in Mindanao)

6. The Ecosystem Research and Development Bureau (ERDB) and Ecosystem Research and Development Services (ERDS) both of the Department of Environment and Natural Resources (DENR)

7. State Colleges and Universities (SCUs) specifically offering agriculture and forestry

Promotion Of Bamboo Production, Conservationand Utilization Through *National Bamboo Conferences*

Since 1996, three or four national bamboo conferences were held in the Philippines. The first was in Sarabia Manor, Hotel in Iloilo City in 1996, the second in Pangasinan State University in Lingayen and the third was in Provincial Capitol, Pili, Camarines, Sur. These served as venues for disseminating scientific information, technologies and products and for getting the support of as many stakeholders as possible.

It was during the first conference held in Bicol that a master plan for the sustainable development of bamboo industry was deemed very necessary. Thus, the second National Bamboo Conference held in Northern Philippines was used as venue to solicit comments and suggestions from the participants. Unfortunately, every after the conference nothing has changed, nothing has improved. There can be some problems somewhere.

Master Plan For The Development Of Bamboo As A Renewable And Sustainable Resource

The master plan crafted in 1997 should have propelled the development of the bamboo industry in the Philippines. However, such plan was only consigned in the dusty shelf and became habitat for subterranean organisms. This is due to lack of political support that could have provided sustained financial allocations for its implementation. Or, there was no concerted effort to push for the implementation of the Master Plan.

Political Actions And Initiatives

Numerous draft bills on national bamboo program have been filed in both houses by so many congressmen and senators already. I have been asked several times to comment on the draft bills. As a good soldier, I always abide. Unfortunately, none has moved even an inch in both houses. I am about to reach my twilight years and my only hope is to see Sustainable National Bamboo and Rattan Program or for that matter National NTFP Program being finally approved and implemented for poverty reduction, socio-economic prosperity, livelihood and environmental protection and conservation.

Renewed Interest On Sustainable Development Of Bamboo Industry

The National Bamboo Development Forum- should serve as a venue for more collaborative, unified, comprehensive, holistic approach to sustainable bamboo industry in the Philippines.

There are existing local and national bamboo organizations in the country. The Bamboo Foundation which, accordingly, was conceived as scientific organization and later became political in nature was the one responsible for holding the previous national conferences on bamboo.

Through this Foundation and through the involvement of the former President of this Foundation as Member of the Board of Trustees of the International Bamboo and Rattan (INBAR), some important/prominent political figures and presidential appointees were able to visit China and be exposed to the wonders of bamboo. A very good well-prepared power point presentation has become available and being used to promote bamboo development in the country.

Through the Bamboo Foundation, Laguna Lake Development Authority (LLDA) and the Rotary Club, a renewed action on bamboo is initiated by again tapping the scientific community: the academe, the research and extension organizations. So many meetings were held and the idea of having bamboo summit surfaced until finally the holding of this National Bamboo Development Forum became the center piece of this renewed interest on sustainable development of bamboo.

A number of bamboo councils with members from academe, research organizations, Local Government Units, civic and religious organizations, accordingly, have already been formed in some regions/provinces in the country. A program on trainors' training on bamboo has accordingly been organized through the initiative of LLDA and Bamboo Foundation. This will train forestry and agriculture graduate to act as trainor in the various parts of the country. The Training Center of CFNR-UPLB is commissioned for this training. I hope this will push through and I sincerely hope it will not remain as a dream.

Creation Of New Bamboo Organization

While renewed interest on bamboo is gaining momentum, a new bamboo organization known as BAMBOOPHIL, was formed. This may be different from the existing Bamboo Foundation.

The need of the time is a UNIFICATION OF ALL THE ORGANIZATIONS/ STAKEHOLDERS so that sustainable bamboo development in the country can progressively move forward.

Conclusion And Recommendations

A lot of research, development and extension initiatives have been done to promote the bamboo industry in the country. There seems to be something lacking to propel bamboo development in the country. Comprehensive and holistic analysis of the problems must be carried out. Some say it is due to lack of political support and political will, financial support and other forms of incentives, discouraging/unfriendly government policies, laws and regulations. Others say, there is no sustainable development plan for the bamboo industry. The following recommendations should therefore be given attention if sustainability of the bamboo industry in the country is to be pursued:

On Development and Conservation:

1. Allocation of areas in the country for bamboo plantation development needs multi- stakeholders consultation and decision.

2. Multi-agencies should join hand in hand to engage in nationwide efforts to develop bamboo farm for various end uses.

3. Government support is required to encourage the plantation development thru incentive provision, financial, flexible policy in harvesting and transport as well as creation of markets.

4. Enabling legislation should be formulated to enjoin local government units to engage in plantation development.

5. In situ and ex-situ conservation areas for bamboo and gene bank must be established.

On Extension:

5. Vibrant extension program should be developed and pursued sustainably.

6. Diffusion of science based bamboo technologies and protocols should be done to the upland and lowland communities.

7. Local communities' participation-cum-ownership should follow a scheme that would ensure equitable benefits.

8. Government and non government support to farmers thru provision of technical assistance to interested clientele.

On Research

9. Harness the potential of climbing bamboos and other lesser-known erect bamboos

11. Micro-propagation through tissue culture for mass production improved genetic materials for the establishment of high quality plantations must be further studied

10. Studies on Carbon sequestration and storage potentials of bamboos and the roles of bamboos on climate change mitigation and adaptation must be conducted.

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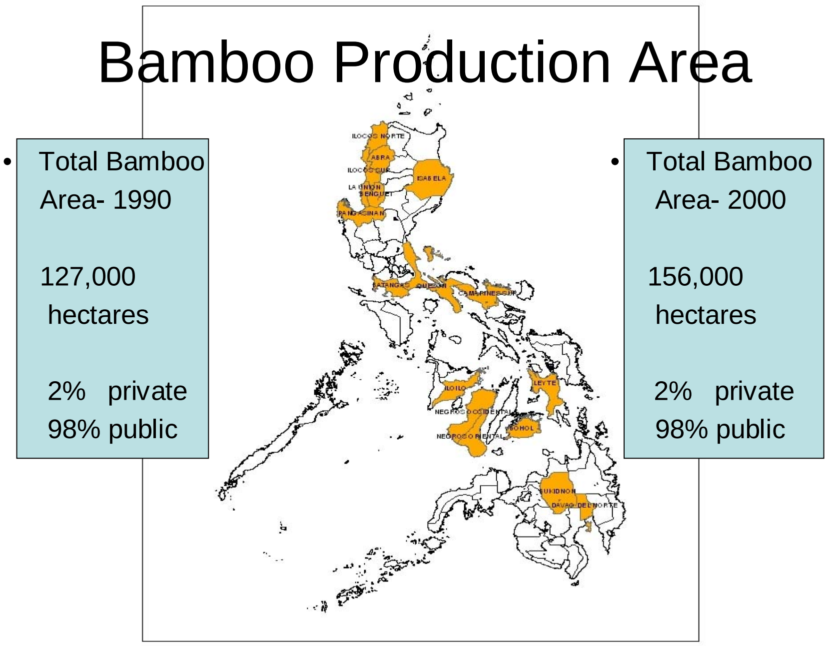

Source: Lobovikob 2005. World Bamboo Resources, FAO

Figure 1. Bamboo production areas in the Philippinensis

Table 1. Bamboo plantation established through the initiatives of private sector

Location		Owner	Species	Area
Luzon				(ha)
	Isla Verde	Jose Pastor	B. blumeana	50
	Pililia, Rizal	Alfonso Domingo		20
	Agno, Pangasinan	Doctor's Farm		5
	Pangasinan	Nepa Q Mart	D. merrilianus	50
	Coron, Palawan	Francisco Fernada		5
	Del Monte, Bulacan	Singh		20
	Bula, Camarines Sur	Mike Caya		3
	Laguna	Various private groups	B. blumeana, G. levis, B. philippinensis	890
			Sub-total	1,043
Visayas	Murcia, Negros Occ.	R. Jalandoni	B. blumeana	160
		T. TRebol		20
		N.L. Agustin Farms		30
	Isabela Negros Occ.	R. Suatenco		5
	La Castellana, Negros	Ferria Farms		14
	Manapla, Negros Occ.	Lamata Farms		14
	Cadiz, Negros Occ.	Mirasol		10
	Victoria, Negros Occ.	Maravilla Farms		10
	Moises Padilla, Negros	Ferria Farms		7
	Valladolid, Negros	Mayor Presbitero		2
	Dingle, Iloilo	Hermontt Enterprises		8
	Duenas, Iloilo	Paterno Larida		10
	Anilao, Iloilo	MaravillaEnterprises	D. asper	10
	Guimaras	Smile	D. asper	12
			Sub-total	312
Mindanao				
	Panabo Dvo. Norte	Tagum Development Company	B. blumeana, B. philippinensis	140
	Davao Norte	Nest Farm		161
		Davao Penal Colony		303
		Wakat Development Corporation		80
		F/S Dizon	B. blumeana, B. philippinensis	110
		AMS-FC		100
		SFC	B. philippinensis	5
		CFI		12
		Davao Fruits		434
		Twin River		132
	Pandadan, Tagum DN	Caasi		5
	Sn Isidro, Nabunturan	Caasi	D. atter	10
	Piang Village S.C.	Virrey	B. philippinensis	2
	Mati, Dvo. Oriental	Rabat	D. latiflorus	5
	Compostela & others	CBMC	B. philippinensis	186
	Sto. Tomas	ARSPMPC		170

	Sampao, KapalongDN			30
	Palmagil, Talaingod	Palmagil Farmers		120
	Banabanon,SanVicente	Banbanon MPC		120
	Monkayo DN	FARCOM		124
	Mapising, Taganan, Mabini DN	MCBDI	B. philippinensis	68
			D. atter	54
	Davao Province	SAWATA	B. philippinensis	2,048
		Davao Bamboo Coop		100
	Asuncion, Montevista	SAWATA	D. atter	20
	Mabini, DN	Individual Farmers		10
	Magbum, Tagum	Daniel Conde	B. philippinensis	200
	Tagum, New Corella	Alma Uy		100
	Magdaum, Tagum	Hijo Plantation		200
	Maparat, Compostela	Davao Fruits		50
	Asuncion, Davao Norte	Soriano Farms		80
	New Corella, DN	Alberta Omega		50
	Panabo, Mabini, Paco	Individual farmers		30
	Panabo, Carmen DN			30
	Anibongan,Carmen DN	Anibongan MPC		10
	Mawab, DN	Dizon Farms		200
	Monkayo, DN	Mr. Tuazon		100
	Compsotela (Valma)	Mr.Balunos		100
			Sub-total	5,699
			Over-all Total	7,054

Table 2. Bamboo Plantation Established through Department of Environment and Natural Resources' (DENR's) program

Location	Year Established	Area (Ha)
<u>Under the regular planting program</u> CAR 1. Laskig Pidigan, Abra	1986	40
2. Lagangilang, Abra		52
3. Itogon, Benguet		22
4. Mankayan, Benguet	1988	48
5. La Trinidad, Benguet	1987	25
6. Paracelis, Mt. Province		38
	Subtotal	225
Region-1 1. Burgos, Ilocos, Norte	1986	23
2. Santiago and SanEsteban Ilocos.Sur		35
3. Libidda, Ilocos Sur		26
4. Pugo, La Union		24
5. Infanta, Pangasinan		33
6. Mangatarem, Pangasinan		52
7. Natividad, Pangasinan		319
	Sub-total	512
Region IV 1. Pinamalayan, Oriental		183
	Sub-total	183
Region VI 1. San Enrique, Iloilo	1993	150
2. Duenas		10
3. Dumarao, Capiz	1989	8
4. Banawa, Aklan	1996	2
5. Jawili, Aklan		1
6. Mambusao, Capiz		1
7. Barotac, Nueve, Iloilo	1993	3
8. Dingle, Iloilo	1996	2
9. Kabangkalan, Negros Occ.		1
10. Lapaz, Iloilo		1
11. Lambunao, Iloilo		1
12. Maasin, Iloilo	1995	10
	Sub-total	190
Region XI 1. Cabuyuan, Mabini Dvo Norte	1990	8
2. Langgam, Maco DN		8
3. Mabunao, Panabo DN		12

4. Marilog, Davao City	1991	20
5. Bunot, Kiblawan, Dvo Sur	1992	20
6. J.P. Laurel, Sarangani	1993	20
7. Acob, Maribel, SC.	1994	20
8. Magamit, New Bataan, DN	1990	31
9.	1991	1
10.	1993-94	50
11. Canidkid, Montevista, DN	1991-92	2
12.		1
13.		5
14. Piang Village, T'boli, S.C.	1990	9
15. Ran-ay, Banga, SC		30
	Sub-total	237
Under the Forestry Sector Loan		
CAR		158
Region I		160
Region II		30
Region III		129
Region IV		45
Region V		10
Region VI		47
Region VII		51
Region VIII		261
	Sub-total	891
Under ERDB andERDS Research Plantation		
Region I	1980	8
Region III	1989	8
Region VI		11
Region VII		11
Region X		11
Region XIII		11
	Sub-total	57
	Grand Total	2,259

Table 3. Research Development Initiatives of Ecosystem Research and Development Services- Department of Environment and Natural Resources in various region of the country that are related to bamboo production

Title of Study	Investigator	Year Conducted/ reported
DENR-CAR		
Market potentials of bamboo in Benguet	Noble	1984
Trial planting of various bamboo species at different elevations in Benguet	Ngales	1988
Integrated bamboo agricultural crop production on ISF farms in Benguet	Estigoy	1994
Effect of traditional burning of bamboo stands on the biophysical conditions	Palaganas	1995
Morphology of dwarf bamboo (*Yushania niitakayamensis*)	Tangan et al	1996
Effectiveness of rooting hormones on the survival and rooting percentage of selected bamboo species in selected areas in the Cordillera Region	Maddumba	1997
Survey indentification and pathogenecity of pest and diseases of exotic and endemic bamboo species in selected areas in the Cordillera Region	Tangan	2000
Economics of bamboo production in the Cordillera Region	Tubal	2001
Documentation of bamboo-based fallow practices management in Sablan, Benguet	Tangan	2001
Various species for rehabilitation of mine tailings pond no. 1 of the Philex Mining Corporation (PMC), Pacdal, Tuba, Benguet	Tangan	2003
DENR R-1		
Bamboo/rattan industry development project	Domingo	1991
Bamboo Research and Development Project	Virtucio et al	No date
Bamboo Plantation establishment along Agno River		
Harvesting methods of bamboo	Orallo et al 1998	
Survival and growth of bamboo species along Agno River	Tomas	2001
DENR Region 2		
Effect of hormone to the different species of bamboo	Callitong	1991
Development of plantation as show window for bamboo	Ramirez	1991
Growth performance of some bamboo species under nursery conditions		
Bamboo technology verification	Soriano et al	1995
Growth and survival of planted bamboo within the Ganano river watershed project	Patricio et al	1997
Showcasing bamboo technology for rehabilitation and development	Soriano	1999
DENR R-3		
Bamboo baseline survey in Bulacan		1998
Blue Crab fattening on bamboo cages	Pajarillaga	1996
DENR R-5		
Verification trial on bamboo marketing using Alfonso's model	Operio and Carino	1990
Masbate community-based bamboo plantation special project	Operio	1992

DENR R-6		
Evaluation of different technology transfer schemes disseminating bamboo production	Talabero	1990
Demonstration and pilot application of technology packages and production systems on bamboo and rattan		
Rehabilitation of old bamboo stands in Western Visayas	Gigare	1997
Establishment of pilot bamboo plantation on selected areas in Western Visayas	Gigare	1997
Adaptability and financial feasibility of mudcrab fattening in bamboo cages at Pan de Azucal seascape, Concepcion, Iloilo	Marquez et al	1997
D. asper pilot plantation establishment in Taminla, Duenas, Iloilo	Escario	1998
Development and designs of deformed bamboo culms for *B. blumeana*	Gigare	2006
Improving and maintaining productivity of bamboos for quality timber and shoots in Australia and Philippines	Gigare et al	2006
Rehabilitation of critical river system using bamboos and vetiver grass	Yraula et al	2006
DENR R-7		
Characterisitcs of 6 bamboo species by culm generation at Camp 7, Minglanilla, Cebu	ERDS Res. staff	1995
Effects of NPK fertilizer application, harvesting, intensity and felling cycle on culm yield of two bamboo species in Camp Minglanilla, Cebu	Lanuza et al	1996
Community-based bamboo production livelihood project in the upland	Tagra et al	1998
Effect of harvesting and felling cycle on culm yield of 5 bamboo species	Bueno	2002
DENR R-8		
Marketing of bamboo and Rattan	Fabella et al	1999
Documentation of existing rattan and bamboo production technologies adopted by farmers	Tamayo	1998
DENR R-10		
Pilot establishment of selected commercial bamboo species	Cacanindin et al	1990
Verification of propagation techniques and plantation establishment for *D. asper* in Bukidnon	Cacanindin	1990
Improving and maintaining productivity of bamboo for quality pole and shoots in Australia and Philippines	Cacanindin	2000
Determination of the demand and supply situation for bamboos in R-10	Palma et al	1994
Effects of nitrogen and phosphorus fertilizer application on the performance of some important bamboo species under the Bukidnon condition	Agne	1997
Performance of some important bamboo species as affected by fertilizer application, intensities of cutting and felling cycles ubnder Bukidnon condition	Decipulo et al	2001
Effect of harvesting age and felling cycle on the performance of some important bamboo species	Tiongco et al	2001
DENR R-11		
Bamboo and rattan livelihood project		
Transfer of bamboo production technology to ISFG beneficiaries in Davao del Norte	Balmocena	1994
DENR R-12		

Survey on the production and marketing of bamboo furniture in Palcan, Polomolok, South Cotabato	Tan et al	2005
Effect of culm size and node length on the early rooting and survival of bamboo cuttings	Jaime	1990
Potential of propagating bamboo branches for planting stock production	Pangod	1990

Table 4. Researches conducted under the National Bamboo Research and Development Project

Title of Study	Investigator	Year Conducted
Specimen collection, classification and identification of the different bamboo species found in the Philippines (nationwide)	Roxas, C.	July 1987-June 1992
Phenological observation of 7 Philippine bamboo species (nationwide)	Sinohin	July 1987 to 1992
Seed germination storage and microflora of some bamboo species (Los Banos)	Dayan	July 1987- June 1992
Vegetative propagation of D. asper and D. merrillianus under nursery condition (Los Banos)	Hoanh	July 1987- June 1992
Tissue culture of economically-important bamboo species in the Philippines	Calinawan	May 1993- may 1995
Effect of nitrogen and phosphorus on shoot development and growth performance of 4 bamboo species under Pampanga condition	Gonzales et al	January 1996 – September 2000
Microflora associated with rhizosphere of different bamboo species	Dayan	July 1987- June 1992
Bambusetum Establishment 1. (Mt Makiling, Los Banos, Laguna with 40 native and exotic species) 2. (ERDS-CAR Loakan, Baguio City with 60 native and exotic species) 3. Nabunturan, Compostela	 Roxas Tangan et al	 1990 1988
Effects of harvesting intensities and felling cycle on culm yield and biomass productivity of 4 bamboo species under Pampanga condition	Umali et al	January 1996 – September 2000
Bio-ecological and management studies of little leaf disease affecting bolo and giant bamboo in the provinces of Laguna and Quezon.	Pacho et al	July 2003 –June 2005

Bamboo (*Denrocalamus asper*) as Raw Material for Interior Composite Panel Manufacture in Thailand

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Abstract

This study reviews some of the findings of various past and ongoing research projects carried out to manufacture composite panels from bamboo (*Denrocalamus asper*) in Thailand. Experimental panels including particleboard, medium density fiberboard (MDF), and sandwich type panels having fibers on the face layers and particles in the core layer were made. Both physical and mechanical properties of above boards were evaluated. Average values of modulus of elasticity and modulus of rupture of particleboard and MDF samples were determined as 2,424 MPa, 22.57 MPa, 2,200 MPa, and 22.70 MPa, respectively. In the case of sandwich type panels such values were 1,840 MPa and 20.91 MPa. In addition to the bending properties, internal bond strength and physical properties including thickness swelling, water absorption of all types of samples resulted in satisfactory values based on Japanese Industrial Standards (JIS) for panels use for interior purposes. Surface roughness of MDF and sandwich type panels was also determined using a stylus type equipment. It appears that bamboo which is considered as under-utilized specie may provide profitable and marketable panels products in Thailand. Such panels are not only environmentally friendly but also one of the alternative ways to convert bamboo in a value-added product.

Introduction

Non-wood material based resources such as bamboo and agricultural fibers including wheat straw, kenaf, rice husk, and rice straw are getting more important as raw material to manufacture composite panels. Thailand has rich natural biological resources and diverse ecosystems that contain many non-wood materials. Unfortunately similar to many developing Asian countries deforestation and over harvesting in Thailand also created environmental awareness which focused exploratory research using non-wood renewable resources in composite panel production.

Bamboo is one of the most diverse groups of plants in the grass family which belongs to the sub-family of Bambusoidae (Zheng and Guo 2003). It is widely recognized as an important non-wood forest resource due to not only its excellent mechanical properties but also its high socioeconomic benefits. Housing, packaging and transportation are only few examples its common utilization for many years in Asian countries (Zhang and Yonglan 1988; Xuhe 2005;Sumardi et al.2005; Wang and Joe 1983). Currently, bamboo is still considered as under-utilized non-wood species, although it has additional limited use as scaffolding, furniture units, plywood, and flooring in Thai constructional industries (Ye 1991; Ganapathy et al. 1992). Its fast growth rate and better characteristics than many other wood species makes this resource an alternative raw material for various composite panel manufacture. One of the first bamboo composite panels developed was in 1940's in China and since then, at least 28 different types of bamboo composite products have been developed (Ganapathy et al.1992). Also there have been several attempts to explore the possibility to produce panel products including particleboard, oriented standboard, plywood, and laminated composite panels from bamboo at commercial level (Bai 1996 ; Hiziroglu et al. 2005; Lee et al. 1996, Li et al. 1994; Li 2004; Chow et al. 1993, Chew et al. 1994, Chen and Hua; 1991).

Although particleboard is also used as substrate for overlays its rough surface may create certain problems resulting show through the thin films or direct finishing applications. Medium density fiberboard which is prime substrate product for furniture and cabinet manufacture is the most widely used interior type of panel in many countries including Thailand. However overall cost of MDF is more expensive and has more complicated manufacturing process than that of particleboard. Combination of fibers and particle in the form of sandwich type of panel would possibly solve this cost problem. Experimental panels with a sandwich configuration were also manufactured from bamboo. Since fibers were used on the face layers it is expected such panels had not only smooth surface with thin layer of fibers on board faces but also their overall properties were enhanced.

The main objective of this study was to explore potential suitability of bamboo to develop value-added interior panel products, namely particleboard, medium density fiberboard (MDF), and sandwich type panels having fibers on the face layers and the coarse particles in the core layer. Both basic physical and mechanical properties of experimental panels made from bamboo were tested to find if bamboo could be used to produce experimental panels with accepted properties.

Materials and Methods

Bamboo (*Dendrocalamus asper*) samples were harvested in Khon Khen, Prachin Buri bamboo plantation in Thailand. The specimens were reduced into chips using a commercial chipper before they were hammermilled for particle production. Figure 1 shows particle and fibers of bamboo used in this study. A laboratory type defibrator illustrated in Figure 2 was employed for disintegration of bamboo chips into the fibers using a pressure of 0.75 MPa, at a temperature of 160 ^{o}C for 1.5 min. before particles and fibers were dried in a kiln at a temperature of 80 ^{o}C until the furnish reached to 4 % moisture content. Later dried fibers were mixed for 4 min with 9 % urea-formaldehyde resin with a specific gravity of 1.27 and solid content of 84.8% in a rotating drum type mixer fitted with a pneumatic spray gun. Half percent wax was also added during resin spraying for the furnish. Twenty and 50% rice straw fibers and particles were also added into the various types of panels to evaluate interaction between two types of materials. Table 1 displays experimental schedule of the study involved with MDF manufacture.

The sandwich type samples with fibers on the face layers and the particles in the core layer were also manufactured using the above set-up. The core of the panels had homogeneous mix of 95% bamboo and 5% rice straw as filler using a 8% urea formaldehyde resin. Fibers of both type of raw material were used at the same ratios for the face layer of the panels using 10 % urea formaldehyde. Particles and fibers were mixed with the adhesive and 0.5% wax in the rotating mixer equipped with pressurized spray gun. Ten replicas for each type of panel in 35 cm by 35 cm by 1.0 cm were manually formed in a plexiglass box and pressed in a hot-press at a temperature of 165 ^{o}C using a pressure of 5.2 MPa for 5 min. Average target density of the panels ranged from 0.65 g/cm^3 to 0.80 g/cm^3. Panels were conditioned in a climate room with a temperature of 20 ^{o}C and a relative humidity of 65% for about two weeks before any tests were carried out. Modulus of elasticity, modulus of rupture, and internal bond strength properties were tested on an Instron Testing Machine Model-22, 5500-R equipped with a load cell capacity of 5,000 kg. Two and six samples were cut from each panel for bending and internal bond strength tests, respectively. Figures 3 and 4 illustrate unpressed MDF and sandwich type mats. Density profile samples were then determined on Quintek Density Profilometer, Model QDP-01X. This instrument can be set to a minimum linear increment of 0.25 mm depending on the sample thickness. Four samples with a size of 15.2 cm by 15.2 cm were used to determine thickness swelling of the panels. Thickness of each sample was measured at four-point midway along each side 2.5 cm from the edge of the specimen. Later samples were submerged in distilled water for 2-h and 24-h before thickness measurements were taken from the same location to calculate thickness swelling (TS) values. Table 2 shows experimental design of sandwich type panels.

Surface roughness of the samples was evaluated using portable stylus type equipment, Hommel T-500 profilometer as shown in Figure 5. Eight specimens with a size of 5 cm by 5 cm were randomly taken from each type of panel for roughness measurements. The profilometer equipment consisted of a main unit with a pick-up drive which has a skid-type diamond stylus with a 5-µm tip radius and 90^{o} tip angle. The stylus traverses the surface at a constant speed of 1 mm/sec over a 12.0-mm tracing length. The vertical displacement of the stylus is converted into electrical signals by a linear displacement detector before the signal is amplified and converted into digital information. Various roughness parameters such as average roughness (R_a), mean peak-to- valley height (R_z), and maximum roughness (R_{max}) can be calculated from the digital information. Typical roughness profiles of samples from four types of panels are shown in Figure 6. Definition of these parameters is discussed in detail in previous studies (ANSI 1985; Hiziroglu et al. 1996, 2004; Mummery 1993). Four random measurements were taken from each side of the samples to evaluate their roughness characteristics. Analysis of variance was used for statistical analysis of the data from the tests.

Results

Results of physical and mechanical properties of different types of panels made from bamboo are displayed in Tables 3 and 4. Medium density fiberboard samples had an average MOE and MOR values of 2273 MPa and 28.66 MPa, respectively. A previous study showed that experimental bamboo particleboard panels had 2,424 MPa and 22.57 MPa for above tests (Hiziroglu et al. 2005). In the case of sandwich type panels MOE and MOR values of the samples ranged from 1,287 MPa to 1,910 MPa and 13.77 MPa to 26.30 MPa depending on panels density as displayed in Table 4. Based on the Japanese Industrial Standard (JIS-A 5905) 13.0 MPa is the minimum requirement for interior particleboard. Based on American National Standards (ANSI-A 208) minimum MOE and MOR requirement for grade 110 MDF for interior applications are 1,400 MPa and 14 MPa. It seems that panels manufactured in such studies, including sandwich type panels satisfied MOR strength requirements for general used based on both standards. Panel type-A with sandwich cross section had the lowest strength properties which can be related to its very low density of 0.65 g/cm^3.

Internal bond strength of the samples followed the similar trend of bending properties of the panels. Overall IB strength values of sandwich type panels ranged from 0.51 MPa to 0.84 MPa satisfying the IB strength requirements based on the JIS for general use of particleboard. Thickness swelling values of both types of samples were found to be acceptable based on the standards. The panels made from 100% bamboo fibers had 7.84% thickness swelling as a result of 2-hr water soaking. Corresponding value for sandwich type panels was 10.25 MPa with 0.75 g/cm^3 density level. Using rice straw furnish as filler in the panels reduced both strength and dimensional properties of the samples.

In general single-layer particleboard with rough surface are not used for thin overlays as substrate for cabinet and furniture manufacture. Average roughness value of bamboo particleboard was within the range of 19 μm. However both MDF and sandwich type panels resulted in much smoother surface with and average R_a values ranging from 5.08 μm to 7.50 μm. It appears that having only 5% rice straw fiber on face layers of three-layers panels did not influence significantly their surface characteristics. Panel density was found to be one of the important parameter controlling surface quality. Samples had better surface roughness with their increasing density which can be related to compactness of face layers. Based on the roughness measurement it is expected that both types of panels having fibers on the face layers can be used as substrate for even ultra thin overlay papers without having any telegraphing effect .

Conclusions

This study briefly reviewed some of the findings of several experimental works related to manufacture different types of composite panels from bamboo. In the light of preliminary results of such studies bamboo which is an under-utilized non-wood resource can be used to produce interior composite panels with accepted physical and mechanical properties. It appears that manufacturing composites from bamboo would provide a profitable and marketable interior panel products in Thailand. Such panels are not environmentally friendly but also provide an alternative way to convert this resource into panel products for furniture manufacture.

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Table 1. Sampling schedule of MDF panel manufacture

Panel Type	Raw material	Number of panels	Test Samples				
			MOE and MOR	IB Strength	TS	Density Profiles	Surface roughness
A	100% Bamboo	5	10	30	10	10	10
B	80% Bamboo-20% Rice straw	5	10	30	10	10	10
C	50% Bamboo-50% Rice straw	5	10	30	10	10	10

Table 2. Sampling schedule of sandwich type panels

Panel Type	Face/Core Ratio	Density (g/cm^3)	Number of panels	Bending (MOE&MOR)	IB	TS	Roughness
A	10/80/10	0.65	8	40	35	40	80
B	10/80/10	0.75	8	40	35	40	80
C	25/50/25	0.70	8	40	35	40	80
D	25/50/25	0.80	8	40	35	40	80

Table 3. Results of the physical and mechanical properties of MDF samples

Panel Type	MOE (MPa)	MOR (MPa)	IB (MPa)	Thickness swelling (%)		Density g/cm^3	Roughness parameters (µm)		
				2-h	24-h		R_a	R_z	R_{max}
(A) 100% Bamboo	2273	28.66	0.71	7.84	19.96	0.73	5.50	40.73	49.02
(B) 100% Rice straw	1484	15.65	0.23	33.03	40.95	0.74	5.20	39.23	46.65
(C) 80 % Bamboo 20 %Rice straw	1936	23.29	0.52	18.52	24.40	0.73	4.88	36.10	43.61
(D) 50 % Bamboo 50 % Rice straw	1850	22.23	0.38	22.26	27.46	0.72	5.20	39.23	46.64

Table 4. Results of the physical and mechanical properties of sandwich type samples

Panel type	Density (g/cm^3)	MOE MPa	MOR MPa	IB MPa	TS (%)	WA (%)	Roughness (µm)		
							R_a	R_z	R_{max}
A	0.65	1,325	13.77	0.68	9.98	38.35	7.5	39.31	54.50
B	0.75	1,840	20.91	0.84	10.25	33.90	6.25	36.82	40.81
C	0.70	1,287	17.17	0.51	23.39	90.11	6.57	38.33	43.62
D	0.85	1,910	26.30	0.73	24.78	72.53	5.08	25.34	36.53

Figure 1. Bamboo and rice straw particles and fibers

Figure 2. Laboratory type defibrator.

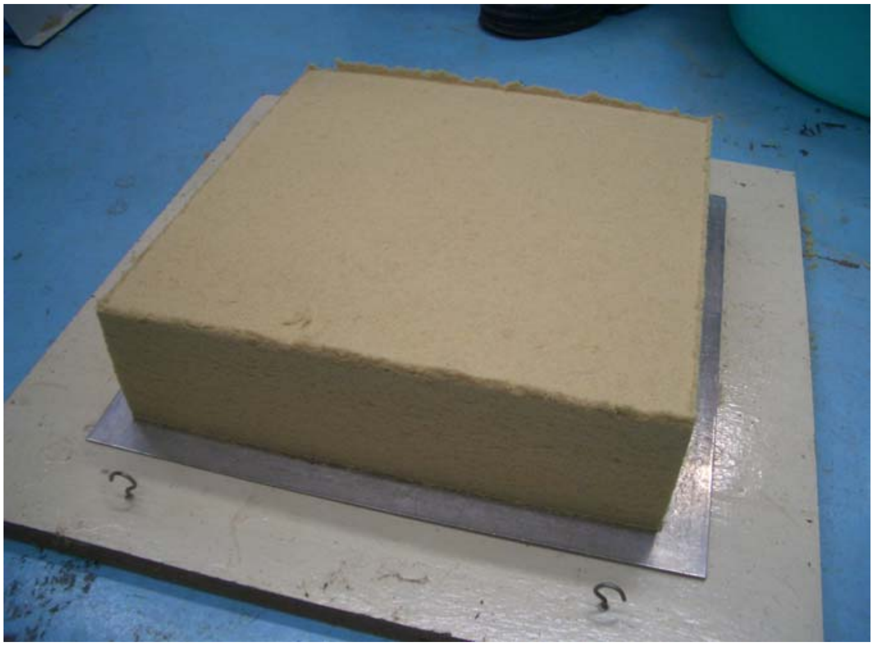

Figure 3. Unpressed MDF mat.

Figure 4. Unpressed sandwich type mat.

Figure 5. Stylus type roughness profilometer.

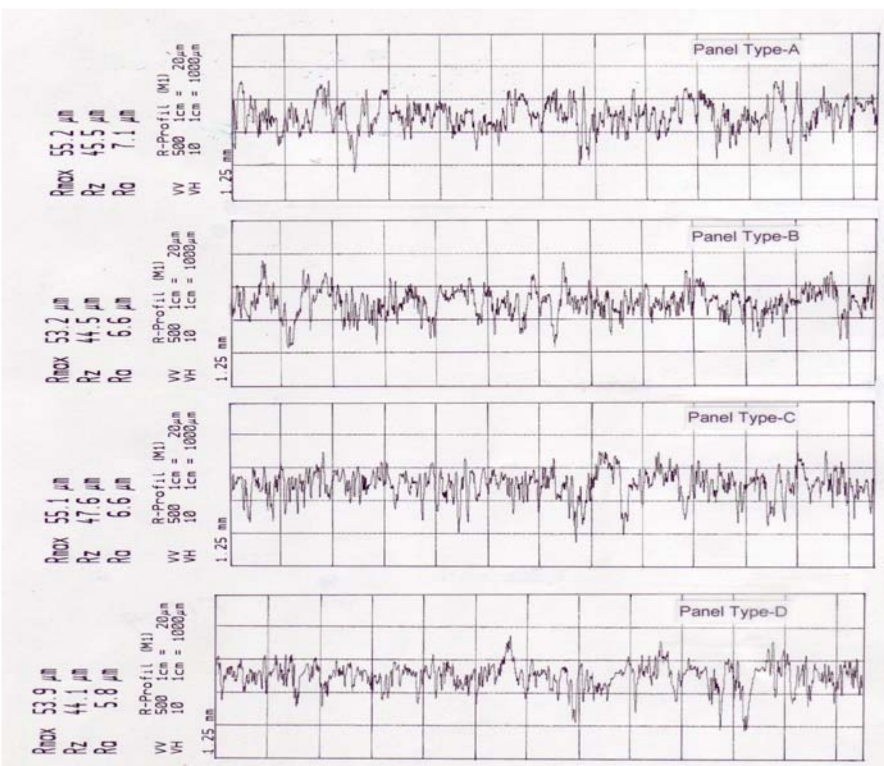

Figure 6. Typical roughness profiles of MDF samples.

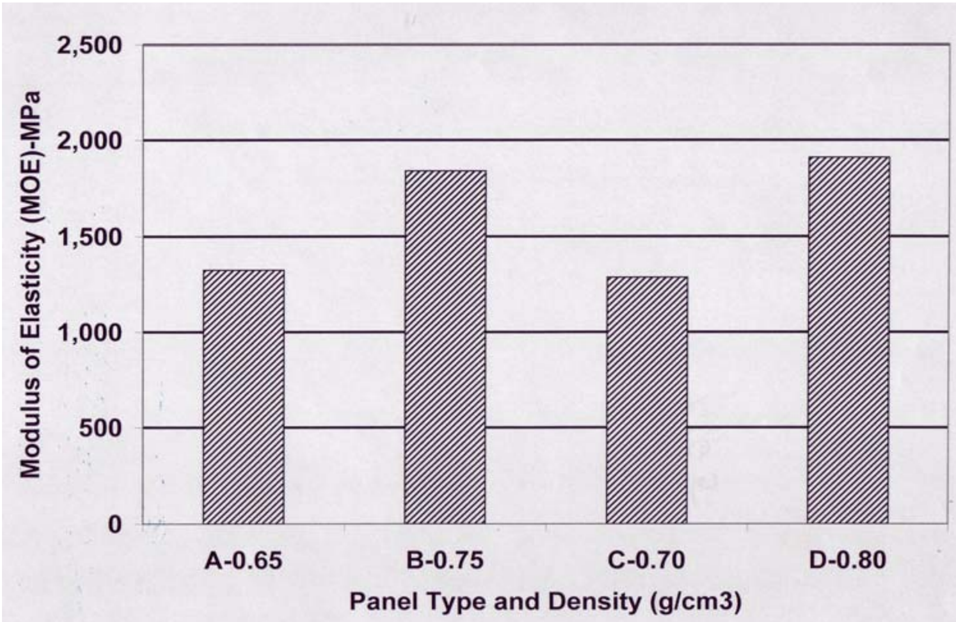

Figure 7. Modulus of elasticity of the sandwich type of samples.

Creating Sustainable Jobs and Incomes to Reduce Poverty: Lessons from Bamboo Supply Chain Development Project in North West Vietnam

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Abstract

In North-West Vietnam, approximately 60.000 families are harvesting 70.000 has of bamboo, for a yearly output of more than 800.000 tons/year. Industrial bamboo is produced mainly in Thanh Hoa province, in the poorest districts. The supply chain is characterized by low efficiency of polluting SMEs and risk of unsustainable exploitation of bamboo resources. 70% of demand for industrial bamboo is for low added-value products such as bamboo culms for construction sector, pulp and paper factories. A large amount of waste is produced in workshops, such as sawdust, planning chippings, and node waste (60 to 75% of processed bamboo culms, compared to 5% in China).

In this context, diverse strategies have been identified to enhance economic development and contribute to poverty reduction. A first approach consists of local interventions involving farmers, collectors, traders, local SMEs and policy makers. A second approach focuses on major markets and leading firms, the objective being to introduce new technologies and increase the demand for bamboo culms with a view to impact positively at scale on bamboo farm gate prices.

This paper draws lessons from those different approaches: how can poverty reduction be effectively achieved and measured; which kind of development should be promoted, and how should one intervene in market systems without creating distortion, how should different approaches be combined?

It provides some recommendations for intervention and underlines the risk of early exposure to major external players, the latter having possibly conflicting strategies and shorter term agendas, which could durably undermine potential for sound and sustainable development, in particular regarding bamboo resources. It also highlights the need for working with and strengthening local actors in order to sustain better practices. Interventions should not focus solely on few bamboo market strands but target multiple bamboo and non-bamboo products and activities.

Keywords: Bamboo supply chain, poverty reduction, nascent markets, lead firms, linkages, inclusion, resilience, income diversification, sustainability

Introduction

Thanh Hoa province: home of industrial bamboo in Vietnam

Thanh Hoa province is one of the poorest provinces of Vietnam, located 150-200 km South-West of Hanoi. Seven districts of the province belong to the 10% poorest districts in the country (61/640). Thanh Hoa North-West districts are mostly inhabited (about 80-95%) by ethnic minorities (Thai, essentially, but also Muong and H'Mong people). The poverty rate is higher than 50%, with a poverty line of 200,000 VND (0,35 USD per day per person). Luong bamboo (*Dendrocalamus barbatus* essentially) represents the main income source for about 30,000 families in the zone. North-West Thanh Hoa is the main production zone (about 70,000 ha) for luong bamboo in Vietnam (about 50% of surfaces over the country), even if there are still natural bamboos in natural (degraded) forests, like Nua (*Neohouzeaua)* or Vau (*Phyllostachys*). Bamboo culms are mostly processed in factories around Hanoi by few leading firms, procuring bamboo from surrounding mountainous provinces. Luong bamboo has good mechanical properties and big size, allowing diverse utilizations such as construction (scaffoldings), dykes reinforcement, chopsticks and paper pulp. Those products (70% of the demand for luong culms) are bringing low added-value. In parallel, high value products are also produced, such as flooring, panel boards, furniture, and handicrafts. Every year, in North-West Thanh Hoa, about 20-25 millions of culms are harvested, among which, about 35-40% are pre-processed in the zone and 60-65% "exported" as culms to the red river delta region, Hanoi, Hai Phong , Thanh Hoa and other big cities.

Main problems encountered by bamboo producers and supply chain

Agroforestry: underinvestment, overexploitation, un-sustainability

Most traders and collectors today are paying farmers according to the number of culms harvested, their size and weight, for low value products. The age is not considered as important for most of the buyers, except for pre-processing and processing workshops, as well as leading firms, requesting 3 years old culms. This is due to the fact that construction and paper industries do not require quality culms. Such practice badly impacts on yields (young culms are firstly contributing to the growth of new shoots) and decreases plantations productivity, farmers' incomes and long term sustainability of the supply chain. Besides, because of the low price paid for bamboo culms, farmers are under investing; in some places they are replacing bamboo by other more profitable crops (cassava, maize or acacia), and investors are reluctant to invest if resources are not secured over the long term. The most accessible plantations are overexploited, especially by very poor families, for whom luong bamboo is a bank for day-to-day petty cash needs (food, traditional events, medicines, school, etc.). There is therefore a need for investment in infrastructure (roads to access more remote plantations), but bamboo is no longer a priority for provincial and national authorities.

Supply chain: low efficiency, low added-value

As in the case of most supply chains in Vietnam, there is limited coordination between supply chain actors and no interprofessional organization. Leading firms (only few main companies) producing higher value products are not located in the province, bringing part of the added-value and skills to richer provinces (with better infrastructures, access to markets, human resources). Local SMEs are active but limited by a lack of skills, capital and access to market information. They are also highly dependent on a few buyers if they can not diversify their production. A diversified industry and increased competition would limit the dependency on a few buyers and enhance the sustainability of local businesses. The present oligopsony and the limited demand for higher quality production are indeed depressing prices at the expenses of small businesses and farmers. The industrial bamboo sector in NW Viet Nam is still nascent compared to China, despite few major players. There are now 80-90 processors making medium and high-value products, but less than one third have a turnover greater than USD 500,000 per year. Of these, only a small number of companies produce high-value products such as flooring or panels.

Project intervention: main principles and achievements

With the main objective of reducing poverty by supporting local economic development, a partnership (between Prosperity Initiative Programme and GRET organization) has been established, aiming at: "Securing investment in new manufacturing plants for high- and medium-value finished Products; raising value added per bamboo culm across the industry (especially among primary processors) by identifying market opportunities for alternative higher value products and assisting small- and medium-enterprises (SMEs) to supply them; establishing sustainable buying mechanisms between buyers and farmers to ensure the sustainable exploitation of bamboo resources while meeting the needs of a growing industry; ensuring that poor farmers own the bamboo and therefore can benefit from rising prices and demand." (Mekong Bamboo 2008). Securing ownership is not an issue in North-West Vietnam, but an important one in Lao or Cambodia for instance.

A project that is being implemented by GRET (Luong Development Project or LDP) since 2005 has been progressively designed to respond to the above mentioned problems. Some activities were related to farmers and resources activities: support to farmer organizations, development of links with enterprises and markets, and establishment of nurseries, plantations, trials and demonstrations, sustainable forest management, testing of short-term intercrops to get earlier incomes for new plantations. Other activities were related to the support to bamboo supply chain down stream: within Thanh Hoa bamboo industrial cluster, facilitate exchange between supply chain stakeholders, build capacities of entrepreneurs, support small and medium enterprises (business plans, trials for new products and process, contacts with buyers, equipments, and access to finance …), support marketing, relations with investors, and tests for diversification of production. Some complementary activities were related to sector enabling environment: discussion with local government on problems and solutions for smallholders and bamboo processing entrepreneurs, multi-actors discussions and seminars, capacity building of local actors, organization of meetings and visits, exchanges with external actors on bamboo.

GRET's strategy is to be permanently present in Thanh Hoa province to implement those activities. Additionally, since end of 2008, the national staff of the project has formed a local service cooperative, the objective being for this cooperative to become autonomous after project completion, as a local service provider. This comprehensive approach and the wide range of activities that had been implemented during the last four years has been driven originally by the private sector (Ikea), together with IFC, then by increasing support of donors, identifying bamboo as a strong opportunity to reduce poverty. In 2007, Mekong Bamboo programme did join this action on bamboo supply chain, partially funding the project and supporting major players (investors, leading firms) to increase demand for higher added-value product.

While some expertise has been mobilized for the design, implementation and impact assessment of the project, no analysis has been done yet on the overall logic of intervention and how it relates to existing literature on supply chain support. Based on project achievements and past exchanges with partners, this paper discusses different approaches for effective and efficient poverty reduction, which supply chain models to promote, and how to work with local stakeholders for sound market development.

Fighting poverty efficiently: raising prices of materials only, or increasing capabilities, creating jobs and activities locally?

Case study: production of mushrooms on bamboo sawdust

Bamboo processing is producing a high quantity of sawdust, particularly from the production of slats for flooring (longitudinal splitting). The project initially worked with one women's group and one small group (five persons), willing to invest in mushroom production from sawdust. It linked the groups to input providers, markets, organized technical trainings and exchanges visits, and provided financial support for the first small steaming kilns and drying kiln. Project financial support was considered necessary given that ethnic minorities in this poor area are not able to invest, and that it was necessary to demonstrate the feasibility of this new business. Three species of mushrooms for three different markets were produced: fresh mushrooms for local market and wedding events, dried mushrooms for urban markets and Linh Chi mushrooms for Vietnamese and Chinese medicinal markets. In early 2009, two years after the start of the intervention, 50 families were involved and 5 groups (2 women groups) created. This organization of production has helped farmers to produce mycelium to extend production, develop processing (drying, sorting, packaging), and be able to reach more markets thanks to a critical size of production.

This small activity, with limited initial investment, helped to create jobs for women; production was relatively easy to manage by beneficiaries after technical support and monitoring. It enhanced technical skills and marketing capacity, provided sustainable diversification of incomes, links with market, structuring of new supply chain, new links between families and communities. Besides, it is an eco-friendly activity, with no use of chemicals and possible re-use of substratum as organic fertilizer. This activity, which targeted very poor families, was highly appreciated and supported by local and provincial authorities. The fact that mushroom production is often seen by farmers visiting project achievements as a key activity they would like to implement themselves is also a good indicator of the attractiveness of such activity. Noticeably, as an income generating activity, it releases pressure on bamboo resources (main source of cash for farmers), allowing therefore better management of bamboo plantations. Such activity is also easily replicable, as it necessitates limited investment, for a high market demand.

Yet, the financial benefit is limited (a net benefit of USD 250 per annum per family for an average production) and the overall impact on poverty in the Region is obviously not significant. Should such small-scale and flexible approaches be promoted and supported by donors, in search of large scale poverty reduction and accountability, or should other approaches, more simple and replicable, be in priority funded? What are the theoretical and practical reasons for favoring and approach or the other?

Impacting on poverty at scale: how to reach poor farmers?

Some argue that if supporting businesses allows a market price increase, it will impact on prices for the bamboo culms paid to farmers and therefore, increase their incomes and reduce poverty. This approach is considering that market forces solely can eliminate poverty, and that other non-market interventions are less efficient, and therefore less relevant; it justifies large scale intervention with major players, at the expense of locally based lengthy, complex, costly and uncertain interventions, directly with the local stakeholders. It considers economic growth, measured in monetary terms per capita, as the central indicator to measure development. To demonstrate this vision, one can measure the impact of an increase of bamboo prices on farmers' incomes, and then extrapolate how many farmers could have crossed the poverty line.

This theory is nevertheless showing some limitations. Firstly, an increase of price can not be easily attributed to a given project, as it is dictated by world prices of bamboo and other factors (price of inputs, cost of workforce, etc.). Secondly, the real price increase is questionable in a context of high inflation rates, when it is difficult to fix a proper rate and the error margin is important. Thirdly, the increase on bamboo price at farm gate can also possibly be relatively limited compared to other farmers' expenses (food, transportation, farm inputs). Thus, even if bamboo incomes did increase during a given period, it is likely, in case of strong increase of real price for many expenses, that most of farmers will be poorer. Finally but most importantly, in the case of bamboo production, an increase of prices without any farmer awareness and long term perspective could lead to overharvesting of plantations, bringing short-term higher incomes, but medium term declining yields and incomes, environmental degradation. Environmental degradation would in return nourish price increase, because of a lower offer of bamboo in quantity and quality.

Such impact assessment method would therefore overestimate the impact of bamboo prices variations at the expense of other important factors impacting also on poverty. It would then justify working without – or with limited - support locally to local actors, focusing on leading firms only in order to achieve this goal of price increase. Such approach refers directly to the "trickle-down theory," supporting that economic growth and technological change benefit the poorest, even if it is under the control of the better-off companies or people. This theory has shown its many limits in rich western countries, it is therefore undoubtedly questionable in poorer countries.

The affirmation that a farm gate price increase will be seen in case of increase of global demand is also questionable if we have a closer look at the Chinese model of development. For instance, in Anji county (Zhejiang province), one of 10 "bamboo homelands" in China, figures (Zhu Zhaohua, 2007) show that price increase is relatively limited: only 60% over 20 years time (1988 to 2006), if compared to increase in production value of moso bamboo products during the same period (210%). The production value is much related to utilization rate of culms (from 25% to more than 85%), but it did not impact much on the price paid to producers. It seems therefore that the expected trickle-down effect of an increase in demand and a better utilization rate on the price paid to farmers is not obvious. According to some findings (Perez 2007), bamboo producers in China are benefiting a lot from bamboo non-agricultural activities, including processing and sales, but those farmers are not the poorest ones. In Anji, most of farmers are also small entrepreneurs and are therefore able to invest in small equipments, new technologies, manage properly plantations, etc. Besides, bamboo production was and is still, but differently, strongly supported by Chinese authorities (subsidies for planting initially, research, promotion of investments, etc.). The hypothesis that people can be taken out of poverty thanks to an increase in demand, based on economic theory or on partial analysis of the Chinese model, is risky. Farm gate price increase should be considered as a priority (and not increase in demand), this not being left to market forces only. Other aspects of livelihoods – not only market factors – should be taken into account to reduce chronic poverty.

Sustainable impact on poverty: a need for a more comprehensive approach

For other development practitioners working on support to supply chains, a recommended impact assessment method (Bekkers, et al. 2008), is to measure, on the following aspects, if some significant changes had been observed: on project expected outputs (promoting new products, number of SMEs trained on specific issues); on outcomes (improvement of services to SMEs, launching of new products); on increased capabilities (change in linkages between stakeholders, awareness on market opportunities); on change in performances and competitiveness of SMEs (resilience to external chocks, increased productivity and benefits); on entry of new actors in the sector, attracted by supply chain up-grading; lastly, on increase of incomes and job creation due to better efficiency of production, new enterprises, or any other activities reducing significantly poverty. This range of tools is useful to measure impact on supply chain but of course does not to give a measurement of poverty reduction. This is nevertheless a more relevant approach to poverty alleviation, as poverty, and more precisely chronic poverty is not only related to cash incomes, but it is a multi-factorial phenomenon.

As defined by Ponte (2008) "the distinguishing feature of chronic poverty is extended duration in absolute poverty. Therefore, chronically poor people always, or usually, live below a poverty line, which is normally defined in terms of a money indicator (e.g. consumption, income, etc.), but could also be defined in terms of wider or subjective aspects of deprivation. This is different from the transitorily poor, who move in and out of poverty, or only occasionally fall below the poverty line." In this view, giving farmers more bargaining power, information on markets and better access to services (credit, inputs, etc.) is important. Diversification of income sources and better linkages to diverse markets is also important. In our example, mushroom production is important in financial terms, but it is also a medium to link the poorest farmers to markets, to show that small entrepreneurs can emerge and be successful. It is also a potential first step and first source of cash incomes to develop other activities.

This complex and comprehensive approach of poverty determinants is not necessarily welcomed by donors, interested by more specific and replicable methods of intervention. Supporting leading firms as a substitute to development practitioners, to demonstrate the liberal view of development processes - if done alone without strong local intervention - is ignoring the inherent causes of chronic poverty. In-depth investment on skilled human resources locally, to support local initiatives and strengthen local entrepreneurs, should not be forgotten. As described below, the quality of the economic development promoted is as important as economic development itself. In Vietnam, very few development practitioners are directly working with local SMEs, but such experiences are very rich ones that could serve as a reference if well documented and promoted at provincial and national levels. Other current trend from donors is the budget support to governments: transfer of important financial means for action to national entities shows an increased concern for the ownership of the development process, but does not provide necessarily added value in terms of intervention methods. Such approaches can be justified in terms of ownership and scale of impact, but experience shows that, even after decades of governmental support in Vietnam, local government bodies are still very weak, especially when it relates to market development.

Up-grading bamboo supply chain: which priorities?

Lessons learned from some innovations in Thanh Hoa province

So far, the support to the development of new manufacturing plants has not been successful. No major new investor did invest on bamboo supply chain to develop new technology. Some direct support to the Vietnamese bamboo leading firms to develop business plan, attract investors, and test new technologies is on-going and should help to increase bamboo processing capacity. The competition between two or three leading firms is still limited and this is impacting negatively on practices along the supply chain: bargaining power of pre-processing workshops is limited and supply chain management is based on short-term considerations, with no long term commitments and no investment on quality up-stream. This failure to attract new investors can be partially explained by the current economic crisis, but it is also related to the lack of attractiveness and competitiveness of the bamboo supply chain in general at the moment. Indeed, despite potential important demand, accessing new markets is very challenging for new comers and out of reach for most if not all of existing SMEs. Weak supply chains – in remote areas, with few small investors - are risky and are not efficient, for many reasons. Important investors, looking for secured and interesting returns, are therefore prioritizing investments on more mature sectors of the economy, mostly in richer locations (Mekong and Red River Delta), with more qualified workers, better infrastructures, easier access to markets.

At smaller scale, it was easier to develop new activities, as local stakeholders were more able to invest locally, investments being less important, less risky, and markets more accessible. For example, aware of the economic importance of secondary species for poor ethnic minorities, and of important markets for incense sticks in South Vietnam (Ho Chi Minh City) and handicraft baskets, the project has made the link between buyers, village authorities and small enterprises. Based on demand of a local small entrepreneur, the project has partly supported several weeks of vocational training for 20 villagers from poorest areas, to be able to produce quality round or square sticks. This activity created locally 20 new jobs, mainly for women, and was an opportunity to add value to secondary bamboo species from natural forests. 100 families used to produce rattan woven bamboo products, were supported to produce and sell bamboo baskets (with new design and better quality), through a local co-operative.

Other locally supported activity has been the building of one pre-processing workshop by the end of 2006 with project support, to produce slats for flooring and chopsticks. The pre-processing locally (near bamboo plantations) was indeed identified as a key priority to improve bamboo supply chain efficiency for the flooring market (less transportation costs and better quality control in particular). However, this business progressively reveals not being profitable – at least temporarily - because of low selling prices of chopsticks and slats, difficult quality control (age of culms in particular), quite remote location from luong bamboo main production zones (high transportation cost), and local market down-turn for bamboo flooring. The project supported the entrepreneur to find new market opportunities (visits, linkages) and the workshop started to produce woven slats for panel boards (used for construction, shrimp farms), a product that is currently imported from China. This production allows much higher utilization rate of raw materials (60%) compared to chopsticks and slats processing (20-25% as a maximum), more added-value and additional job creation. By-products (40% of wastes) are used to produce woven mats and other handicraft products, which enjoy high market demand. Such switch of production is creating much more work for the same quantity of bamboo. In the current situation, with overexploitation of bamboo, this strategy is more profitable and sustainable. In this case, the project facilitated linkages with buyers and provided useful market information, but didn't interfere with local actors. Convinced that this activity was more profitable, the entrepreneur did switch his business model and is today less dependent on the flooring market. If the first strategy (support the development of pre-processing for flooring) revealed not being successful, entrepreneurs were nevertheless able to cope with a new situation and diversify products. Without project intervention, the pre-processing workshop would have probably stopped its activity. This intervention is questionable as it can be seen as a market distortion, the project trying to help in particular one actor at the expense of others. On the other hand, initial investments were used to produce new products, more profitable ones. Therefore project support had been useful to diversify market outlets and reinforce the resilience of this entrepreneur to market fluctuations, as well as other actors later on, eager to follow this example.

Discussion

The examples above are showing that large scale investments are difficult to promote. Besides, when supporting major players (which are not locally based due to the weakness of infrastructures) there is no guarantee that the latter will necessarily invest locally and reinforce local actors. The link between major firms and local actors is indeed very weak in Vietnam, vertical integration being non existent and collaborative approaches not yet common on bamboo supply chain.

Stefano Ponte (2008) demonstrates that "integration of people or areas into global value chains and trading relationships will exacerbate chronic poverty if the 'normal functioning' of these chains is left unchecked. This is especially the case for value chains that are driven by retailers and branded manufacturers. Where value chains are less clearly driven from Northern-based actors, integration in even 'normal' strands of value chains can have substantial and positive impacts on poverty, and where appropriate, chronic poverty. In other words, the conditions of inclusion in and/or exclusion from value chains and trade more generally are more important than inclusion and exclusion per se."

Ponte is asking to be cautious on how to support supply chains, and is demonstrating how a too fast and too strong connection to global markets can endanger local stakeholders. As it was demonstrated within the project, it is more feasible to support local SMEs to reach emerging small markets, even if the overall impact is limited. Doing so, entrepreneurs are progressively exposed to diverse external markets, the local autonomy is slowly growing, capabilities are increased and the supply chain is becoming more resilient to market changes. Supporting local and reachable markets also allows easier starting of small scale production, trials and errors. At this scale, a project can support partially the risk; provide small grants, be involved with limited expertise on market prospection. The above short case studies are showing that inclusion of actors locally was possible because entrepreneurs found opportunities to invest with limited risk, in a known – close – business environment. More profitable but more distant and risky markets have not been explored by local entrepreneurs, despite project support and sufficient private investment capacity. Moreover, the current crisis is showing that external funds are more volatile than local money, the later being attached to local networks and commitments (political, familial, and economical). Lastly, experience showed that global investors and leading firms are more reluctant to invest in nascent industry and prefer to secure existing and reliable investments.

Such trade-offs when supporting supply chain stakeholders should be clearly identified, support and mitigating measures strongly supported. It means that the pace of supply chain support and promotion of competition should be wisely assessed. As mentioned by Ponte, the conditions of inclusions are, for this kind of nascent markets, more important than inclusion itself. Sustainable production (taking into account economic, but also social and environmental aspects of production) is necessary for a sound development. In Vietnam, leading firms still have low awareness about the benefits they could receive from a better and more responsible management. It is therefore risky to support such actors if the conditions of support are not discussed to try to improve the impact of their practices up-stream with suppliers, poor workers, farmers and bamboo resources.

If there is no “big bang” impact to be expected from such local and small scale support, it is more responsible and sustainable to give priority and seek for local markets, not to depend too much on international markets and leading firms, and a positive dynamic within a production cluster can facilitate replication. It is indeed critical to increase capabilities locally and sow the seeds of future endogenous development. If this approach can appear frustrating to development practitioners or donors – seeking short-term visible results– it is nevertheless more adapted to local actors’ capacities and expectations, and therefore facilitate ownership of promoted activities.

Businesses and other supply chain stakeholders should consider their medium term interest: more investment up-stream and better integration of suppliers would help to increase quality, secure supply and diminish transaction costs and risks. Indeed, transaction costs are high because lead firms are procuring on bulk bamboo markets; it therefore necessitates sorting culms, controlling quality and age of culms. This approach is currently risky, as it is difficult to control quality properly. In the current situation, a leading firm producing bamboo flooring estimated that 10 to 20% of culms did not reach quality requirements. With a better integration up-stream and traceability, farmers would cut only quality culms, improve bamboo plantations management, and therefore have significant positive environmental impact.

Local entrepreneurs, more embedded in local dynamics, should be linked to leading firms to promote those sustainable practices. Facilitating linkages along bamboo supply chain in Vietnam, from farmers to leading firms, is a key issue for better efficiency and sustainability.

Intervention methods: finding the balance between interference and indifference

Creating new markets: the example of bamboo active charcoal

Before project intervention, there was no significant production of active charcoal from bamboo in Vietnam. This production necessitates kilns building, technical and financial support for first burning cycles, and markets. There is a large diversified potential market with high demand: charcoal from wastes (lowest prices); tube charcoal (small-sized luong or other species, presented in bamboo baskets). Wastes of active charcoal and active charcoal itself can also be used to produce activated carbon, for which Vietnam has to import more than 95% of production. The project is currently supporting the development of a production plant for activated carbon, local investors and responsible businessmen being ready to invest. Despite this high potential demand, local entrepreneurs were not able to take this opportunity alone and supply distant national markets or international markets.

The minimum procurement for active charcoal being one container – i.e. the capacity of few kilns during few weeks - it is out of reach for most of local SMEs. Taking into account this demand and the critical size needed to reach markets, local entrepreneurs were supported by the project. The latter invested initially in the building of few kilns (hiring highly skilled workers from other provinces, convincing entrepreneurs to invest in materials and land), the majority of other kilns being built with the support of a foreign investor from the Region, seeing interest in diversifying its production sites. In addition to the construction of kilns, accessing this market necessitates costly analyses and certificates. Samples were analyzed by the project, specifications for procurement developed. For the production of activated carbon, investments and technologies needed are much more important, and the project is in this case acting as a broker to attract investors, disseminating information and advocating for local investment.

As described above, there was initially very limited supply of bamboo charcoal, and there were many entry barriers that could not be lifted by local entrepreneurs alone: financial, but also technical ones. Given the potential economic but also environmental impact of active bamboo charcoal (bamboo charcoal as a substitute to wood charcoal), the project considered that this new product was strategically important to develop. To date results are still limited to few sales of bamboo active charcoal, but if activated carbon is produced, it would have an important impact on local job creation, poverty reduction, and would also help Vietnam to limit imports of activated carbon.

Is such strong and external support justified? Is there a risk of market distortion in this particular case? Can a project so strongly interfere with the local economy? If major similar opportunities are identified, what are the alternatives for a project willing to help local businesses, if direct intervention should not be – in theory – recommended?

Discussion

The current recognized best practice when supporting supply chains in order to reduce poverty can be found in "market working for the poor initiative" (M4P) synthesis (2008): "M4P is an approach to developing market systems that benefit poor people, offering them the capacities and opportunities to enhance their lives. […] M4P requires that organizations play a facilitating role. Standing outside of the market system, facilitators work with different players within the system, to make it work more effectively. Their essential role is active and catalytic, to enable others to do rather than do themselves – stimulating changes in a market system without becoming part of it." The definition of "within" and "out" of the market system is important here. In the example above, we can say that the project is "out" of the market system when facilitating contacts between investors to develop an activated charcoal production plant, but we can say that it is "within" when subsidizing the building of kilns for active charcoal, helping entrepreneurs to buy new machines, searching actively for outlets for a new market. This choice to support directly local entrepreneurs to develop new markets is a risky and strategic one. The project is accepting to support partially a risk with stakeholders they are working with. Doing so, they are becoming part of the market system, which is contrary to best practices promoted in this field. But when the role of projects is to act as service provider, to facilitate linkages, strengthen entrepreneurs, it is sometimes difficult to identify the limit between market support and market distortion. Is it justified to support one pre-processing workshop if the manager is facing difficulties with buyers? How far the project should support this entrepreneur, share the risk with him?

One could argue that if local entrepreneurs can not invest themselves, leading firms could be major players. Some experiences had been conducted by the project with leading firms but it was not successful, short-term commercial views overtaking longer term agreements. The above paragraph stressed that in the current situation it is easier for SMEs to sustain growth locally, as no proper linkages are in place with leading firms. In Vietnam the latter are indeed exerting pressure for cost reduction and compressing the margins of their suppliers, more especially in a situation of Oligopsony, as it is the case in Thanh Hoa. Before lead firms being able to contribute to local development, a long term intervention to up-grade supply chain for more collaborative approaches is necessary, involving leading firms and promoting responsible business and sustainable management of resources; in parallel, a short term strategy to support in priority SMEs and favor more competition between leading firms is also important to create the conditions for sound future development.

To facilitate local sustainable development at scale without leading firms and with limited project intervention, attracting responsible investors is recommended: it means that market development will not be artificially supported and that better practices, more sustainable development will be favored. It is the case for instance for the bamboo activated charcoal. When investors can not be identified, it means that the risk is too high for them. If the project is investing instead of private actors, then the decision process should be very methodically justified (environmental impact, poverty reduction, cleaner production, etc.), and the risk should be supported and accepted by donors. Doing so, the project and donors are setting a – more or less formalized - public-private partnership promoting innovation, more responsible and sustainable businesses. As noted by Warner and Kahan (2008), such involvement of donors can make the venture more attractive to other potential investors.

When development practitioners are operating in disadvantage areas, even if a real potential exist, it will not be easy to attract investors or have the support of leading firms, the latter having often short term strategies and constraints not compatible with long term and balanced development of nascent markets. Supporting directly and strongly SMEs, in this context, should not be disregarded as market distortion, as – in fact – market should be modified, in the sense of better functioning, more innovation, diversification of production, etc. To achieve this goal, public financial support (from donors and local authorities) can be used to support local actors and attract private participation into risky supply chains. Lead firms have also an important role to play, if they agree to promote more sustainable practices, for their long term interest. They should therefore not be opposed to SMEs or farmers, but linked up-stream as much as possible to increase awareness and long term commitment.

Conclusion

Up-grading bamboo supply chain for poverty reduction is a common objective of many development actors in Vietnam and in other countries. The Chinese model is attractive as it showed - in the richest provinces of China - a huge potential for jobs and value creation. Yet, determinants of poverty reduction are very complex and embedded in local situations (social, political, cultural, environmental) and global economic evolution.

Connecting local actors to global important markets can seem attractive to some experts as it could in theory have huge impact on demand locally, prices paid to farmers. But prices are determined by global factors, and experience shows that price increases are rarely significant at farmers' level. In the case of Vietnam, leading firms have the capacity to procure any materials – including pre-processed bamboo culms, in virtually any country from the Region, at lower prices if necessary. The bet that a "big bang" can appear with new technologies or big investors is therefore hazardous and impact on prices would anyway be diluted before reaching farmers if linkages up-stream are not improved, in a sustainable manner. Such work needs time and local investment, which are not necessarily compatible with the pace of investors or leading firms.

Lessons from experience are showing that the priority should be on increasing capabilities and promoting sustainable practices locally. This is possible if relatively small innovations are promoted and supported by local entrepreneurs. If the impact can only be limited in terms of scale, it is stronger and of major importance in terms of ownership and sustainability, resilience to external chocks. A too rapid and massive intervention on a nascent market would not give enough time to local actors to adjust to the new situation. As agricultural systems are quite rigid and fragile, resources could be threatened, but also the local economy. If in theory a liberalized market allows easier destruction and creation of businesses toward more efficient systems, in disadvantage areas such processes can inhibit local initiatives and mitigation measures for nascent markets can be justified.

Sowing the seeds of future economic expansion at small scale, locally, is not gratifying but is necessary for the development of nascent markets, in poor and often remote areas. The fact that some products are not necessarily promising in financial terms– such as mushroom production or bamboo baskets – does not mean it should not be promoted as it can have longer term structuring impacts. Diversification of productions and job creation, linkage to local markets, capacity building, and empowerment of actors are fundamentals that can not be easily measured in terms of contribution to the economy but that are however crucial for sustainable and responsible development. If such fundamentals are in place, linkages down-stream with leading firms will become more relevant and less risky for the local economy and bamboo resources, market development being sustain by a more resilient and more sustainably managed supply chain.

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[1] Sources: Gret documents (Luong Development Project) and Mekong Bamboo programme

[2] Project funded by various donors to support the bamboo supply chain in Thanh Hoa Province

[3] International Finance Corporation, World Bank

On-Farm Participatory Research for Development of Integrated Management of Bamboo Plantations in Northern Mountainous Areas of Vietnam

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Abstract

Development of luong bamboo (*Dendrocalamus barbatus)* plantations, with more productive and sustainable practices, promises solution to address both problems of poverty and soil erosion currently faced by a major part of the population of several districts of Northern mountainous areas of Vietnam. In Thanh Hoa Province, were about 55 000 ha of luong represents the major source of income of a large part of the inhabitants, 50% of the population, mainly ethnics, is still leaving beyond the poverty line. They are also facing a major problem of widespread soil degradation. Despite farmers are concerned by soil erosion and environmental sustainability, it is not a driving force in their adoption of new practices and they keep on looking for strategies allowing a quick improvement of their incomes.

Lessons from experience outlined the relevance of a participatory research approach to define and disseminate new technologies allowing farmers to get high income while ensuring environment sustainability. The On-Farm-Research (OFR) experimental design, implemented to test and develop more sustainable intercropping systems in new luong plantations, showed the relevance and efficiency of this approach. It also demonstrated the importance of a large scale action to get a good understanding of the array of constraints hindering farmers' strategies and ensure a broad-adoption of best-practices.

This communication deals with the main lessons drawn from these 3 years of on-farm-research and extension work on intercropping in new luong plantations, from both technical and methodological point of views. It makes recommendations on the best practices to be promoted, but also shows the difficulty to implement on farm research and promote bamboo plantations despite its many interests.

Last it gives some recommendations on the way to ensure the transfer of capacities to local actors in order to ensure a long-term agricultural development by defining by themselves the technologies addressing the changing range of constraints they are facing.

Keywords: on farm research, intercrops, bamboo, *Dendrocalamus barbatus*, groundnut, participatory planning, sustainable development

Introduction

Luong bamboo: a major source of income and a way to reduce soil erosion

Thanh Hoa province, located 150-200 km South-West of Hanoi, is one of the poorest provinces of Vietnam. According to the official list of the 61 poorest districts (61/640), seven districts of this province are belonging to the 10% of poorest districts of the country. In these mountainous districts, mainly inhabited by ethnic minorities (Muong, Thai), poverty rate is higher than 50%, with a poverty line of 200,000 VND/month/person (1 USD= 17 500 VND). The livelihood of these smallholders is based on mixed farming (lowland rice, short term crops such as cassava, sugarcane and maize on slopes, small livestock farming, bamboo plantations and forests) and relies on a large extent on a giant Bamboo (*Dendrocalamus barbatus*, locally known as Luong) plantations. Most of them grow bamboo as a "living bank", providing regular and safe income available at any time. With about 55 000 ha, North-West Thanh Hoa is the main production zone for *luong bamboo* in Vietnam (about 50% of surfaces over the country). Every year, in North-West Thanh Hoa, about 20-25 millions of luong culms are harvested (more than 550 000T/year). Luong good mechanical properties and big size allow a wide range of utilizations, such as construction, dykes reinforcement, paper pulp, and production of chopsticks, flooring, panel boards and handicraft (Gret 2008).

In Vietnam 75% of the total land area is hilly or mountainous, with a large part (about 35%) suffering from various degrees of water erosion or fertility decline (Thai Phien et al. 2002), after several years of short term intercrops grown with unsustainable practices generating high rate of soil erosion (cassava, sugarcane, maize, etc…). Upland soils, especially steep slopes, are highly prone to quick soil erosion and depletion, due to their light texture, low organic matter and low levels of nutrients (Howeler 2002; Thai Phien et al. 2002; Storey n.d.). These soils, once they are bare (or only partially protected by low vegetal cover), are very sensitive to run-off (Podwojewski et al. 2008; Valentin et al. 2008; Orange et al. 2007), especially in areas like Thanh Hoa, where heavy rainfalls and storms occur in a short period (May to September). Thanks to "its extensive fibrous roots system, the leafy mulch it may produce on the soil surface, its comparatively dense foliage which protects soil against beating rains, and its habit of producing new culms from underground rhizomes which allows harvesting without disturbing the soil" (Zhou et al. 2005) bamboo is favored for its ability to reduce run-off and fertility loss (Kleinhenz et al. 2001; Farelly 1984; Storey n.d.). Planting *luong* is therefore a sustainable source of incomes for smallholders, having positive environmental impact and bringing sustainable incomes.

Main limitations to luong planting

In the 70's and 80's, government local agencies were widely involved in the support and incentive to the augmentation of surfaces dedicated to luong plantation. Most of the researches on luong plantation and management practices were conducted in the 70's (PI, 2008) and only few were carried out afterwards (PI 2008, Nguyen Hoan Nghia 2005). However, researches on bamboos of Vietnam were not totally completed for a field or species at a period of time, but various and scattered in different units and regions, so that this makes it difficult for people to follow and apply (PI 2008). Moreover, except some technical procedures edited by extension services, like "The Technical procedure to plant Luong" (MARD 2000), few actions are currently carried out by government agencies promoting luong sustainable development. It results in difficulties for developing luong compared with crops more integrated to the market through agro-industries companies (sugarcane, cassava, maize but also acacia for paper). Indeed, such companies provide active and strong incentives to farmers (technical advices, advances for inputs…). These difficulties are reinforced by the lack of income during the early years of luong plantations, as one has to wait 5 to 7 years before the first harvest.

Main principles and objectives of project action

To tackle these issues, identify and transfer to farmers best practices for luong planting and management, in 2005, Research and Technological Exchanges Group (Gret) started to locally assess and select a comprehensive set of practices, from luong planting to harvest management (planting density, quality of seedlings, season of plantation, intercropping in early years, fertilization of newly planted and mature plantation, rehabilitation of degraded plantations, harvest management), before running activities to disseminate the best practices. Most of the tested techniques will not show significant results before one or two more years. However, trials on intercropping newly planted bamboo with other crops, launched in 2006, already provided interesting results.

These activities are part of the comprehensive set of actions implemented by Gret to develop and structure the local bamboo value-chain and to improve the positioning and income of small-holders. One component focuses on farmers and resources, through the support to the development of homestead nurseries and new plantations, the implementation of trials and demonstrations on planting and sustainable forest management, the support to farmers' organizations and creation of links with enterprises and markets. Other activities are related to the support to bamboo supply chain down stream: facilitate exchange between supply chain stakeholders, build capacities of entrepreneurs, support small and medium enterprises, support marketing, relations with investors, and tests for diversification of production. Some complementary activities were related to sector enabling environment: discussion with local government on problems and solutions for smallholders and bamboo processing entrepreneurs, multi-actors discussions and seminars, capacity building of local actors, organization of meetings and visits, exchanges with external actors on bamboo.

This communication deals with the main lessons drawn from these 3 years of on-farm research and extension work on intercropping in new luong plantations, from both technical and methodological point of views. It makes recommendations on the best practices to be promoted, but also shows the difficulty to implement on-farm research and promote bamboo plantations despite its many interests. Thus, it shows how long sustainable practices promotion can be hindered by smallholders' short term agendas and specific financial and social constraints, and need a comprehensive approach to ensure a sound long-term development.

Project Methodology

On-Farm-Research and Participatory Research

OFR is a research model based on a cooperative effort (between researchers, technicians and farmers) targeting the identification, development or adaptation, and use of technologies specifically tailored to meet farmers' needs and constraints.

Main principles of OFR and Participatory Research

The concept of Participatory and On-Farm Research initially attained wide-scale use in the 70's by researchers and agronomists, as a response to the failure of top-down Transfer-of-Technology model. Technology packages developed under controlled conditions of research stations failed to meet resource-poor farmers' needs and means (for example they were requesting more inputs that what farmers could afford, were not taking into account farmwork planning,...) and where not broadly adopted. Participatory approach is primarily based on the assumption that agricultural technology must emerge from the farmers' needs as they co-identify them. It underlies the need to consider farms as complex systems composed by an array of interrelated matters (technical, environmental, institutional , social and economic) which hinder farmers strategies and practices (Selener n.d.) to define technologies which can be effectively adopted by farmers and benefit to the farm as a whole.

This OFR process is based on innovation co-construction, through:

1. Introduction of technical innovations which are locally not yet found on steep slopes (new crops and/or new tending practices);
2. Adjustment of techniques and extension method to the variability of the local conditions (different types of soil, slopes, etc) and to the farmers' means and constraints;
3. Improvement of dialog and confidence between farmers and agronomists;
4. Dissemination (or extension) of these practices from Farmers' Fields' Schools.

Farmers do not only provide land and labour, they are also involved in the selection, monitoring and evaluation of the tested technologies. OFR involves several levels of control and management exercised by farmers and researchers (from Researcher-Managed OFR to Farmers-Participatory OFR). Rhoades (1982) defined four stages in which farmers could be more or less involved: 1) Definitions of problems to be solved; 2) Research of possible solutions; 3) Experimentations of these solutions; 4) Assessment of the results. The method adopted here sought a participation of farmers in all stages. Indeed success of Participatory Research is embedded in the quality and steadiness of exchanges between farmers and researchers. The local anchorage of the project agronomists and technicians (who are living in the countryside, in two traditional houses located at less than 1 hour from all trial fields) is one key of its intervention success.

A participatory definition of problems and planning

Participatory Rural Appraisals were organized in each communes of action and identified the lack of income during the early years preceding the first harvest (usually done 5 to 7 years after planting) as a main constraint preventing farmers from planting luong (together with the competition with other crops and tree species providing higher income on the short and medium run while getting incentives from agro-industries companies). It also outlined that farmers are used to intercrop newly planted luong with short-term intercrops providing high income with techniques having negative impact on both soil fertility and luong growth. Prior to project action, there was no specific research or technical advice for farmers regarding these issues.

Then, focus groups were organized in 3 communes to select crops improving erosion control while ensuring short-term income. Farmers and agronomists discussed the negative impact of cassava, sugarcane and maize on both soil fertility and bamboo growth due to unsustainable practices (no or low mineral fertilisation, no cover crop). They also debated the possible interest of replacing them by other short-term crops: groundnut, soybean, mongo bean and sesame. Indeed these crops and more especially groundnut were proved to have better impact on soil erosion thanks to faster-developing and wider vegetal cover (Steiner 1985, Putthacharoen et al. 1998, Thai Phien et al. 2002). Legumes were also expected to increase the quantity of N available in the soil for luong while not much competing with it for light, water and other nutrients (thanks to a low spatial competition of foliage and roots systems between the two crops).

Farmers who were interested in running trials were registered and involved in trials design and implementation. They were provided with technical and financial support from project and had to respect one specific crop management sequence, to ensure a homogenous experimental design. Financial support (initially project covered 50% of expenses) was provided to allow poorest farmers to get involved in trials and follow agreed crop management sequence. Such financial support is also often necessary to encourage farmers to shift from cultivation of crops for which they get advances on inputs from agro-processing factories. Other farmers registered to get seeds and technical support and test these crops on “demonstration plots”. For these “demonstration plots” there were no fixed operational sequence and part of the plots was monitored to provide “transitional results” on operational sequences less extensive than in trials (as farmers applied lower density and less fertilizer). Last, several farmers decided to keep growing the same intercrop than usually (cassava, maize, sugarcane) and their results were monitored too as “reference crops”.

A strong technical support

Farmers were provided with a strong and steadiness technical support through:

1. One-Day Farmers’ Field Schools (half day dedicated to theory, half day for practicing in field) organised at hamlet and village scale on intercropping practices (for each crop : sowing date, fertilization, planting density, tending practices, pest management);
2. In 2008, two technical leaflets: (addressing groundnut and soybean intercropped with luong) were printed to be used as a technical reminder for trained farmers (as farmers are not used to take notes during trainings) and to facilitate dissemination of sustainable practices;
3. Regular visits of technicians providing farmers opportunities to discuss and solve agronomic problems likely to reduce yields (pest, diseases, unsuitable practices, etc…).

A joint evaluation of results

A particular attention was paid to allow a common evaluation of trials results, involving farmers, local authorities and agriculture services. Two types of restitution seminars were organised a few days before harvest:

- One-Day Seminars were organised in each village. They gathered farmers involved in trials on short-term intercrops but also those benefiting from project support for luong new plantations, village leaders and project collaborators.

- One-Day specific Seminar was organised in one commune (gathering most of project trials) in which were also invited commune and district authorities and representatives of agricultural extension services.

These seminars gave stakeholders the opportunity to visit trials ran in the commune, to discuss results presented by project technicians and to make proposals for the following cropping seasons (which new crop or techniques to be tested? Where? ...). In addition to these seminars, project organised visits for farmers and local authorities from other projects (Hadeva in Phu Tho, Gret project in Houa Phan Laos). These projects working on luong plantations were planning to test, promote or support short-term intercrops in new luong plantations. They visited trials and demonstration plots and met some farmers growing short-term intercrops in their new luong plantations.

An iterative process

Five series of trials and demonstration plots on short-term intercrops were run from spring 2006 to autumn 2008 (Table 1). Running trials during several seasons and in different locations is essential to assess both agronomic and economic results under variable annual climatic and market conditions while promoting wide-scale extension. It was also the opportunity to regularly refine trials through an iterative assessment process: after each harvest, farmers where invited to discuss the results. Crops selection evolved according to results, to confirm the suitable crops and replace unsuitable ones. In 2007, following good yields obtained for groundnut, farmers decided to test new cultivars (L14 and L20) purchased by project in other provinces. These improved varieties were expected to provide higher yield than “local” variety. At the end of the second phase, farmers decided to test mixed intercrops (luong + groundnut + cassava, luong + groundnut + maize). They target win-win strategies: gain profit from positive impact of groundnut on soil and additional income from cassava or maize, while reducing economic risk (diversification).

Project support method evolved too (Table 1). In 2008, to avoid some problems met during previous year (some farmers were not able to purchase enough fertilizer or to spend enough labour due to family problems) it was decided to increase the financial support of farmers running trials to cover 100% of the expenses. To improve the homogeneity of the experimental design, it was also decided to reduce the number or farmers involved in trials and do several replications on each plot. Indeed, soil condition can drastically change from one plot to another one (due to cropping history, slope...) and even within one plot (soil fertility being usually lower on the top of slopes than on the base). Doing several replications in one plot allowed to reduce this variability.

Table 1 : main evolution of trials objectives, scale, assessment and reorientation

Project phase	*Objective*	*Trial scale*	*Results of participatory assessment*	*Reorientation*
LDP 1st phase (spring 2006)	Compare: - Food and industrial short-term crops (groundnut, taro), - Spice and medicine crops (kudzu, ginger) - tephrosia hedgerows)	-12 trials, - On 5 species, - In 3 communes. - 1 district (Ngoc Lac)	- Kudzu and taro not suitable - Groundnut, Ginger and tephrosia suitable	- Keep on assessing groundnut and tephrosia - Test other crops (soybean, mongo bean and sesame) in both spring and autumn seasons
LDP Interim phase (spring-autumn 2007)	Compare: -"Reference" crops (cassava, maize, sugarcane) - Groundnut, soybean and sesame; - Keep on assessing tephrosia	- In 5 communes - In 2 districts (Ngoc Lac, Thuong Xuan); - 83 households (for trials, demonstration and reference crops) - 105 *sao** (5.25 ha)	- Groundnut ensure the best agro-economic results; - Cassava and sugarcane keep arising farmers interest	- Keep running trials on groundnut, soybean and sesame - Run trials on mixed intercrops (groundnut + cassava, groundnut + maize).
LDP 2d phase (spring-autumn 2008)	- Keep on running trials on legumes and sesame. - More trials on groundnut as previous trials outlined its agronomic and economic interest. -Introduce and test 2 new cultivars L14 and L20 - Less trials (but replications)	- In 9 communes; - In 4 districts**; - Results monitored for: 45 Households; 95 plots	- Groundnut ensure the best agro-economic results; - L14 is the most suitable variety; - Mixed intercrops showed good results	- No more trials but support for seeds for "demonstration plots" - more demonstration plots on groundnut with new practices (high density, early sowing) - keep testing mixed intercrop

* 1 sao = 500m²

** Project activities extended to 2 new districts (Ba Thuoc and Quan Hoa), located in the north-western part of Thanh Hoa province.

Extension Work

As explained above, seeds and technical support were provided to a larger number of farmers who were not involved in a formal OFR. Such "demonstration plots" were expected to promote a wider and more sustainable adoption of the appropriate techniques. Crops and technical trainings were achieved together with OFR similar activities. Support for seeds was limited to 2 *sao*/household (0.1 ha), in order to maximise number of beneficiaries. From spring 2008, project decided to provide its support through the establishment of seeds banks. Seeds were provided to farmers as a loan to be reimbursed right after harvest. Then seeds were borrowed to other farmers for the following cropping season. That way, seeds banks were expected to expand and sustain the dissemination of crops (especially groundnut): demonstration plots outline the agronomic and economic interests of these crops, while seed banks encourage more farmers to try such model on their own plots (by reducing investment costs). They also gave access to more farmers to new cultivars not locally available (L14 and L20). More than 400 families grew groundnut on about 30 ha of new luong plantation during this project's stage. More than 90 families grew soybean on 10 ha. About 50 km of Tephrosia were also planted as contour line and hedgerows.

Description of project achievements

Trials results

Outcomes expected form crops (legumes and sesame) tested by farmers were threefold:

1. Provide a short term income similar or higher than crops traditionally intercropped with newly planted luong (cassava, maize, sugarcane);
2. Limit the soil erosion occurring on local steep slopes and increased by crops usually selected;
3. Promote luong growth, instead of competing with it, to ensure a faster development and allow earlier first harvest.

Results presented here were discussed with and agreed by both farmers and local authorities

Agro-economic results (Vogel 2007, 2008)

The main result drawn from this OFR is that groundnut is the most suitable crop to be intercropped with newly planted luong on steep slopes within this locality.

Table 2 : Yield of crops monitored in 2007 and 2008

T/ha	Spring 2007	Autumn 2007	Spring 2008	Autumn 2008	**Average**
Groundnut[1]	2.8	1.1	1.9	1.1	1.7
Soybean[2]	0.9	1.0	1.9	0.6	1.1
Sesame[2]	0.4	0.3	0.4	0.3	0.3
Fresh cassava		52.3		16.5[4]	34.4
Dry cassava		18.5		8.1	13.3
Sugarcane[3]		64.8		41.2	53
Maize	2.7	1.4	N.D.	1.8	2.0

[1]Yield of dry pods (as farmers are used to sell this crop);

[2]Yield of dry seeds (as farmers are used to sell this crop);

[3]Mean for a 3 years' cycle; [4]Contrary to legumes and sesame, yields of cassava, maize and sugarcane were not monitored on the same plots in 2007 and 2008, so variation may not be linked to climate variations or cropping sequences;

Groundnut is well adapted to local conditions and is not much sensitive to diseases and climatic disturbances. Yields (Table 2) are close from those quoted by Thanh Hoa local Agriculture office (2.4 T/ha in 2007). Yields were lower in 2008 due to the exceptional bad weather which occurred in winter and delayed the two cropping cycles. Groundnut ensures high incomes (more than 30 millions VND/ha/year) (Table 3). Trials also outlined that groundnut got higher results when sown before the 5th of March with a high density (more than 20 plants/m²). However, groundnut is sensitive to shadow, so that it should not be grown once luong vegetative cover is well developed (2 to 3 years-old plantations). Last, the variety L14, introduced in the area by the project, ensured the best yield and income in this area (compared with local variety, and another variety introduced by project L20).

Soybean has a good potential on slope (1.7T/ha for a Net Income of 15 millions VND/ha) but should be proposed on good land and with intensive care only. Average yields obtained were lower than 600kg/ha (Table 2), leading to a negative net income average (main expenses being for fertilizers supported by project). Indeed, this crop is sensitive to soil and weather conditions and to pests and diseases regularly occurring on steep slopes, where farmers are not used or able to provide intensive cares.

Sesame mean yield was 300kg/ha (Table 2), and several households got low yields due to heavy rainfalls at sowing and/or flowering time. They got Net Income almost nil (main source of expenses being fertilizers). Nevertheless, sesame also provided good yields (600kg/ha, net income =11.5 millions VND/ha) when these two growing stages were not affected by rain.

Table 3 : Economic results of the most interesting crops monitored in 2007 and 2008

			Spring 2007	*Autumn 2007*	*Spring 2008*	*Autumn 2008*	***Annual Average***
Groundnut	NI[1]	1000VND/ha	22 860	18 564	12 608[4]	16 780	**35 406**
	ROI[2]	%	4.6	5.5	1.0	2.0	3.3
	NI/ FLD[3]	VND/day	95 250	77 350	26 913	47 026	61 635
Fresh cassava	NI	1000VND/ha		40 562		5 212	**22 887**
	ROI	%		30.9		1,7	16
	NI/ FLD	VND/day		126 757		44 962	85 859
Dry Cassava	NI	1000VND/ha		44 853		8 030	**26 442**
	ROI	%		34.2		3	18
	NI/ FLD	VND/day		131 922		10 037	70 979
Sugarcane	NI	1000VND/ha		6 193		10 762	**8 477**
	ROI	%		0.4		0.5	0.5
	NI/ FLD	VND/day		47 467		204 637	126 052
Maize	NI	1000VND/ha	6 162	2 840	ND	3 363	**9 002**
	ROI	%	5.9	2.3	ND	1.7	3
	NI/ FLD	VND/day	32 434	21 850	ND	46 364	33 549

[1)] NI = Net Income;

[2)] ROI = Return on Investment = Net Income/ Total expenses;

[3)] NI/LD = Net Income/Family Labour Days;

[4)] Groundnut pods sale price is higher in autumn than in spring. Yields obtained in spring 2008 were higher than in autumn but due to winter bad climatic conditions, production quality was lower and farmers got lower price.

In 2007, **cassava** prices benefited from a 50% increase (Table 4), allowing a high economic interest (more than 30 millions VND/ha for fresh pods for a high yield of about 50T/ha) and encouraging farmers to grow cassava on larger surfaces in 2008. Nevertheless, international market fluctuations led to a drop in prices, which were reduced by half. Net Income (Table 3) drastically decreased (about 10 millions per ha, for a yield of less than 20T/ha).

Table 4 : Main evolutions of cassava price from 2006 to 2009

Price (VND/kg)	*December 2006-January 2007*	*December 2007-January 2008*	*December 2008*	*January 2009*
Fresh cassava	400	800	500	350
Dry cassava	1500	2500	1500	1300

Net Income from sugarcane (Table 3) remains lower than the one obtained for cassava and groundnut and provides a low Return on Investment (less than half of invested amount) as amount of inputs (for fertilizers and labour) is high. Moreover, harvest is very restrictive: date of this time-consuming activity is fixed by the factory and may compete with other farm activities (like rice transplanting, groundnut sowing…).

To a lesser extent, maize is also traditionally intercropped with newly planted luong. In most of the communes of project intervention, maize is grown in a very extensive way with low inputs, leading to low and variable Net Income (except in Cao Ngoc where it is widely grown due to the establishment of a maize processing company facilitating access to fertilizers). However, project did not monitor enough plots and there was a too great variability among results to draw any firm conclusion on agro-economic results of maize intercropped with luong on steep slopes. A last crop locally intercropped with luong was upland rainfed rice. Nevertheless, it was identified in few places only and was not monitored by project.

Impact on soil erosion

In Thanh Hoa Province, 2/3 of the territory is covered by hills and mountains. These soils are highly prone to erosion, especially when they are bare, due to a light structure, a low depth and low level of organic matter, especially when short-term crops were grown with unsustainable practices (no or inappropriate mineral fertilisation, no cover crop...) during several years (Tran Dinh Tro 2001, Valentin et. al 2008). Heavy rainfalls occurring in the area (1800 mm/year, concentrated in few months, from April to July) are also an aggravating factor. Mature luông plantations allow to reduce soil erosion (thanks to high roots and vegetative covers), but not the newly planted ones (4-5 first years). Intercrop can partially solve this problem if suitable crops and practices are selected. OFR trials were run to assess the impact of different intercrops on soil erosion in less than 1 year-old luong plantations.

Table 5 : Main results of trials on impact of several cropping associations on soil erosion

Cropping associations	*Spring 2007*				*Spring 2008*			
	Time	Pp (mm)	Eroded soil (kg/ha)	%	Time	Pp (mm)	Eroded soil (kg/ha)	%
Bamboo + Mongo bean + Soybean	18/06/07-06/08/07	297.3	48.6	17.3				
Bamboo + Cassava			107.8	38.4				
Bamboo+ Sugarcane			280.4	100				
Bamboo + Groundnut					25/05/08-10/06/08	147	171.2	33.1
Bamboo + Soybean							370.4	71.5
Bamboo + Maize							518	100

In spring 2007, trials showed that the amount of eroded soil with luong intercropped with legumes was only 20 % compares with luong intercropped with sugarcane and 50% lower than with luong intercropped with cassava. Trials ran in spring 2008 showed that run-off when intercropped with groundnut was only 33% of the one observed with maize, while soybean was 71.5% (Table 5). However, as soybean was harvested earlier and not immediately followed by another crop, soil erosion drastically increased after harvest. These results should be used as a rough guide only. Indeed these trials on soil erosion, done in short period (less than 3 months) without repetition were done for a demonstrative purpose rather than a scientific one. However, they corroborate other trials ran on more scientific bases in other North Vietnam hilly area ((Nguyen The Dang et al.; Thai Phien et al. 2002) and other parts of South Asia. For example, trials ran in Thailand showed that cassava grown for root production caused more than twice as much dry soil loss by erosion as mungbean, and three times more than maize, sorghum, groundnut and pineapple (Putthacharoen et al. 1998).

Other practices were also tested by farmers with project support, but results were not monitored or did not allow to draw any firm conclusions (not enough samples, too much variability). *Tephrosia candida* seeds were provided to be planted between luong lines. This two-years-cycle legume is commonly known for reducing soil erosion and improving soil when its residues are returned to soil. Trials run in Vietnam North Provinces (Nguyen The Dang 2002) showed that *"when hedgerows of tephrosia candida and/or vetiver grass were added, erosion declined to only 40-49% of reference treatment"*. From spring 2008, farmers also started to test mixed intercropping (groundnut + cassava, groundnut + maize, groundnut + sugarcane) in their new luong plantations. Such cropping systems are already commonly grown on lowlands (without luong) but not on slopes. Farmers were satisfied by results, especially for groundnut +cassava.

Further researches should be done on soil erosion reduction. Other practices showed good results in other provinces. For example, Thai phien (2002) reported that the combination of these two measures (Intercropping cassava with legumes and *tephrosia candida* hedgerows) *"improves soil fertility, resulting in higher yields of cassava and intercropped legumes as compared to the control treatment without hedgerows"*. Moreover, except one farmer who grew groundnut during 3 cycles (spring, autumn, winter) and who get low yield, slopes are left fallow during winter and are more exposed to run-off. More work could be done to identify a cropping system ensuring a proper soil cover through the year. Studies were already carried out in other hilly areas of North Vietnam on cover crops (Affholder et al. 2008). However, although farmers are concerned by soil erosion and environmental sustainability, it is not a driving force in their adoption of new practices. They are first looking for strategies allowing a quick improvement of their incomes (Orange et al. 2008).

Impact on luong growth

Two series of trials were run to assess the impact of different crops on luong growth. Best luong survival rates were obtained with groundnut, while the worst one was observed for luong intercropped with cassava. More shoots were obtained with legumes and sesame. Biggest shoots were observed for clumps intercropped with soybean while clumps intercropped with sugarcane produced the highest shoots. Worst results were obtained with cassava (Table 6). The second series of trial confirmed the negative impact of cassava on luong growth: luong produce smaller and weaker shoots when grown close to cassava. Nevertheless by applying a distance of more than 1m between luong and cassava plants this negative impact was reduced. Mixed plantations of acacia (*keo*), luong and cassava gave the worst growth for all crops.

Table 6 : Results of trials on impact of several intercrops on luong growth

Treatments (Year 2007)	*Bamboo Survival rate (%)*		*Number of shoots/clump*		*Shoots diameter (cm)*		*Shoot height (m)*	
	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Bamboo + Groundnut	95,9	97,2	2,1	4,3	1,1	1,4	1,7	1,9
Bamboo + Soybean	94,5	94,5	2,3	4,1	2,1	2,4	1,5	2,4
Bamboo + Mongo bean	94,5	94,5	2,2	0,0	1,9	0,0	1,7	0,0
Bamboo + Sesame	94,7	94,7	2,1	3,7	1,5	2,2	1,7	2,3
Bamboo +Cassava	57,5	53,5	0,3	0,6	1,4	1,1	1,1	1,7
Bamboo + Maize	85,3	85,3	1,7	2,7	1,4	2,3	1,3	1,9
Bamboo + sugarcane	94,3	91,3	1,4	2,4	0,9	1,3	2,0	3,0

Negative impact of cassava, sugarcane and maize on young luong is mainly explained by competition for light and nutrients (as their canopy is higher and their roots system more developed). This impact is limited in sugarcane fields due to the high rate of fertilizers applied. Nevertheless, it has been observed that the burning of sugarcane residues after harvest and trucks may dramatically damage bamboo shoots and leaves. On the contrary, legumes do not compete with luong for light and competition for nutrients and water is limited, while reducing soil erosion and improving soil fertility. Luong develops more and bigger shoots and can be harvested earlier.

Two years after plantation, demonstration plots implemented in Kien Tho (by the *green hill* farmers' group) showed marked differences in luong clumps development with different intercrops. Luong intercropped for 2 years (4 cropping seasons) with legumes, and more especially groundnut, showed a development close from the one usually observed for 4 to 5 years-old luong planted in traditional way, while luong intercropped with sugarcane and maize showed a slow development.

Discussion on the main lessons drawn from experience

Running trials through OFR research was expected to provide accurate results on agro-economic potential results of different intercrops while initiating the spreading of the intercrops identified by farmers as the most suitable ones.

Scientific value of OFR

The statistical rigour of results obtained through OFR can't be the same as for agronomical trials run in station. For statistically significant information on crops (like impact of several techniques on yield and income, comparison of several cops…) a larger number of plots is requested to have enough replications of different cropping systems and/or treatments and conduct variance analysis. With OFR, it is difficult to set a large experimental design of plots with similar soil conditions, as farmers are smallholders with specific soil conditions (various locations, cropping history...). Then, even with financial support, farmers tend to adapt recommended techniques to their means, working calendar (trials barely coming first) and most of all, short-term strategy (leading them, for example, to reduce time invested for one crop showing low development to limit financial risks). Such modification in operational sequence make analysis and comparison more complicated. Moreover, trials are highly time consuming and request skills (for monitoring, data capture and analysis). It limits the number of crops and techniques which could be successfully tested and monitored by project. As a consequence, it was not possible to get all the statistically significant data initially expected, more especially regarding mixed intercropping in luong plantations.

However, the statistical rigour of results obtained on research station often failed to ensure their broad-adoption. OFR has another scientific dimension based on a systemic perspective essential to tackle the complexity of farmers' real constraints. The assessment of real potential of a technical innovation is inseparable form the understanding of the array of constraints hindering farmers' strategies. As outlined by Chambers et Al. (1985), "the criterion of excellence is not the rigor of an on-station or in-laboratory research, or yields in research station or resource-rich farmer conditions, but the more rigorous test of whether new practices spread among the resource-poor".

Factors behind Best-Practices Wide-Scale Adoption

This 5-seasons experience was the opportunity for technicians and farmers to define test and compare several intercropping systems. Being involved at each step of the research process allows farmers to identify and select practices adapted to their needs and means. The most compelling proof is the adoption of the most suitable practices (groundnut, groundnut + maize or cassava) by most of the farmers who tested it during the following cropping seasons, until luong was too much developed to ensure a proper growth of groundnut (2-3 years after luong plantation). Moreover, in each commune, the number of people interested in intercropping groundnut with newly planted luong increased after one year of OFR and extension work. In any communes where LDP carried out activities on intercrops, some farmers started to grow legumes (mostly groundnut) on their slopes and/or luong new plantations, without project support. Most of them started after observing results of their neighbors who got support from project. Some of them were already used to grow legumes on their lowlands but not on their slopes. This multiplying effect was facilitated by the creation of seed banks allowing a wider number of people to test groundnut without additional investment from project. OFR also provided crucial additional information on agro-economic results of the main cropping systems implemented on slopes in project area and their insertion in local farming systems. Trials also led project staff to learn more about recommendation to be done at local level for yields improvement (sowing time, density).

Moreover, most trials and demonstration plots were supported though the establishment of farmers' groups. When most of farmers' plantations are grouped in the same location, it arouses an emulation, especially in one commune where most of farmers replanted luong on the same hill (after several years of sugarcane) and enthusiastically named it "the green hill" (*doi si xanh*). This enthusiasm was reinforced by the numerous visits of their plots organized for farmers and local authorities from other communes, districts and provinces (and even three visits of Laotian people). These visits also allowed to initiate the spreading of these practices in these new locations (for example, after their visit of the "*green hill*" in Kien tho, farmers from Phu Tho, supported by Hadeva, showed a great interest for intercrop and agreed to grow them in their new luong plantations). Farmers running trials or demonstration plots were involved in each visit, and their exchanges with farmers from other places were fruitful in outlining the interest of legumes to be intercropped with luong on steep slopes.

Last, regular information and consultation of local authorities and extension services (who were more particularly involved in the pre-selection of techniques to be tested, the design of technical leaflets, restitution seminars) was also a factor of success. They appreciated the new developed practices and their positive impact on both farmers' incomes and environmental sustainability. They were supportive and facilitate project activities (by delivering on time authorizations to work in the area, to organize trainings, to establish farmers groups …)

Adoption of "Best Practices" hindered by Farmers' Short-Term Agendas

Groundnut proved to be the most suitable crop to be intercropped with newly planted luong on slopes, as it ensures high and stable income while limiting soil erosion and promoting bamboo growth. Nevertheless, other crops, such as cassava and sugarcane or maize, still arouse farmers' interest, limiting groundnut spreading on slopes. These crops also compete with the expansion of luong plantations. In Northern Provinces of Vietnam, these three crops are widely and unsustainably cultivated on slopes, despite their negative impact on soil erosion, for several reasons. Predominance of these crops in the landscape is in a large extent linked to the proximity of processing companies. Indeed, these companies offer several assets to the farmers. They provide them with technology packages (trainings, ploughing engines, access to quality seeds or seedlings, quality-fertilizers, technical advises or technical sequence...), advances to buy inputs (seeds, fertilizers, labour...) and guarantee the production purchase (but usually not the price). This way, factories compensate for three main constraints of farmers: the lack of technical advises, the access to quality inputs and the access to capital. Moreover Vietnamese farmers mostly focus on short-term agendas and are easily attracted by short-term speculative crops such as cassava and maize mainly produced to be sold abroad. As illustrated by recent evolution of cassava prices (see above part on agro-economic results), such short-term orientated speculations are often risky.

In this context, the promotion of other models and strategies requests a specific and comprehensive support, involving all concerned stakeholders (farmers, local authorities, technicians, local agricultural extension services, agronomists, companies likely to provide input or credit…) to identify and spread best practices and provides farmers with the means to adopt them. Such approach requests appropriate means and time.

The scale of intervention into question

Gret experiences on intercropping in particular and luong in general show that the selection and sustainable diffusion of best practices request a relatively large scaled intervention, in terms of time and locations. First of all, running trials and implementing extension work in several locations (several districts and communes) allow to adjust to the variability of soil conditions (slopes, soil fertility due to different cropping history…) and economic situations (kind of infrastructures, impact of processing factories…). This variability induces the predominance of different cropping systems (sugarcane in Kien Tho, Cassava in Xuan Phu) with various yields (Table 5). As a consequence, results obtained in one commune may not appear interesting in another one (for example, trials ran in Kien Tho will not convince Tan Thanh farmers, as income obtained Kien Tho for groundnut are lower than the one obtained for cassava in Tan Thanh where soil fertility is higher).

Table 7: Comparison of yields obtained by OFR in 2008 in 3 communes

Commune (district)	*Main characteristics*	*Groundnut*		*Fresh Cassava*		*Sugarcane*	
		Yield kg/ha[1)]	*NI million VND/ha*	*Yield T/ha*	*NI million VND/ha*	*Yield T/ha*	*NI million VND/ha*
Tan Thanh (Thuong Xuan)	Groundnut and cassava were grown on cleared plots (following degraded forest)	4600	33,0	22,0	21,9	37,0	3,6
Kien Tho (Ngoc Lac)	All crops were grown on plots eroded by several years of monoculture (sugarcane, cassava…)	2280	13,7	11,0	14,3	40,0	14,0
Xuan Phu (Quan Hoa)	Groundnut and cassava were grown on cleared plots (after degraded forest)	3530	32,8	20,0	20,6	-	-

[1] Results obtained for two seasons (spring + autumn)

Furthermore, it appears essential to implement OFR during a long period (never less than 2 years) to overcome the intra- and inter- variability of climatic conditions and measure impact of crops such as legumes on soil fertility. Crops grown in spring 2008 were affected by the bad weather conditions which occurred (the longest and coldest winter faced by North Vietnam in more than 20 years). Running trials at this time only would not have show the real potential of groundnut as an intercrop with bamboo. Trials on planting and managing luong request even longer trial period as 2 to 5 years are necessary before observing first results (in mature plantations, impact of tending practices on new shoots are obvious after 2 years of applications, while for new plantation, ones has to wait first harvest before assessing impact of introduced techniques on productivity).

Moreover, techniques introduced are often new and considerably change farmers' uses on luong plantations. Beyond the introduction of new practices, it is a matter of changing the way farmers consider their plantations. Indeed, farmers currently consider them as "safety bank", in which they invest a minimum amount of time and money (which they prefer to invest for short-term speculative crops (see § 4.b.)). To initiate a change in farmers' conception, it is essential to give them the way to test new practices during several seasons. The first years, farmers were reluctant to implement techniques proposed by agronomists (higher density, more fertilizer, more care ie. more labour), but season after season, seeing high potential of groundnut they agreed to apply these practices (even on demonstration plots, without financial support).

Beyond the issue of project scale, is the one of long run impact of such participatory research once the project withdraws the locality. Final target of such project should not be the development and diffusion of one set of new technologies, but the transfer of research and experimentation capacities to local actors to ensure farmers will be able to keep adjusting them with changing circumstances in a sustainable way. Project already paved the way to tackle this issue by supporting the creation of a local NGO (recently registered as a local cooperative) already skilled in the implementation of OFR and participatory activities. This cooperative already wins some legitimacy among local authorities and farmers, thanks to the concrete technical results already obtained, discussed and transferred by the project and the cooperative. A complementary approach could be to reinforce farmers' capacities to innovate, experiment and adapt their practices by themselves, without external support, and move toward a "farmer to farmer" experimentation network. In this case, further work has to be done to reinforce farmers' capacity to identify problems they want to address, design trials, implement experiments, assess and share results, without external support, or with a limited one from local NGO (for example to get access to information or technologies not available locally).

Conclusion

Development of Luong bamboo production and supply chain is commonly described as a way to reduce poverty while preserving environment in North Vietnam poorest districts. Despite an active period of research on luong plantation and management practices of luong in the 70's, Vietnamese authorities are currently granting few means to research and extension work for this crop.

One may be attracted to solve this issue by using results of past researches or running some additional researches in one site. However, Gret field experiences on luong supply chain in general and intercropping in new luong plantation in particular, outlines the high relevance of a more participative and comprehensive approach. Indeed development of luong and introduction of new practices are hindered by several constraints (especially the competition with other crops providing a priori a better answer to farmers' short term agendas). Such constraints have to be removed progressively and in an iterative way, by defining practices well adapted to local conditions and constraints. On-Farm-Research, with a participatory definition of tested practices and trials planning and a joint evolution was proved to be an efficient way to demonstrate local interest of these practices and sound their sustainable adoption.

However adoption of such practices is hindered by short-term agendas of farmers and competition from other crops whose adoption is facilitated by services offered by agro-factories. As a consequence promotion of more sustainable model ensuring higher income request a relatively large scaled intervention, in terms of time and locations which may exceed project framework always limited in time. To ensure a sustainable agricultural development, project has to reinforce research and experimentation capacities of local actors. It could be done by the creation or reinforcement of local NGOs or services cooperative able to support farmers and extension services in adapting practices to new constraints. Capacities of farmers currently involved in trials could also be enhanced to create farmers to farmers' experimentation networks able to define, implement and assess their own experimentation and spread technologies and practices allowing to develop themselves their agriculture in a sustainable way.

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[1] List provided by the Ethnic Minorities Working Group (EMWG).

[2] Technical content was based on results from previous trials completed by information from the agricultural development state services at district level concerning standards and recommendation in the area for the related crops.

[3] Standards provided for lowland and intensive fertilization and tending practices

[4] Average yield obtained by excluding all plots which did not get yield. By taking them into account when, average is 600kg/ha

[5] Results not included in this table: yield in autumn = 5.1T/ha, with a Net Income = 11millions VND/ha with a ROI = 4

[6] Cassava monocropping system without fertilization.

[7] In autumn 2008, there were 2 farmers in Tan Thanh (where there was only 1 trial), 2 farmers in Phung Giao (where there was only 1 trial) and 8 farmers in Kien Tho (where there were several trials and numerous demonstration plots).

Impact Assessment of Bamboo Harvesting in the Seima Biodiversity Conservation Area, Mondulkiri, Cambodia

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Abstract

Impact on bamboo forests and local livelihoods in SBCA involves clearance for agriculture, traditional harvest for family uses, and harvest for making bamboo incense sticks. To study the impact of bamboo harvesting on bamboo resources and on family livelihoods, research was carried out in the villages of Srae Levi and O Rona. Bamboo harvesting for making incense sticks has a positive impact on the income of families in O Rona and generates a higher income than that in Srae Levi. In particular, it helps Bamboo Harvesting Families (BHFs) to alleviate food shortage during the lean period. BHFs can generate more income than non-Bamboo Harvesting Families (non-BHFs). More importantly, it is an income generating activity that supplements but does not compete with farming activities. However, the harvesting is not entirely sustainable and has negative impact on one bamboo species, *Reusei Thngor*, because its regeneration capacity cannot respond to the current level of harvesting. In addition, traditional harvest for family uses provides other benefits to families of both villages such as building materials, utensils, farm equipment, bamboo shoots for consumption, use as fallow crops in shifting cultivation and other uses in cultural ceremonies. It does not have a negative impact on bamboo forest since bamboo plants are given enough time to re-grow within the three to four years of harvesting cycle. Bamboo clearance for agriculture, on the other hand, has a more serious impact on the condition of bamboo forest in the area when compared with harvesting for making incense sticks. Furthermore, O Rona, which has better access road, easy access to market facility, and a higher population and immigration level, the rate of bamboo extraction is relatively higher than at Srae Levi.

Keywords*:* harvesting, bamboo incense sticks (BIS), impact, income and conservation

Introduction

Bamboo is largely concentrated within the world's tropical and subtropical belt in eastern and southern Asia, and South and Central America (Ohrnberger 1999). Bamboo plays a very important role in rural poverty alleviation, culture, biodiversity conservation and environmental protection in these regions (INBAR 2004; Lobovikov et al. 2007). However, this is not possible when bamboo resources are not managed sustainably. As an example, Lou and Miao (2006) reported that, in China, managing bamboo for short-term economic returns has resulted in long-term biodiversity and productivity losses.

In Cambodia, bamboo is distributed throughout the provinces in the southwestern, northeastern and eastern parts of the country. As of 2006, bamboo forest areas covered 35,802 ha, equivalent to

0.33% of woodlot forest areas in Cambodia (FA 2007). Similar to other countries, bamboo forest is important in supporting the subsistence livelihoods of rural Cambodians, protecting the environment and conserving biodiversity. Furthermore, it used to be a vital raw material for the pulp and paper industry in the year 1961 with 50,000 m^3 of bamboo culms extracted for the industry (Hang 1995). These uses have decreased since bamboo forests have come under threat from land economic concessions, agricultural land expansion, settlement, and dying-back after flowering and forest fire (ESI/SCS 2007).

The Seima Biodiversity Conservation Area (SBCA) in Mondulkiri province is a protected area of 305,590 ha, of which 6881 ha is natural bamboo forest (WCS/FA 2008a). At present, the bamboo in SBCA has great value for biodiversity conservation and local livelihoods. Nevertheless, there has been a concern about the impacts of harvesting practices on bamboo in the area from such activities as conversion to agriculture, harvesting for making Bamboo Incense Sticks (BIS) and traditional harvesting for household uses. Currently, these threats pose a challenge for SBCA. To deal with this challenge, this paper aims to assess the specific impacts of harvesting practices on local livelihoods and natural condition of bamboo forest, and to develop recommendations for improved management that would consider a compromise between livelihood enhancement and conservation within the protected area.

Methods

The Study Area

SBCA, formerly a forest concession area of the Malaysian company Samling International, was established in 2002 under the *prakas* (Declaration) of the Ministry of Agriculture, Forestry and Fisheries. At present, its management is the responsibility of the Forestry Administration (FA) with financial and technical support from the Wildlife Conservation Society (WCS). SBCA has been classified by Bird Life as an important bird area, by WWF as comprising two global 200 eco-regions, and by WCS as a last wild landscape (WCS/FA 2007). The area covers eight communes (Srae Khtum, Srae Preah, Srae Chhouk, Memong, Chongplas, Saenmonorom and Romanea) of Mondulkiri and one commune (Khsem) of Kratie province. The study was conducted in Srae Khtum commune where O Rona and Srae Levi villages were selected using cross section method. The selection of the two villages was based on two criteria (1) largely covered by bamboo forest and (2) difference in biophysical conditions. O Rona was located closer to the main road and market center, and has a higher total population than Srae Levi (Figure 1).

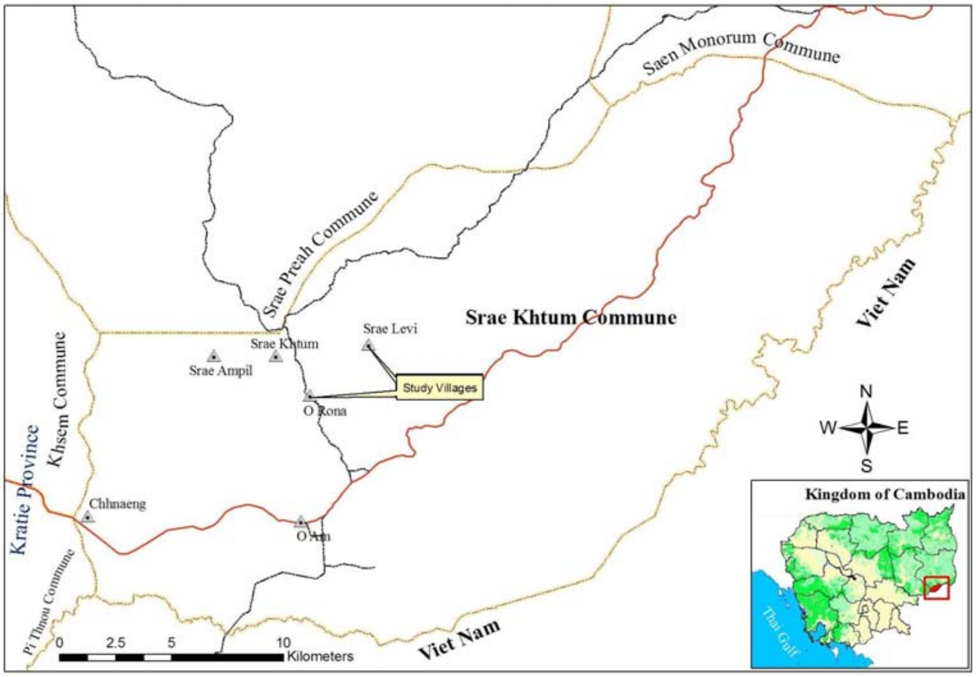


Figure 1 Map showing the location of Srae Khtum commune and the selected study villages, O Rona and Srae Levi. O Rona is located in the buffer zone and Srae Levi is located seven kilometers from the main road in the core zone.

Data Collection

Family questionnaires, key informant interviews, participatory mapping and direct field observations were used to collect primary data. With ten percent errors, 63 out of total 168 families of both villages were sampled. 43 out of 139 families in O Rona and 20 out of 29 families in Srae Levi were randomly chosen for interviews to collect socio-economic data related to income sources, food security and immigration. Key informant interviews were conducted with two village elders, two key staff of SBCA and the participatory land use planning and natural resource management committee to collect data related to the management system of bamboo resources in the area. Participatory mapping was conducted to delineate village boundaries and identify bamboo harvesting areas. Finally, direct field observations were made to collect the coordinates of the harvested bamboo forest areas using Geographical Positioning System (GPS), to identify the regeneration capacity of bamboo and to assess the appropriateness of current harvesting techniques. Desk review was employed to collect secondary data related to rules and regulations governing bamboo resources, population and map of bamboo forest areas.

Data Analysis

Descriptive statistics were used to analyze data related to income, food security and immigration, harvesting technique, harvesting volume, ownership of bamboo and other uses of bamboo. Bivariate analysis was used to test the relationship between the engagement in bamboo harvesting and the period of insufficient rice production. Mann Whitney U test was used to analyze the impact of BIS income on family income at village level by comparing the mean ranks of family income in O Rona with mean ranks of family income in Srae Levi. Furthermore, all sampled families were categorized as Bamboo Harvesting Families (BHFs; n=31) and non-Bamboo Harvesting Families (non-BHFs; n=32). BHF refers to family who engage in bamboo harvesting to make incense sticks and non-BHF refers to family who does not. In order to analyze the specific impact of BIS income on BHF's income, Independent Sample T test was used to compare the difference of income means of both family categories. ArcGIS was used to analyze GIS data and produce maps illustrating the site impacts. T o analyze the different impact of harvesting practices on the condition of bamboo forest, secondary data of bamboo forest area 2002 was used as a baseline data to compare with GIS data collected from the filed. Finally, qualitative method was used to analyze data related to management rule and regulation of bamboo resources in the area.

Results

Village Demographics

Population in O Rona and Srae Levi is mixed of Khmer, Phnong and Stieng ethnicities. The population at O Rona is about 79% higher than that of Srae Levi (Local Administration Unit 2007). Furthermore, a greater proportion of immigrants (37.2%) was found in O Rona than in Srae Levi (5.0%), possibly because of the better road condition and market access (Table 1).

Table 1. Distribution of immigrants by village

Village	Population type		Total
	Original	Immigrant	
Srae Levi	19 95.0%	1 5.0%	20 100.0%
O Rona	27 62.8%	16 37.2%	43 100.0%

Livelihoods

The important livelihood activities of families in O Rona and Srae Levi include upland rice farming, paddy rice farming, animal raising, cash crop cultivating, resin tapping, bamboo harvesting, laboring, government work, fishing and other wild products collecting. Rice is produced in upland and paddy fields for consumption while other activities are important in producing supplementary food and generating cash income.

Income Generation

In Srae Levi, cash crops are the main contributors to total family income (71%), followed by resin (17%), wage labor (8%), civil service (3%) and livestock (1%) (Figure 1). There is no income from making bamboo incense sticks in this village. However, in O Rona, making BIS is the greatest total family income contributor (44%), followed by cash crops (41%), wage labor (10%), resin and civil service (2% each) and livestock (1%) (Figure 2).

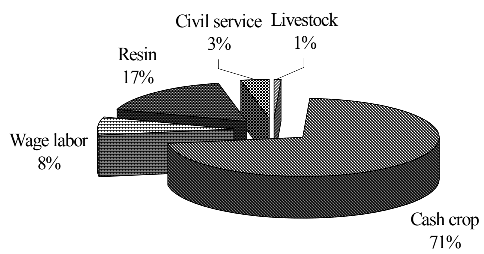


Figure 2

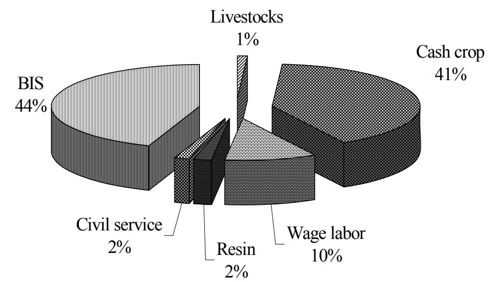


Figure 3

Figure 2: Income sources for families in Srae Levi

Figure 3: Income sources for families in O Rona

Currently, income generated from making BIS is essential for the livelihood of BHFs in O Rona since they have fewer income sources than non-BHFs. BHFs generate income from making BIS (58%), cash crops (29%), wage labor (12%) and civil service (1%) (Figure 4). There is no income generated from resin or livestock.

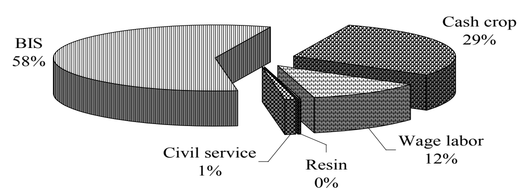


Figure 4: Income sources for BHFs in O Rona. BIS contributes more than half of the total income.

Food Security

Food shortage is a major problem of families in O Rona and Srae Levi. Only 3.2% of families (2 out of 63) reported having sufficient rice to eat year round, while 96.8% (61 out of 63) did not (Table 2). On average, they face rice shortage for 9.35 months per year. This period is even longer for BHF, i.e. almost 11 months. Those who do not have sufficient rice production must search for other livelihood options, including bamboo harvesting, to compensate for rice shortage.

Table 2. Percentage of families with sufficient or insufficient rice production

Status of rice production	Frequency	Percent
Sufficient	2	3.2
Insufficient	61	96.8
Total	63	100.0

Correlation co-efficient of Pearson Correlation test showed that there was a very strong linear relationship between the engagement in bamboo harvesting (P=.000<0.01) (Table 3). The positive relationship (.474) means that the longer the period of insufficient rice production, the more families will engage in bamboo harvesting. Therefore, it can be concluded that the increase in the period of insufficient rice production is the motive for families to engage in bamboo harvesting to make incense sticks.

Table 3. Correlation between the engagement in bamboo harvesting and period of insufficient rice production

Dependent variable	Statistic	Period of insufficient rice production
Engagement in bamboo harvesting	Pearson Correlation	.474**
	Sig. (2-tailed)	.000

**Correlation is significant at the 0.01 level (2-tailed).

Bamboo Harvesting Practices

Bamboo Harvesting for Making Incense Sticks

The data show that 72.1% of families in O Rona are BHFs (Table 4). Frequency data show that 77.4% of BHFs harvest bamboo for 15-30 days per month and 22.6% harvest for 4-14 days per month, with an average of 17.45 days per month (Table 5). Per harvesting activity, they harvested 10-50 culms, with an average of 19.13 culms (Table 6).

Table 4. Number of families who engage in bamboo harvesting to make incense sticks by village

Family category	Village	
	Srae Levi	O Rona
BHF	0 .0%	31 72.1%
non-BHF	20 100.0%	12 27.9%
Total	20 100.0%	43 100.0%

Table 5. Number of days per month BHFs harvest bamboo to make incense sticks

Number of days	Frequency	Valid Percent
4-14	7	22.6
15-30	24	77.4
Total	31	100.0

Table 6. Number of bamboo culms harvesting per harvesting activity

	N	Minimum	Maximum	Mean	Std. Deviation
Number of culms harvested	31	10	50	19.13	9.875

For harvesting techniques, 93.5% of BHFs reported clear cutting of bamboo rather than selective cutting (Table7). Additionally, bamboo was largely harvested from the forest as an open resource as 90.3% of BHFs do not own bamboo plots, only 9.7% reported owing bamboo on their farmlands (Table 8). It is clear that the current harvesting is not sustainable since BHFs do not have appropriate harvesting technique and bamboo is a free resource to be harvested from the forest.

Table 7. Percentage of BHFs reporting about clear-cutting and selective-cutting of bamboo

Harvesting technique	Frequency	Valid Percent
Selective cutting	2	6.5
Clear cutting	29	93.5
Total	31	100.0

Table 8. Percentage of BHFs reporting about owning of bamboo plot

Ownership	Frequency	Valid Percent
Own	3	9.7
Do not own	28	90.3
Total	31	100.0

Traditional Bamboo Harvesting for Household Uses

Traditionally, families in both villages have harvested bamboo for building their houses, kitchens and farm storage huts. Currently, 50.8% of families harvest bamboo for building their houses, 15.9% for their kitchens and 54% for their farm storage huts (Table 9).

Table 9. Percentage of families who use bamboo as building materials

Type of building	Cases				Total	
	Included		Excluded			
	N	Percent	N	Percent	N	Percent
House	32	50.8%	31	49.2%	63	100.0%
Kitchen	10	15.9%	53	84.1%	63	100.0%
Farm storage hut	34	54.0%	29	46.0%	63	100.0%

Moreover, 95.2% of families of Khmer, Phnong and Stieng ethnicities use bamboo-made utensils (Table 10). Bamboo-made utensils include *Sas* and *Waes* (baskets carried on the back), *Kaveng* (a tool used for weeding), knife and hoe handles, *Chhneang* (a basket used for fishing) and *Chang A* (a tool used for blowing away rice husks). Furthermore, the culms of one bamboo species (*Reusei Pok*) can be split into a thin piece which in the past was used to cut the meat of hunted animals; nowadays it is still used by the Phnong family for slicing tobacco leaves.

Table 10. Percentage of families using bamboo-made utensils and equipment by ethnicity

Answer	Ethnicity			Total
	Khmer	Phnong	Stieng	
Use	15 88.2%	41 97.6%	4 100.0%	60 95.2%
Do not use	2 11.8%	1 2.4%	0 .0%	3 4.8%
Total	17 100.0%	42 100.0%	4 100.0%	63 100.0%

Remarkably, bamboo shoots are an important food source for families of both villages as 71.4% of families consume bamboo shoots (Table 11). In particular, ethnic Phnong and Stieng families eat sour shoots in combination with rice when there is nothing else to eat.

Table 11. Percentage of families consuming bamboo shoots

Cases				Total	
Included		Excluded			
N	Percent	N	Percent	N	Percent
45	71.4%	18	28.6%	63	100.0%

Traditionally, ethnic minorities of Phnong and Stieng families practicing shifting cultivation used bamboo forest in fallow system. Moreover, bamboo is used by families of all ethnicities for building pig (25.4%) and chicken pens (27.0%) (Table 12).

Table 12. Percentage of families using bamboo culms for housing animals

Type of animal house	Cases				Total	
	Included		Excluded			
	N	Percent	N	Percent	N	Percent
Pig pen	16	25.4%	47	74.6%	63	100.0%
Chicken pen	17	27.0%	46	73.0%	63	100.0%

In the past, bamboo was commonly used by indigenous family, especially Phnong, in cultural ceremonies, but now this practice has decreased. Bamboo is still used by Phnong families in *saen proloeng srov* (rice spirit ceremony) during the rice growing stage. Data show that 66.7% of Phnong families still use bamboo for this ceremony (Table 13). The reason that some Phnong families have stopped using bamboo for *saen proloeng srov* is that there are no upland rice plots and that there has been a religious shift to Christianity.

Table 13. Percentage of families using bamboo in cultural ceremonies by ethnicities

Answer	Ethnicity			Total
	Khmer	Phnong	Stieng	
Use	0	28	0	28
	.0%	66.7%	.0%	44.4%
Do not use	17	14	4	35
	100.0%	33.3%	100.0%	55.6%
Total	17	42	4	63
	100.0%	100.0%	100.0%	100.0%

Besides harvesting for making incense sticks, the majority of families harvest *Reusei Thngor* for family uses such as housing materials, animal pens, woven materials, tools and food (85.7%), while 14.3% harvested other species for these purposes (Table 14).

Table 14. Percentage of bamboo species being harvested for family uses

Bamboo species	Frequency	Percent
Reusei Thngor	54	85.7
Other species	9	14.3
Total	63	100.0

Overall, traditional bamboo harvesting for family uses do not have a negative impact on the condition of bamboo forest since it provides enough time for bamboo to regenerate. Generally, bamboo is harvested for building, utensils and equipments every three to four years when bamboo materials start to decay.

Conversion of Bamboo Forest to Agriculture

The majority of the decrease of bamboo forests in both villages was caused by clearance for agriculture. In O Rona, within a period of seven years (2002-2008), 911 ha (41.12%) of the total bamboo area was cleared for upland rice, cashew nut and cassava production. Additionally, 184 ha (8.31%) of the area was harvested for making incense sticks. Only 1120.2 ha (50.57%) of forest remain (Figure 5).

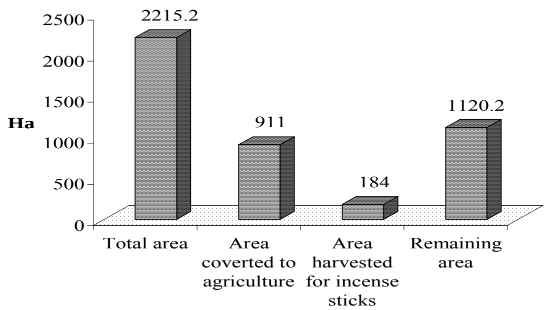


Figure 5: Decrease of bamboo forest area in O Rona over seven years

Likewise, in Srae Levi, within the same period of seven years (2002-2008), 179.05 ha (30.29%) of the total bamboo area was cleared for upland rice, cashew nut and cassava production, with 412.07 ha (69.71%) remaining (Figure 6).

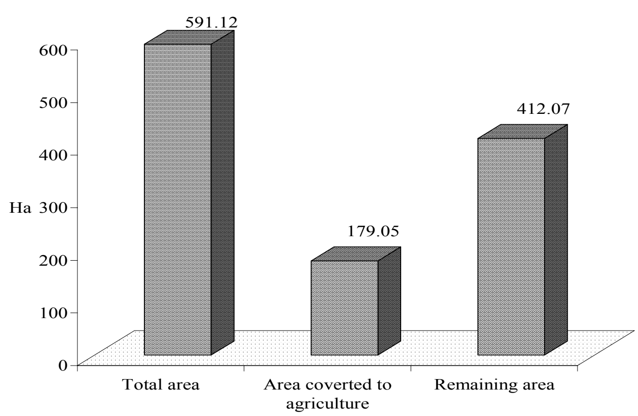


Figure 6: Decrease of bamboo forest area in Srae Levi over seven years

Rules and Regulations

There are no specific regulations governing bamboo resources in SBCA. Bamboo is classified as NTFP and managed under the existing Forestry Law (2002) together with other forest resources (Kingdom of Cambodia 2004). Management, however, is not sustainable. Similarly, the traditional rules of both villages are ineffective because bamboo resources have been depleted and the demand increased due to better road access, market availability and increasing immigration. Additionally, the draft Participatory Land Use Planning (PLUP) By-Law (2006) in O Rona which aims to sustainably manage land and natural resources tends to be ineffective. The weakness is that Chapter 9; Article 36 of the existing PLUP By-Law governs only the management of the forest resources as a whole, and does not specifically guide the sustainable management and use of bamboo resources (WCS/FA 2008b), even though bamboo is an abundant and important resource in the village. On the other hand, the PLUP committee established in 2006 is in the process of becoming legally responsible under the national land law for implementing the PLUP By-Law.

Discussion of Impacts

Impact on Family Income

The result of Mann-Whitney U test reveals that there is a significant difference between the mean ranks of total family incomes of Srae Levi and O Rona villages, 20.50 and 37.35 respectively, with P=.001 < 0.05 (Table 15). It can be hypothesized that, through harvesting bamboo culms to make incense sticks, families in O Rona can generate higher income than those in Srae Levi. Therefore, bamboo harvesting to make incense sticks does have an impact on family’s income in O Rona.

Table 15. Result of Mann-Whitney U test showing the different mean ranks of total family income between Srae Levi and O Rona

Village	N	Mean ranks of total family incomes	Asymp. Sig. (2-tailed)
Srae Levi	20	20.50	.001
O Rona	43	37.35	

Impact on BHF Income

The result of Independent Samples T test shows that there is a very significant difference between the income means of BHFs and non-BHFs, with the significance at .000 level. Mean difference shows that BHFs can generate an average income of 3530933 riels (US$882.73) per year, which is higher than the income of non-BHFs (Table 16). Therefore, it can be hypothesized that BIS income does have impact on BHF income. This BIS income is vital for BHFs in O Rona to solve the problem of rice shortage for 11 months per year.

Table 16. T-test for equality of income means of BHFs (n=31) and non-BHFs (n=32) in thousands riels local currency

Assumption of variances	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Equal variances assumed	4.553	61	.000	3530.933	775.455	1980.314	5081.553

Impact on Wildlife Habitat

Factors that have led to the depletion of bamboo forests in both study villages were conversion to agriculture and harvesting for making incense sticks. Traditional bamboo harvesting for family uses appears to have no negative impact on wildlife habitat as families harvest bamboo for housing materials and other utensils or equipment every three to four years and only by cutting old culms. This harvesting cycle provides enough time for bamboo plants to regenerate.

It is clear that conversion to agriculture is the leading factor for depleting bamboo forests in both villages. This loss of bamboo forests has negatively impacted wildlife habitats, e.g. those of Asian Elephant (*Elephas maximas*) and Orange-necked Partridge (*Arborophila davidi*) (Pollard et al. 2007). Within the same period of time (2000-2008), total bamboo forests converted to agriculture in Srae Levi and O Rona was 1090.05 ha, which is about six time greater than the area harvested for incense sticks (184 ha). , harvesting bamboo for making incense sticks has fewer impacts on wildlife habitat since only one bamboo species is harvested for this purpose.

The site impacts of bamboo harvesting in O Rona and Srae Levi are illustrated in Figures 7 and 8 respectively.

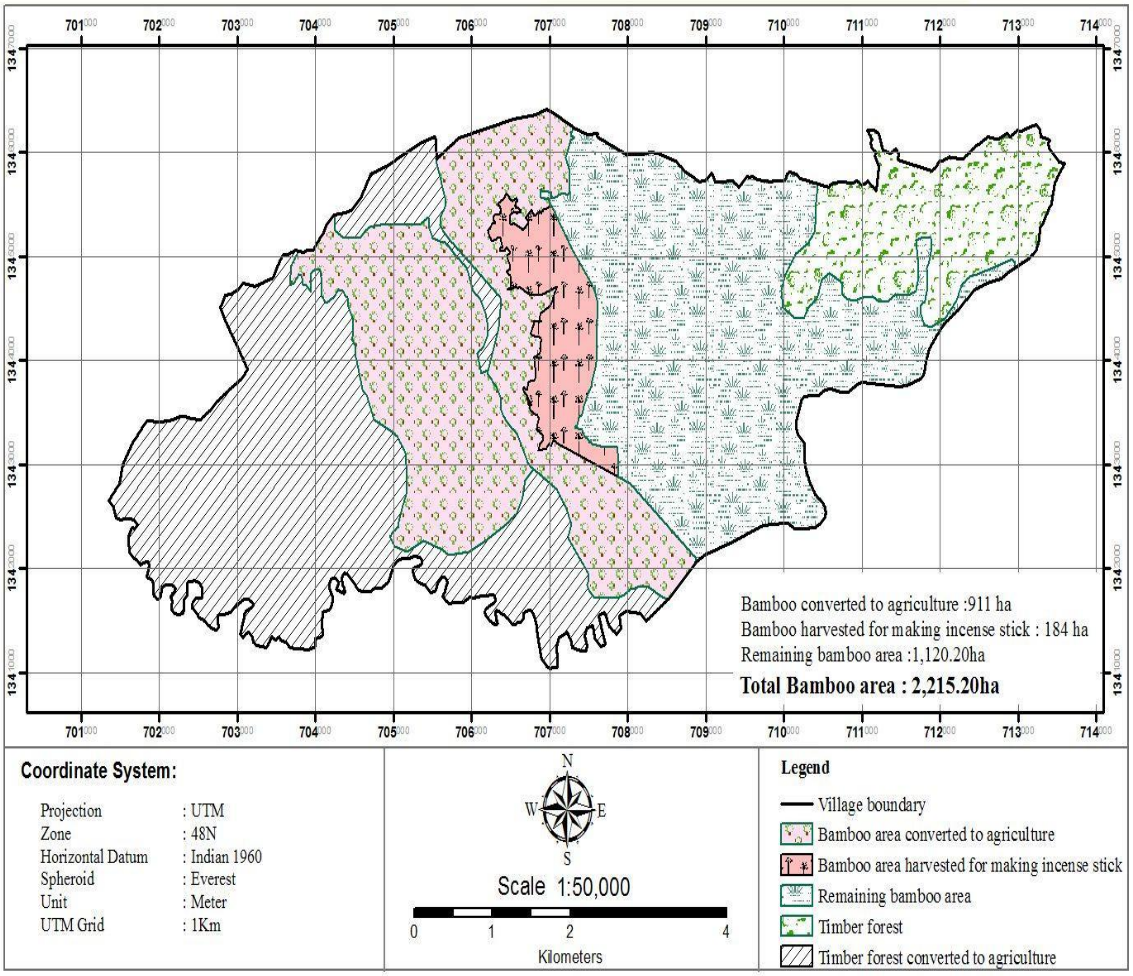


Figure 7: Map of O Rona illustrating different sites of bamboo forest affected by harvesting to make incense sticks and clearance for agriculture, see legend for the affected sites. The map also illustrates the remaining bamboo forest and timber forest areas, and timber forest area converted to agriculture.

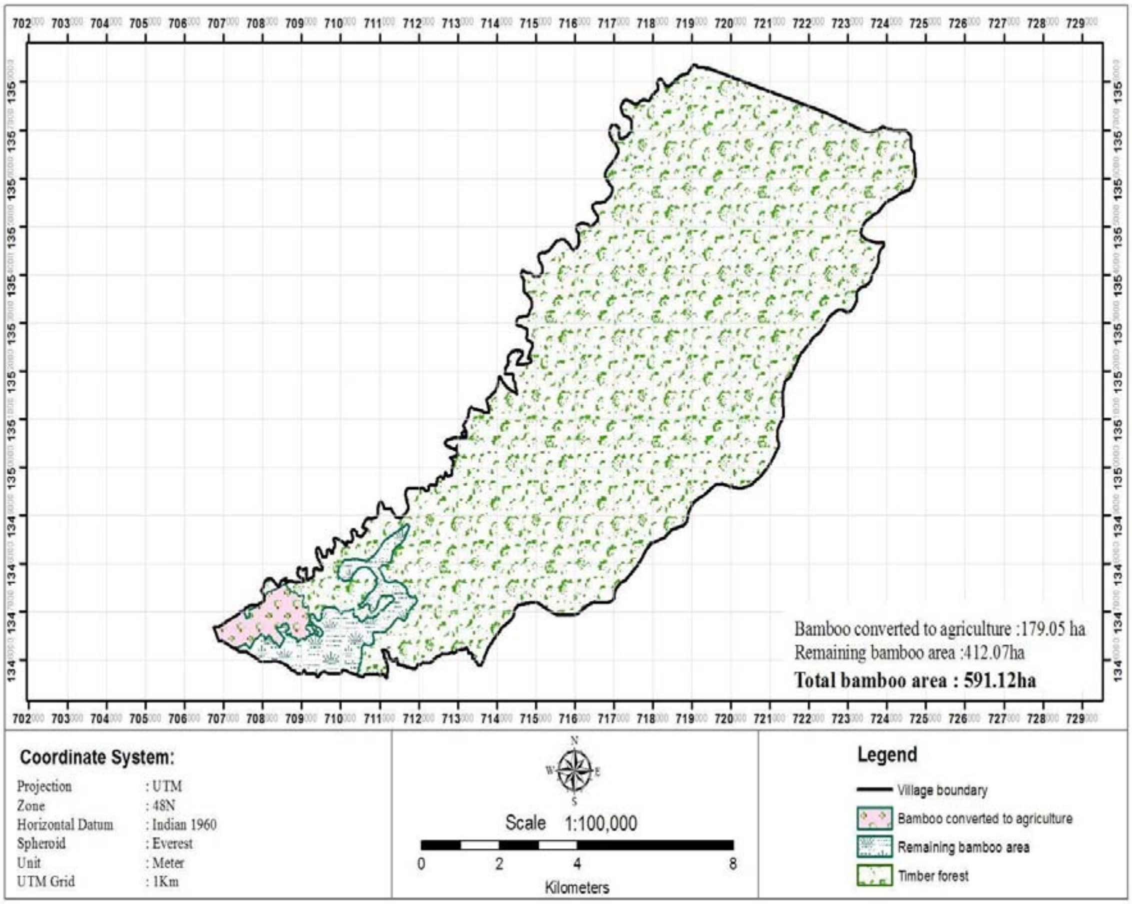
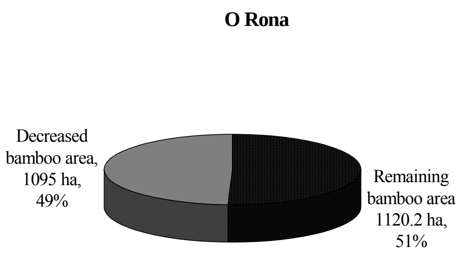


Figure 8: Map of Srae Levi illustrating the site of bamboo forest affected by clearance for agriculture, see legend for the affected site. The map also illustrates the remaining of bamboo forest and timber forest areas.

Impact of Infrastructure and Population on Bamboo Forest

The impact on bamboo forests is more serious in O Rona that has better infrastructure, market accessibility, a larger immigrant and total population. The level of bamboo extraction in O Rona is higher than Srae Levi, 49% and 30% respectively (Figures 9 and 10).



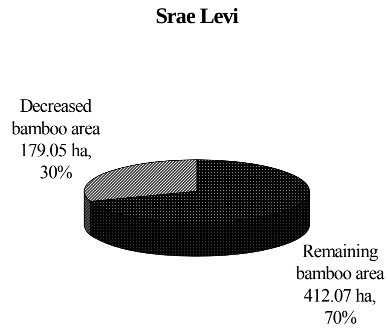


Figure 9 Figure 10

Figure 9: Decreased bamboo forest area in O Rona over seven years (2002-2008)

Figure 10: Decreased bamboo forest area in Srae Levi over seven years (2002-2008)

Impact on Bamboo Species

The dominant bamboo species in the area is *Reusei Thngor* which is used by BHFs and non-BHFs for making incense sticks and family uses. All BHFs reported harvesting *Reusei Thngor* for making incense sticks since it has long internodes (30-45 cm) and is easy to split and slice into small sticks. This bamboo species is clear-cut. Besides harvesting for making incense sticks, the majority of families harvest *Reusei Thngor* for household uses such as housing materials, animal pens, woven materials, tools and food. Observation of old bamboo plots harvested in 2005 and 2006 showed poor regeneration after three to four years of harvest. Botanically, like other plants, bamboo needs to photosynthesize and absorb nutrients to boost growth. This function was completely disabled as culms were clear-cut from the clumps, weakening regeneration capacity (Figures 11 and 12). Apparently, it can be assessed that harvesting for making incense sticks is a threat to *Reusei Thngor* because its regeneration capacity cannot respond to the current harvesting. The heavy dependence of households on *Reusei Thngor* for incense sticks and household uses together with inappropriate harvesting techniques may lead to the local extinction of the species.

Figure 11

Figure 12

Figure 11: Clear-cut bamboo clumps showing no regeneration after four years because of competition with trees for sunlight and nutrients

Figure 12: Clear-cut bamboo clumps showing poor generation after three years

Conclusion

Bamboo harvesting for making incense sticks has a positive impact on family's economy in O Rona in terms of income generation. The income helps BHFs to cope with food shortage during the lean period. However, it is not sustainable because BHFs do not have appropriate technique to harvest bamboo culms and good management practice is not in place. Most BHFs (77.4%) freely harvest bamboo almost every day per month. On average, BHFs harvested bamboo 17.45 days per month with an average of 19.13 culms per activity. They just clear-cut bamboo culms from the clumps for as long as the culms can be sliced into small sticks without considering about the suitable age of the culms to be harvested. Such harvesting does not provide enough time for bamboo plants to regenerate. Hence, it will be a threat especially to *Reusei Thngor* which is a target species for both making incense sticks and for family uses. Additionally, field assessment reveals that the regeneration capacity of *Reusei Thngor* is not able to respond to the current level of harvesting, and that re-growth of new shoots in the harvested clumps is still poor or no regeneration after three to four years. More seriously, bamboo clearance for agriculture has been identified as having a negative impact on the natural condition of bamboo forest since the cleared area is a lot bigger than the area under harvesting for making incense sticks within the same period of time. It will have negative impact on wildlife habitat if management is not improved. Besides, traditional bamboo harvesting for family uses includes building materials, utensils, farm equipments, shoots, use as fallow crops in shifting cultivation and other uses in cultural ceremony. It does not have negative impact on bamboo forest since it allows three to four years for bamboo plants to regenerate to their full size.

Recommendations

Bamboo in the area must be managed sustainably since bamboo is a very important resource for families' income generation and subsistence livelihood support as well as for biodiversity conservation. To maintain these functions, the improvement of current harvesting practices and management system is critical.

With respect to harvesting technique, agricultural department and/or other agencies that specialize in sustainable bamboo forest management, should provide appropriate harvesting techniques to BHFs to ensure the sustainable harvest and continued productivity. For instance, Chaturvedi (1988); Prasad (1988) and Suwannapinunt (1988) reported that selective cutting of mature bamboo culms at an age above three years in plots with a three-four year rotation appears to be sustainable and more products.

Additionally, SBCA should develop a management rule for managing bamboo resource building upon the existing PLUP By-law in O Rona by clearly defining the rights, user groups, collective actions arrangements and bamboo areas to be harvested. BHFs should be formed into groups to implement the rule.

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Assessment of Genetic Diversity in *Bambusa bambos* from Thailand using Microsatellite Markers

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Abstract

Analysis of 270 individuals of nine *Bambusa bambos* populations from Thailand using nine microsatellite loci showed that that a total of 296 alleles were identified with the average number of alleles per locus per population 3.66. The percentage of polymorphic loci ranged from 66.67 to 88.89 with 76.54 in average. The genetic diversity (expected heterozygosity) ranged from 0.314 to 0.415 with 0.369 in average. The genetic distances among populations were congruent with their geographic distribution. The genetic differentiation among populations (Fst) was 0.243.

The obtained results suggested that *B. bambos* populations with high genetic diversity (He > 0.369) should be regarded as *in situ* gene conservation areas in the following regions of Thailand: Amphur Maueng, Sa Kauw (He=0.440); Phukradueng, Lauy (He= 0.398); Ngao, Lampang (He= 0.415) and Saiyok, Kanchanaburi (He=0.376).

However, the *ex situ* conservation sites of *B. bambos* should be established also in other regions in Thailand using the genetic materials from the aforementioned populations. In addition,, to reduce the pressure on harvesting the shoot and stem of bamboo species in the natural forest, the bamboo food banks and plantations should also be established close to the local communities surrounding or close to the forest.

Keywords: Bamboo, *Bambosa bambos*, genetic diversity, microsatellite markers, gene conservation

Introduction

Bamboo is in the Gramineae family, which distributes naturally nearly in the whole world Dransfield and Widjaja (1995) reported that there are about 77 genera and 1,030 species of bamboos in the world. Bamboo is important for economy and livelihood of the people in Asia, Africa and America (McClure, 1966). In Thailand, 15 genera and 82 species of bamboos were recorded and most of them are sympodial type, and are commonly found in deciduous forest (Pattanvibool *et al*, 2001). Bamboos are one of most socioeconomically important species in Thailand. They grow incredibly fast and are well known as pioneer species. Bamboos are multipurpose species for many uses of basic living including food, household construction, supporting poles, baskets, handicraft, firewood, paper pulping etc. (Pattanavibool, 1998).

There are ten important commercial bamboos in Thailand and *Bambusa bambos* is one of those species. Since most of the indigenous bamboos in the forest are harvested for any various purposes the genetic status of bamboos in Thailand needs to be investigated. The extent and distribution of genetic variation within species are of fundamental importance to their evolutionary potential and chances of survival. Therefore, the assessment of genetic variation is of key importance for developing effective gene conservation plans and strategies. In this study the genetic diversity of *B. bambos* in Thailand was assessed using microsatellite markers.

Materials and methods

Young leaves of *B. bambos* were collected from nine populations in different parts of Thailand: Central, Northern, Northeastern and Southern part of Thailand. Thirty leaf samples from each culm (which was at least 100 meters distant from other culms) were collected from each population (Table 1).

DNA extraction

The procedure to extract DNA from bamboo leaf tissue was modified from Doyle and Doyle (1990) and Changtragoon *et al.* (1995). About five grams of clean leaf tissue sample were ground into powder with liquid nitrogen using a cold mortar. Then each sample was suspended in 800 µl of 2X CTAB (cethyltrimethyl ammonium bromide) extraction buffer in a microcentrifuge tube. The extraction buffer contained 4% CTAB, 2.8 M NaCl, 40 mM EDTA, 200 mM Tris-HCl, pH 8.0, and 0.4% 2-mercaptoethanol. Samples were incubated at 65 ^{o}C for approximately one hour, mixed with an equal volume of chloroform-isoamyl alcohol (24:1), and centrifuged at 13,000 rpm for 10 min at room temperature. The supernatant was transferred to a clean microcentrifuge tube, repeating this step twice. The aqueous layer was collected and precipitated by adding 0.6 volumes of cold isopropanol. The DNA was pelleted by centrifugation at 13,000 rpm for ten minutes. The supernatants were removed and the DNA pellet washed with 700 µl of 70% ethanol, repeating this step a second time. The pellet was dried for 20 minutes at 50^{o}C and then dissolved in 50-100 µl of 1X TE buffer (10 mM Tris-HCL EDTA, pH 8.0). The quality and quantity of DNA from each sample was checked by agarose gel electrophoresis. The obtained DNA samples were kept at -20 ^{o}C.

Micosatellite analysis

Nine primer sets (Table 2) were used for the amplification of DNA from leaf samples of *B. bambos*. Polymerase chain reactions (PCR) were carried out in a final volume of 10 µl, containing approximately 20 nanograms of genomic DNA, 0.5 units of *Taq* polymerase (Invitrogen) 1X *Taq* polymerase buffer (Qiagen,Germany), 2mM $MgCl_2$ (Qaigen,Germany), 2.5 mM of dNTPs (Eppendorf) and 10 pmol of each primer. Amplification reactions were carried out using a PTC-200 Peltier Thermal Cycler (MJ Research) using the following cycling profile: 94 ^{0}C for 3 min followed by 35 cycles at 94 ^{0}C for 30 seconds, 50-60 ^{0}C for 30 seconds, and 72 ^{0}C for 1 minute, and a final extension step at 72 ^{0}C for 1 minute. The PCR products were stored at 4^{o}C before analysis.

For DNA fragment analysis, aliquots of the amplification products were loaded on 30% polyacrylamide gel. Gels were run for 45 minutes at 1000 volts. The DNA fragments were then checked and visualized by real time fragment analyzer, Gel Scan 3000 (Corbetta Robotics). Alleles and genotypes of each sample were scored according to molecular weight, and were estimated by comparing with a 50 bp ladder (Invitrogen).

Statistical analysis

The following genetic parameters were estimated: number of alleles per locus, allelic diversity, allele frequency, percentage of polymorphic loci, observed (Ho) and expected heterozygosity (He) , genetic distance (Nei, 1978), genetic differentiation among populations (Fst), inbreeding coefficient within populations (Fis) and inbreeding coefficient of the total population (Fit) (Weir and Cockerham, 1984; Wright, 1978) and UPGMA clustering analysis (Swofford and Olsen (1990). All calculations were made using TFPGA program (Miller 1997).

Table 1. List of the investigated *Bambusa bambos* populations

No.	Population name	Location	Sample size per population	Latitude °N Longitude °E
1	Boploy, Kanchanaburi (1)	Central	30	14o15'36. 66" 99o42'41.88"
2	Saiyok, Kanchanaburi (2)	Central	30	14o41'56.59" 98o39'50.41"
3	Thongpaphum, Kanchanaburi (3)	Central	30	14o09'46.59" 99o05'20.41"
4	Ngao, Lampang	North	30	18o41'56.10" 99o42'25.49"
5	Chaingdoa, Chiangmai	North	30	19o16'09.55" 98o54'57.44"
6	Koenkchium, Ubonrachatani	Northeast	30	15o18'29.90" 105o30'23.51"
7	Phukradueng, Lauy	Northeast	30	16o51'57.94" 101o46'07.21"
8	Amphur Maueng, Sa Kauw	Northeast	30	13o59'50.06" 102o16'38.79"
9	Amphur Maueng, Surathtani	South	30	8o57'41.73" 99o05'51.86"

Table 2. Primers details and expected PCR product size of *Bamboosa bambos* at each locus

No.	Primers	Base composition (5'→3')	Repeat types	Expected PCR product size (bp)	GenBank Accession number
1	DTLBb1	F: GTGCGCTGATGTTGTTTGTG	$(GTT)_2TGT(GTT)_2$	200	-
		R: CGGCCAATATCCATATTTCCATC			
2	DTLBb8	F: AGGTTGACCAATTTGGGGAAAG	$(CT)_3$	160	-
		R: TTTGTGTATGGTTGTAGGAAGTCG			
3	DTLBb15	F: GCC TAA AA T TTC GGG TGA TCC	$(CAA)_{19}$	280	-
		R: CAG CCG TCA CAG CTC ACA AC			
4	DTLBb20	F:CTG CCA TGG TGA CAC TAG AAC G	$(GT)_9A(TA)_3(GA)_{10}$	290	-
		R: CCT CAA ACA CAG GAA TTT CAA GC			
5	DTLBb29	F: TTACAACCAAGAGAGCGCGATAC	$(GA)_5GG(CA)_8$	160	-
		R: GCAGACACTTTACCGACTTCAGC			
6	DTLBb47	F: GATCAGACTTCAACACAAACGTAC	$(CT)_{16}AT(CT)_7$	140	-
		R: TGTGTCAACTGTCAAGTCCTCTTC			
7	DTLBb50	R: GATAAATAACTGCATCGTTGGT	$(CT)_{16}$	150	-
		R: CAGAAGTTACTGTCAGAGAGACG			
8	AJ507491	F: TTC GTT GCT CCT GCA AGG	$(CA)_7$	150	AJ507491
		R: CTG TGG TTC TAC TAT GCG C			
9	AJ507492	F: CTA GCA AAC GCA CAG TG	$(AC)_3C(AC)_2GC(AC)_4$	206	AJ507492
		R: CAG TGT GAT ACA CGT CC			

Results and discussion

Number of alleles per locus and allelic diversity in each *Bambusa bambos* population are shown in Table 3. The average number of alleles per locus per population was 3.66. Across the nine microsatellite loci analysed in 270 individuals of nine *Bambusa bambos* populations, a total of 296 alleles were identified.The percentage of polymorphic loci ranged from 66.67 to 88.89 with 76.54 in average (Table 4). There was no significant deviation from Hardy-Weinberg equilibrium at most of the investigated microsatellite loci . The genetic diversity (expected heterozygosity) ranged from 0.314 to 0.415 with 0.369 in average (Table 4). This was rather high comparing to other wild plant species in Thailand (Table 4). Even though there were some genetic studies on some bamboo species, they were mostly focused on phylogenetic relationships and clone identification (Lai and Hsiao, 1997; Nayak *et al*, 2003; Ramanayake *et al*, 2007). As shown in Figures 1 and 2 the genetic relationship among populations tentatively reflected their geographic distribution. However, one population (Amphur Maueng, Surathtani province) was closely related to Kanchanaburi population from central Thailand. This may be because some bamboo materials from Kanchnaburi may have been introduced to Amphur Maueng, Surathtani province in the past by local people. The genetic differentiation among populations (Fst) was 0.243

which was rather high comparing to Fst of other wild plant species in Thailand and ranged from 0.082 to 0.250 (Table 4). However, the inbreeding coefficient within populations (Fis =0.2060) was lower than the inbreeding coefficient of the total population (Fit = 0.4007).

Bambusa bambos populations containing much genetic diversity (expected heterozygosity) and higher than the average of genetic diversity (He=0.369) are suggested to be used as *in situ* gene conservation areas in the following regions of Thailand: Northeast: Amphur Maueng, Sa Kauw (He=0.440); Phukradueng, Lauy (He= 0.398); North: Ngao, Lampang (He= 0.415) and Central: Saiyok, Kanchanaburi (He=0.376) (Table 3). However, the *ex situ* gene conservation of *B. bambos* should also be established in additional regions in Thailand using the genetic materials from the populations included in the present study.

Table 3 Number of alleles per population and average number of alleles per locus in each population of *Bambusa bambos*

Population	Number of alleles per locus									Number of alleles per population	Average number of alleles per locus in each population
	DTL Bb 1	DTL Bb 8	DTL Bb 15	DTL Bb 20	DTL Bb 29	DTL Bb 47	DTL Bb 50	AJ 5074 91	AJ 5074 92		
1.Kanchanaburi (1)	2	1	1	3	3	12	8	4	3	37.00	4.11
2.Kanchanaburi (2)	1	1	2	8	3	12	6	2	4	39.00	4.33
3.Kanchanaburi (3)	1	1	1	7	2	10	7	2	3	34.00	3.77
4. Lampang	1	2	2	4	3	8	8	3	3	34.00	3.77
5.Chiangmai	1	2	2	2	4	9	3	2	3	27.00	3.11
6.Ubonrachatani	2	2	1	5	2	10	6	2	2	32.00	3.55
7.Lauy	3	1	2	4	1	10	5	3	4	33.00	3.66
8.Sa Kauw	2	1	2	5	2	5	7	3	4	31.00	3.44
9.Surathtani	2	2	2	2	2	8	6	2	3	29.00	3.22
Total	15	13	15	40	22	84	56	23	29	296	32.96
Average	1.66	1.44	1.66	4.44	2.44	9.33	6.22	2.55	3.22	32.88	3.66

Table 4. Heterozygosity and percentage of polymorphic loci of investigated *Bambusa bambos* populations

No.	Population names	Location	Number of alleles per population	Average number of alleles per locus in each population	Heterozygosity Ho He	Polymorphic loci(%) at 95% criteria
1.	Bor Ploy, Kanchanaburi (1)	Central	37.00	4.11	0.332 0.374	66.67
2.	Saiyok, Kanchanaburi (2)	Central	39.00	4.33	0.305 0.376	66.67
3.	Thongphaphum, Kanchanaburi (3)	Central	34.00	3.77	0.263 0.314	66.67
4.	Ngao, Lampang	North	34.00	3.77	0.278 0.415	88.89
5.	Chaingdoa, Chiangmai	North	27.00	3.11	0.284 0.340	77.78
6	Koenkchium, Ubonrachatani	Northeast	32.00	3.55	0.265 0.334	55.55
7	Phukradueng, Lauy	Northeast	33.00	3.66	0.272 0.398	77.78
8	Amphur Maueng, Sa Kauw	Northeast	31.00	3.44	0.332 0.440	88.89
9	Amphur Maueng, Surathtani	South	29.00	3.22	0.318 0.334	88.89
Average			32.88	3.66	0.294 0.369	76.54

Pops	1	2	3	4	5	6	7	8	9
1	*****								
2	0.0783	*****							
3	0.0674	0.0382	*****						
4	0.1341	0.0858	0.0991	*****					
5	0.2114	0.2405	0.2361	0.1001	*****				
6	0.1350	0.1667	0.1452	0.3007	0.4463	*****			
7	0.2444	0.2000	0.2124	0.1644	0.3250	0.4693	*****		
8	0.3905	0.3463	0.3570	0.3032	0.3772	0.5704	0.0821	*****	
9	0.1010	0.1232	0.1682	0.1169	0.2695	0.3369	0.1474	0.3287	*****

Figure 1 Nei's unbiased (1978) genetic distance among *B. bambos* populations

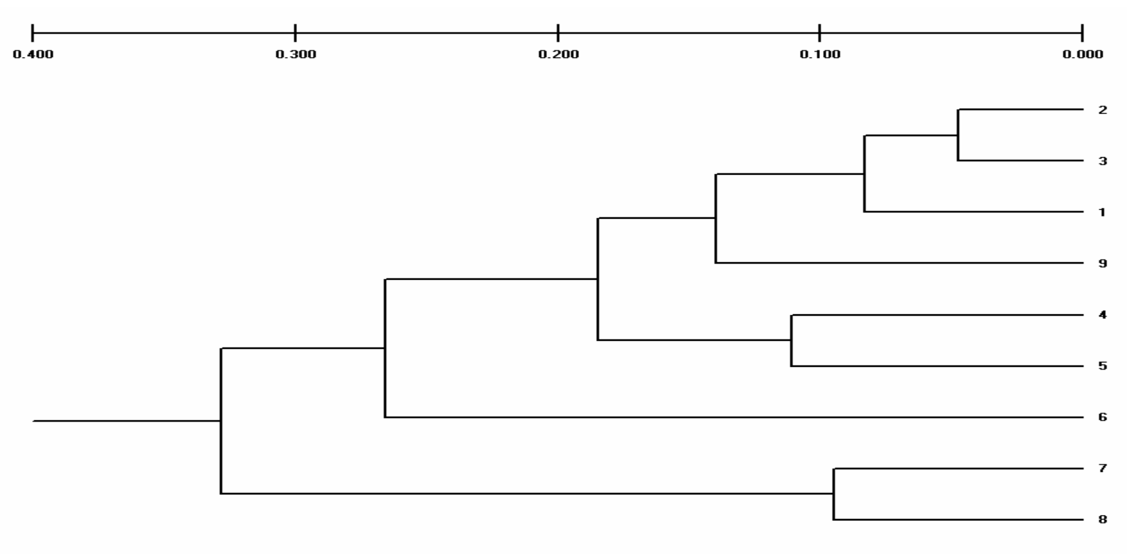

Figure 2. Genetic relationships among investigated *B. bambos* populations using UPGMA cluster analysis

Table 5 Comparison of genetic diversity(Expected herozygozity)and genetic differentiation(Fst) among populations of *B. bambos* to other wild plant species in Thailand

Species	Type of molecular markers		Genetic diversity (He: Expected heterozygosity)	Genetic differentiation among populations (Fst)	References
	Isoenzyme gene markers	DNA markers			
Bamboosa bambos		SSR (microsatel-lite)	0.369	0.243	Laphom and Changtragoon, 2005
Paphiopedilum exul		AFLP	0.301	0.082	Wanichkul and Changtragoon, 2005
Pinus merkusii	/		0.058	0.104	Changtragoon and Finkeldey, 1995
Tectona grandis	/	RAPD	0.310	0.217	Changtragoon, 2001a; Changtragoon and Szmidt, 1999; Changtragoon and Szmidt, 2000
Rhizophora apiculata	/	AFLP	0.316	0.250	Changtragoon, 2007
Rhizophora mucronata		AFLP	0.385	0.212	Changtragoon, 2007

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Connecting the Poor: Interventions in the Bamboo Value Chain. A Case from Houaphanh, Lao PDR

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Abstract

The global bamboo industry lead by China is seeing an immense growth and it is expected that this will continue even further. Lao PDR has opened its boundaries to the market economy and is promoting itself as being on the crossroads of trade between China and Southeast Asia. Although policy reforms are continuing, doing business in Laos is still a challenge for the private sector. Houaphanh a poor and remote province possesses extensive bamboo resources but is not benefiting from the bamboo business in neighbouring Thanh Hoa province, Vietnam or elsewhere. A bamboo value chain analysis demonstrated that there is potential for Houaphanh to develop its bamboo handicrafts, semi-processed products and raw materials. The bamboo sub-sector in Houaphanh is undeveloped due to a lacking enabling environment to stimulate the private sector to invest in the province. Capacity of government staff to tackle reforms and necessary insights to promote and develop marketable products is limited. Consequently private sector and poor communities have few incentives to sustainable manage and gain from trading bamboo resources. SNV builds the capacity of key actors in and around the value chain to enhance their performance in realising poverty reduction. In the bamboo value chain improvements in three key areas are made: 1. Knowledge brokering to improve the business environment; 2. Handicraft promotion and development, and 3. Piloting pro-poor business models. Through action learning, with the participation of all actors in the bamboo value chain, lessons from the field are shared to build capacity and awareness to achieve sustainable poverty alleviation by developing the private sector.

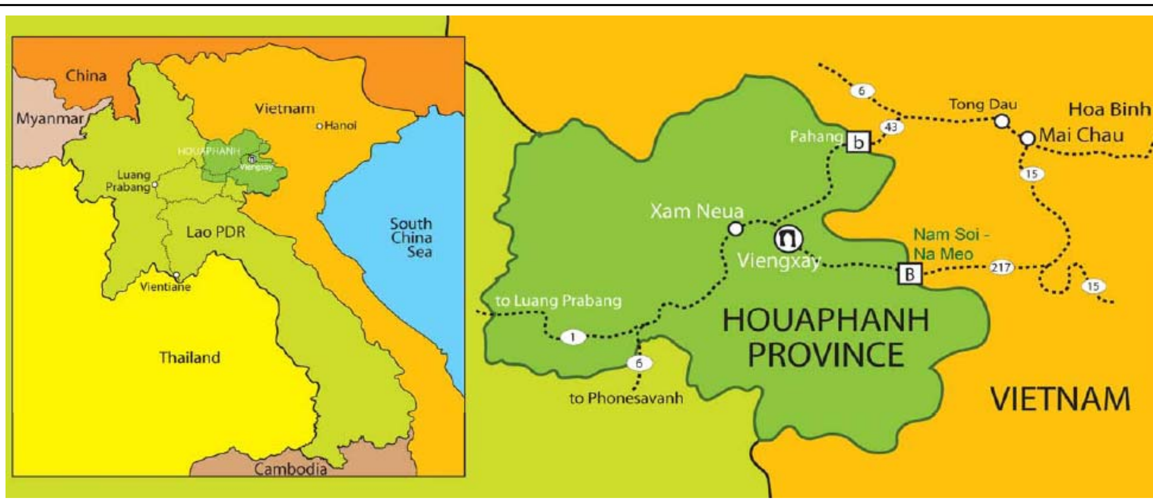
Introduction

China successfully has been the main driving force in the global bamboo industry's development over the last 15 years, with a global share of almost 80%. The total world market for bamboo is worth USD 7 billion/year with handicrafts taking up just over 40%. Oxfam Hong Kong *et al* (2006) predicts that the global market will continue to grow to an estimated value of USD 15-20 Billion/year by 2017.

In recent years Thanh Hoa province in North Vietnam has benefited from the Chinese lessons to drive local economic development (GRET – Prosperity Initiative 2008). Vietnam, Cambodia and Lao PDR together currently generate USD 261 million/year with Thailand the most important market for Cambodian and Lao bamboo sectors (Oxfam Hong Kong *et al* 2006).

Lao PDR is located in the centre of the Mekong Region, consisting of 80% mountains and plateaux and 20% lowlands adjacent to the Mekong River. The climate is dominated by monsoons with a characteristic dry season from October to April. Lao PDR is an ethno-linguistic society of 49 ethnic- and some 160 subgroups. About 60% of the population is Buddhist and 34% are belonging to indigenous religions (Schuhbeck *et al* 2006).

The Lao PDR was proclaimed in 1975 after 20 years of political struggle. Initially the communist government sought development through collectivization of agriculture designed to gain state control over production. With the introduction of the New Economic Mechanism in 1986, reform measures were made to move toward a market economy (Bestari *et al.* 2006).



Location of Laos PDR, Houaphanh Province and Vietnam, Thanh Hoa Province

Source: Provincial Tourism Office Houaphanh and SNV Netherlands Development Organisation.

Development of the country is lead by National Socio-Economic Development Plans and the Public Investment Programmes including promotion of international cooperation and domestic and foreign investment. The country promotes itself as “land-linked” instead of “landlocked”, emphasizing its potential role as a trade crossroads between China and Southeast Asia (Phimmavong and Chanthavong 2008). In recent years, foreign investment flows into the country jumped in 3 years almost six-fold to USD 2,700 million in 2005. Main foreign investors are Thailand, China and Vietnam with interest in sectors such as hydropower, mining, agriculture, processing industries and tourism (SNV 2009). Laos in considered one of the fastest growing regions of Southeast Asia in economic terms with agriculture the largest sector of the economy with 51% of Gross National Product, which still only contributes to 7% of trade exports (Shaw *et al* 2007 ; SNV 2009). Despite its abundant natural resources basic infrastructure such as roads, telecommunications, water and electricity is underdeveloped (SNV 2009). Actual reforms in the various sectors lag behind government intentions as a result of inconsistent implementations, bureaucratic hindrances to application processes, lack of transparency in the regulatory framework and lack of skilled staff.

Houaphanh is the poorest province in Lao PDR and three quarters of the population are classified as poor. It has a per capita income of less than USD 50 (Kurukulasuriya 2006) against the national average of USD 491 (SNV 2009). Most socio-economic indicators also lie far below the national average. Some 90% of its land area is made up of mountainous terrain and its remoteness is measured in a 24 hours drive from Vientiane and 8 hours from Hanoi (Greijmans *et al* 2007).

Box 1. Lao Development Indicators

	Laos	Houaphanh
Population, in millions	6.1	0.3
Annual population growth rate (%)	2	3
Population living on less than USD 1 per day (%)	45	78
Under-5 mortality rate (%)	7.5	12
Labour force employed by agriculture (%)	80	94
Adult literacy rate (%)	68.5	55
Population using improved drinking water source (%)	51	23

Sources: UNDP 2002; GOL 2006; ADB 2008; SNV 2009.

Bamboo and other Non-timber Forest Products play an important subsistence role in Laos and in particular rural areas. Rural Laotians collect bamboo to use as a building material, and shoots for consumption and sale. Many farm houses are mainly composed of bamboo roofs, wall partitions and floors, ladders and furniture. Bamboo stems are also processed into fishing tools and farm implements and sometimes musical instruments (Greijmans *et al* 2007).

Houaphanh possesses extensive bamboo resources – one third of the provincial land area – but has not yet been able to take advantage of the possibilities in the world market, although it shares its border with Thanh Hoa in Vietnam, which has a thriving bamboo business. A bamboo value chain analysis, carried out and mapped in 2007, demonstrated that Houaphanh has the potential to develop its domestic bamboo handicraft markets and to increase exports of semi-processed products and raw materials. Five separate chains were recognised: 1) raw bamboo stems; 2) handicrafts; 3) split bamboo; 4) bamboo slats and 5) bamboo shoots. Numbers of producers are difficult to estimate since communities are scattered with a low percentage of households only seasonally involved in bamboo practices. A handful of traders, mainly located near the main export borders, are involved in buying raw bamboo and handicraft products from villagers and. Semi-processed bamboo products such as chopsticks, toothpicks, blinds, incense sticks and barbeque skewers are produced in 2 factories in Viengxay district, both operating under Lao-Vietnamese ownership and exporting to Vietnam for final product development. In Sobboa district a new factory buys bamboo stems to covert into pulp destined for the Taiwanese market. Bamboo shoots are sold fresh, boiled or dried to the local market in Xam Neua the provincial Capital, or send for canning in Laos and Vietnam.

Lao products such as bamboo mats and walls are of relatively simple design with some exceptions with regards to handicrafts. However, the quality and design ranges of baskets, boxes and bags remain somewhat limited.

Box 2: SME promoter pushes reform of Government official's role.
"One of the steps we intend to take to improve the business climate in Laos is to change the attitude of government officials, so they do more to facilitate business rather than put up obstacles" said Manohak Rajchak, Deputy Director of SMEPDO.
Source: Vientiane Times Newspaper - September 18, 2008.

The bamboo sub-sector in Houaphanh is undeveloped for a series of reasons. So far provincial promotional bamboo policies are yet to be developed and the local government struggles to attract the private sector to invest in the province. On the other hand inconsistent implementation of existing policies and *ad hoc* government orders still control businesses rather than creating an enabling environment. Both the private sector and communities are confronted with a confusing atmosphere of tenuous applications for a business license - varying from 2 weeks to 3 months -, sudden decisions on tax and fee collection, the setting of arbitrary quota, or the issuing of orders to halt the harvest of bamboo stems and bamboo shoots. These government rulings are often uninformed and investigations fuelling the decisions are non-existent. Information sharing or collaboration between departments for the sake of economic advancement has proven little effective and is further confused by the contradicting roles and responsibilities of the various offices. Common in this situation of stagnation is the lack of staff capacity to tackle a required reform and the necessary insights to for instance assessing market opportunities and identifying products for development. At the end of the day, depressed prices are paid to bamboo producing communities by traders who need to deal with a complex system of quotas and taxes (Greijmans *et al* 2007).

Thus, for both the private sector and communities few incentives exist to form strong business relationships. Consequently communities have few incentives to sustainable manage and gain from trading bamboo resources. A common complaint from government stakeholders is the destruction of large bamboo areas in Viengxay district and elsewhere in the province which are temporarily converted into maize plots.

In line with the goals and objectives of the Lao government's socio-economic development plan and the poverty eradication strategy, SNV supports the development of the bamboo value chain in Houaphanh province. Growth of the sub-sector and especially private sector growth is essential to create jobs and raise incomes. With smart interventions in the bamboo value chain and by working with key actors the intention is to alleviate poverty in Houaphanh. Expected outcomes are:

- an enabling business environment[1] in which effective and efficient investments are made
- an improved handicraft sector, with diverse products with an enabled market access, and
- sustainable business models between private sector and local producer groups.

The value chain approach and capacity building

Rural entrepreneurship development is more likely to flourish in rural areas where bottom up and the top down approaches complement each other. It requires not only the development of local entrepreneurial capabilities but also a sound local strategy. A top down approach can be effective when it is modified to the local environment that it intends to support, but ownership of the initiative need to remain in the hands of members of the local community. Local government departments need to be entrepreneurially minded and recognise bamboo activities as one of many possible activities that contribute to rural development, and seek new entrepreneurial uses of land and support local initiatives. Networking between different agencies involved in the promotion of rural development through entrepreneurship is crucial. One of the principal challenges of economic development of rural areas is the development of a socio-economic environment that is attractive to investors.

In order to create a better understanding of the workings of the bamboo sub-sector in Houaphanh a value chain analysis supported by field studies, a provincial validation workshop, and a desk study were carried out (Greijmans 2008). A value chain examines key activities that are required to bring a product from its conception, through different phases of production, to its final customer, and studies the relationships between value chain actors and their performances. The value chain approach helps to provide insight to improve the overall productivity of a sector and, where possible, benefit all actors (M4P 2008). Besides the mapping of the value chain and its involved actors and the flow of products, three other aspects need are considered, these are governance, distribution of benefits and value adding opportunities. 1. Governance in the value chain analysis is highlighted by who has power and makes decisions in the chain. External governance means the policies arrangements in place affecting the chain, enabling or not. 2. The distribution of benefits of the actors in the chain should be determined as to understand where opportunities lie to increase support, especially to benefit the poor. 3. Identifying possible improvements in quality and product diversification can be an entry point to gain higher value.

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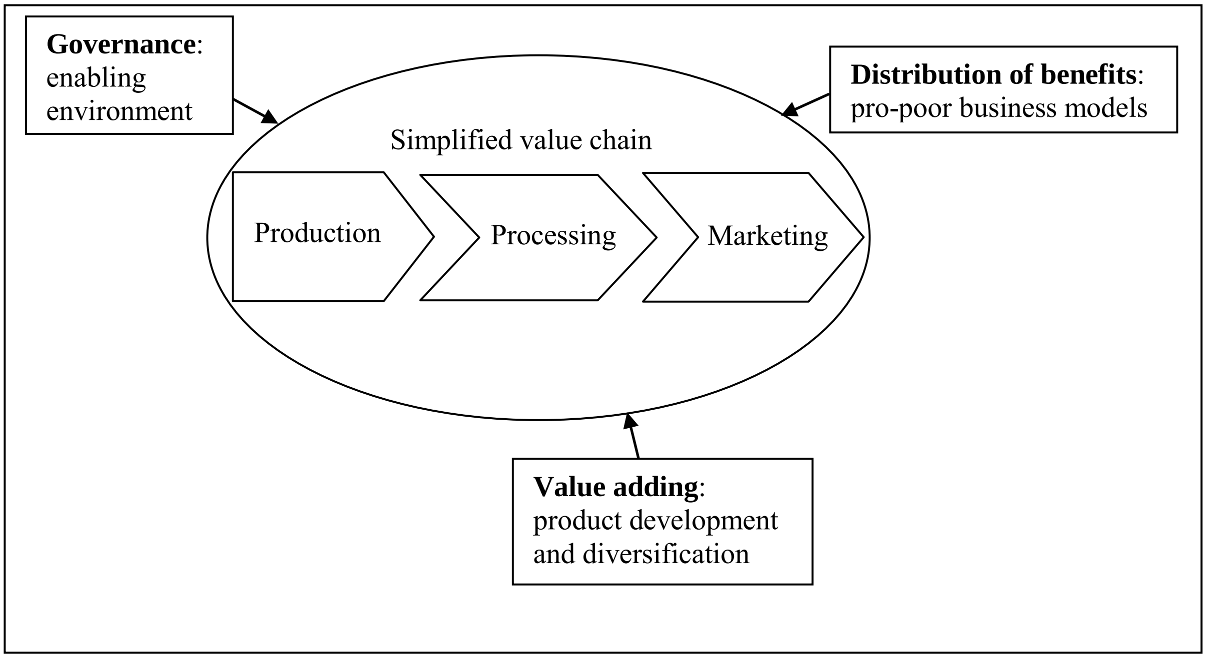
[1] The Donor Committee for Enterprise Development defines the business environment as a complex of policy, legal, institutional, and regulatory conditions that govern business activities (DCED 2008)



SNV's core business is capacity development, to support local actors to strengthen their performance in realising poverty reduction and good governance. Through the selection of competitive and value adding value chains capacity building services are provided directly and indirectly to value chain actors aiming at poverty reduction and improved inclusion of the poor. To maximise this, alliances with international and national partners are made. Key is to systematically strengthen the in-country ability for sustainable development and local capacity builders are involved and supported in the development of value chains. These local capacity builders are envisioned to replace SNV's direct services more efficiently and effectively (SNV 2007a/b). In the value chain analysis key stakeholders around the bamboo value chain emerged, both government and private sector. Organisations which play key roles to potentially make a difference and improve the value chain are assessed for their ability to contribute to this development and engaged in the development of a capacity building plan.

Bamboo value chain interventions

Key intervention areas to support the development of the bamboo value chain are the enabling business climate, handicraft sector and piloting business models aiming at providing benefits for both the private sector and communities.

Knowledge brokering to improve the business environment

Starting in 2007 and continuing in 2009 the governance aspect of the bamboo value chain continues to be an essential attention point. To appreciate the potential of the bamboo sub-sector, provincial departments and private sector participated in a study trip to Thanh Hoa province in Vietnam and to Anji in China, organized by SNV's partner Prosperity Initiate. Anji County is renowned for its successful developments in bamboo sub-sector, and Thanh Hoa has showed that lessons from Anji can be replicated. Participants responded very positive and decided that a bamboo strategy is necessary to guide developments in Houaphanh province. Subsequently, lessons learned and discussions on the economic potential of the bamboo sub-sector were followed with by a draft bamboo vision for the province. This vision states to improve and develop:

1. policies and regulations to attract investment in the bamboo sector and increase competition,
2. facilities for better access to bamboo resources,
3. a model of sustainable management for natural bamboo resources, while allocating resources to individual households to manage and plant bamboo while increasing its areal,
4. bamboo resources into products, businesses and industries resulting in increased jobs and incomes for Houaphanh people, especially the poor.

In 2009 a provincial bamboo strategy will be created as part of the overall provincial social economic development plan 2010-2015. A series of workshops, started in 2008, are lead by the Department of Investment and Planning (DPI) and Department of Industry and Commerce (DOIC) to address hindering issues in attracting investment to the province. To take advantage of the existing national investment promotion laws it is vital to develop clarity of roles and responsibilities and improve the coordination between involved government departments. In support of this initiative the Small and Medium Size Enterprise Promotion and Development Office (SMEPDO) will play an important role. SMEPDO a representative of Ministry of Industry and Commerce has the mandate to create an enabling business environment for small and medium enterprises (SMEs) and facilitate SME development in all sectors. Previously SMEPDO shared with Houaphanh stakeholders the importance of SMEs for economic development and poverty reduction and introduced how to best promote SMEs.

Based on value chain interventions designed and implemented with key actors, lessons from the field have triggered the need to arrange discussion platforms around the bamboo business. At regular intervals over the year and at various levels – provincial, district and community – discussions between government departments, the private sector and communities are facilitated. On these occasions progress in the value chain is shared but also the appropriateness of certain policy implementations evaluated. Most importantly it allows the private sector and bamboo communities to discuss constraints they are facing and provide feedback to government departments to overcome these. It also reminds government staff of the role they are expected to perform.

Handicraft promotion and development

Provision of support to SMEs and facilitating domestic and export market development for local products is the job typically in the mandate of DOIC. However, in practice DOIC’s strength lies in developing promotion policies, while it has limited understanding about the market demand and developing access to markets. A more viable provider of such services is a renowned local handicraft designer who has successfully developed and traded bamboo handicraft products and has even won local awards. This local expert is working closely with DOIC to train communities to develop a diversified range of handicraft products currently in demand, by using new and appropriate techniques and designs. He is also acting as a trader to sell the products while exploring new markets and updating market information for himself and the community groups. To ensure a sustained supply of products the local capacity builder is engaged in organising group formation of handicraft producers.

As a result of declining timber resources for furniture making, the local designer alias trader is now approached by furniture factories partner up in setting up a bamboo handicraft training centre as well as a local handicraft association.

The strength of a local capacity builder lies in his permanent local presence to provide support at appropriate times. Benefiting from the results DOIC is eventually able to organise handicraft promotion activities, such as a local bamboo trade fair.

An added benefit and likely supporting the reform of regulations, is the exposure of DOIC staff to local developments. Lessons and concerns identified will have a better chance to be more effectively communicated. These typically will be the need to ensure user rights and sustainable manage bamboo areas, but also in providing policy support to stimulate the development of strong bamboo groups able to negotiate for better trade deals.

Piloting pro-poor business models

SNV started to engage with the private sector in 2008. Suphaphone bamboo factory in Viengxai district has the desire to expand its operations and is interested to develop improved business relations with local bamboo supplying communities. Currently the supply of raw stems is low due to low prices paid to the communities. The factory owner argues that the lack of a supporting business environment forces him to reduce prices. To support the factory in its vision, and to ensure local people have a higher income from bamboo, business model scenarios are tested to identify a feasible and “win-win” business format. Scenarios range from lending, leasing and selling of simple and appropriate technologies and technical services to the community up to a co-sharing set up. Simple bamboo processing machines will be demonstrated and operational use taught to selected communities before business models can be introduced. Key to develop a sustainable business relationship with the factory is to prove to the communities that better prices will be received. Other factors which need to be considered are social acceptability of new technologies and activities, willingness and capacity of community members to take responsibility over machine use and maintenance, and potential to involve the poor and disadvantaged in the community.

On the other side, the factory owner requires to adjust his mindset. Working closely with rural communities requires patience since a business attitude of community members will need to be gradually built. Building of trust is crucial in the beginning stages and requires the provision of close support and delivery of all types of services. This will include initial business deals with communities and price agreements, which will suffer setbacks which should be allowed for.

Once the initial business model is operating for a while, lessons will need to be drawn before considering upgrading to a next scenario. By this time more serious business contracts and village business plans will be more viable to develop. Access credit will likely not be an option this year.

The promotion of the selected business models and lessons from these pilots will be shared with policy makers. Key objective is to advocate the potential pro-poor role and thus development of the province which can be credited to the private sector. These occasions are further suitable to tackle the various barriers encountered.

One of the key constraints of the factory to scale up its activities is the refusal of the local officials to increase the bamboo quota and setting aside land for a bamboo concession. Land and forest allocation is yet to be finalised in Houaphanh, or in fact in most of Lao PDR, and ownership and management of natural resources remains in the hands of the government. It argues that there is little proof to trust communities or private sector to manage bamboo resources sustainable. The factory has been unable to build up a smooth relationship with officials and poorly detailed requests do not argue in its favour.

The World Wildlife Fund for Nature (WWF) and SNV Rattan Project in Bolikhamxai province, southern Laos, has recently convinced the Department of Forestry (DOF) to award local communities to manage and trade rattan resources directly with the private sector. Key to this success was a solid management plan based on an extensive participatory inventory of rattan resources. DOF, the National Agriculture and Forestry Research Institute (NAFRI) and Provincial Agriculture and Forestry Office have now allowed further testing in the whole province. Such lessons are crucial and will be used to convince the Houaphanh government to reconsider.

Considerations

The sluggish development of the private sector opportunities in Houaphanh province is nothing new. Although it is recognised that poverty reduction requires economic growth, in many developing countries the business environment is hostile to market-led growth and private sector enterprises suffer unnecessary from regulatory barriers and regulatory costs (DCED 2008). Good governance is the key to develop a more conductive business environment. The intentions of the government are confirmed, but to keep these commitments alive they need to be held accountable. The best forum for now is in public-private dialogues between sub-sector stakeholders stimulated by Houaphanh's own backyard lessons. Such intentions need to be transformed into the willingness to listen and accept other actor's viewpoints, up to a point when reforms are facilitated aiming at stimulating private sector growth and thus of the bamboo sub-sector and increase income and employment opportunities for the poor.

The Donor Committee for Enterprise Development provides some key messages as to provide guidance in sustainable poverty alleviation through development of the private sector (DCED 2008) are:

1. A healthy business environment is essential for growth and poverty reduction.
2. Business environment reform is complex and a thorough diagnostic analysis is needed.
3. Business environment reform is always political: coalitions of support and engagement with those who wish to protect the status quo are important.
4. Government should lead and own reform

5. Ensure the inputs and participation of all stakeholders and enhance stakeholder capacity for ongoing and future reforms.
6. Ensure donor coordination, and take responsibility for quality and consistency of advice and assistance.
7. Work on "quick wins", take advantage of *ad hoc* opportunities and have a long-term perspective to ensure sustainability.
8. Understand and manage the implementation gap between the adoption of regulation or principles, and changing practice and enforcing regulations on the ground.
9. Ensure that reform process has a strong communication programme to engage and point out the benefits to stakeholders

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Our Mission

SNV is dedicated to a society in which all people enjoy the freedom to pursue their own sustainable development. We contribute to this by strengthening the capacity of local organisations.

We help to alleviate poverty by focusing on increasing people’s income and employment opportunities in specific productive sectors, as well as improving their access to basic services including water and sanitation, education and renewable energy.

Our motto, 'Connecting People's Capacities', reflects our focus on the empowerment of people and local organisations in the fight against poverty.

Establishing Industrial Bamboo Enterprises Through the Value Chain Approach

Insights from recent experiences in South East Asia

Nigel Smith and Timothy De Mestre

Abstract

Many have recognised the great potential of bamboo as an industry, yet few countries have been able to develop their bamboo industries on a large scale. A second generation of bamboo processing technologies are now offering new opportunities to overcome the technical and commercial obstacles faced by many emerging industrial bamboo sectors.

The authors reflect on experiences working with the emerging industrial bamboo sector in north western Viet Nam, Lao and Cambodia. They present a review of major challenges that have made it so hard for others to repeat the success of China's bamboo industry. Critical characteristics for lead industries in emerging industries are proposed and several established and new products are evaluated against these criteria. One product in particular stands out as a credible candidate as a lead industry for kick-starting the competitive industrial bamboo sectors in new locations around the world.

About the authors

For the last four years Nigel Smith and Tim De Mestre led a major bamboo industry development programme in Viet Nam, Lao and Cambodia – Mekong Bamboo. Working directly with businesses, government authorities and farmers they have been intimately involved in efforts to establish a competitive industry focusing on the industrial bamboo sector. Before leading the Mekong Bamboo programme, initially under IFC and Oxfam and later under Prosperity Initiative, both authors had successful careers spanning the private sector and development assistance.

Executive Summary

This paper aims to inform the reader of recent developments in the bamboo industry what will be of interest to investors, development agencies, Governments and farmers alike.

Many have recognised the great potential of bamboo as an industry, yet few countries have been able to develop their bamboo industries on a large scale. A second generation of bamboo processing technologies are now offering new opportunities to overcome the technical and commercial obstacles faced by many emerging industrial bamboo sectors.

Recently, in the Indochina region, significant advancements have been made in establishing a viable industrial bamboo industry. These efforts have sought to promote a profitable industry, with commercial depth and a sustainable resource to improve the lives of people in poor households.

Progress has been achieved through in-depth work with private business along the value chain, farmers and community forest groups, national / local authorities and drawing on expertise from around the world, particularly China. At the same time the industry has also suffered set-backs.

These industry development experiences, including the valuable lessons of what not to do, are now sufficiently robust to be considered in other regions and countries aspiring to establish local bamboo industries. Lessons can be drawn upon for the need to balance commercial competitiveness, correctly position products in the market and deal with the complexity of the supply chains.

Specifically, experience from the emerging industrial bamboo sector in Vietnam, Lao and Cambodia suggests that, despite the apparent simplicity of the processes adopted by the Chinese industry for achieving high levels of efficiency and competitiveness, the challenges for emerging industries in replicating these are enormous. In particular, the need to simultaneously develop the right mix of secondary manufacturers, linked together within an efficient but complex supply chain, has proved beyond the means of most individual businesses or government agencies.

However, the commercialisation of second generation processing technologies and changing patterns in market demand for bamboo products may be changing the industry and, at the same time, creating new opportunities for emerging industries. Some of the new generation of technologies have important differences in their manufacturing process and product qualities that may overcome the technical and commercial obstacles faced by emerging industries.

Evidence from recent experience strongly supports the conclusion that strand woven bamboo, or similar products such as laminated woven bamboo board, are likely to be the most suitable lead industries for helping industrial bamboo sectors succeed in new locations around the world.

Introduction

Many have recognised the great potential of bamboo as an industry, be it for handicrafts, shoots or industrial processing. Yet few countries have so far been able to develop their bamboo industries beyond their traditional handicraft markets to exploit the huge potential for rural economic growth and the resulting poverty reduction. While bamboo handicrafts exist around the world, the industrial bamboo sub-sector is too often notable only by its absence.

Considerable challenges exist for those aspiring to replicate the success of regions such as Anji, Li’nan and Fujian in China. Such leading regions and their associated industries have set the benchmark in terms of cost and efficiency of production, exploiting competitive advantages from the development of dense industrial bamboo clusters. At the same time they have seemingly lowered technical barriers to entry by commercialising much of the technology and opening the markets to bamboo-based products.

So why, with available technologies, developing markets and local bamboo resources, has it proved so difficult for others to replicate the success of China? Why have industrial bamboo clusters not emerged more widely and achieved the same large impacts on rural development and poverty reduction?

This paper reflects on the practical experience of working with the nascent industrial bamboo sector in Vietnam over the last four years in collaboration leading local businesses and experts from the Chinese industry. During this time the Vietnamese industry has had considerable success but has also suffered set-backs, not least in the recent economic crisis which has highlighted vulnerabilities in the young industry.

This paper draws lessons from this on what has worked, and what has not.

It begins with a discussion of possible reasons why industrial bamboo sectors has so far failed to grow significantly beyond China. It then proposes a number of characteristics to be identified in a lead industry for the development of industrial bamboo sectors in new locations and finally compares three similar, but different, industrial bamboo products[2] against these characteristics: conventional laminated bamboo flooring; strand woven bamboo lumber (or SWB), and; laminated woven bamboo panels.

The following section then provides further details on the product - SWB - that offers the greatest potential as a lead industry in developing the industrial bamboo sector in new locations around the world.

Finally, suggestions are offered on how some of these lessons can be turned into practical actions by those keen to kick-start the development of an industrial bamboo sector in their region, to the benefit of businesses and poor farmers alike.

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[2] Variations on these products are also used extensively.

Definitions and Products

In the bamboo industry there few fixed definitions for products, especially with new products appearing all the time. For the purposes of this paper the following terms are used;

- ***Industrial bamboo sector***: is defined as the use of the hard bamboo stem, or culm, for wood-type products – everything from panels to paper, flooring to furniture, or chopstick to window frames.
- ***Conventional laminated bamboo flooring***: Flooring or panels made of regular rectangular shape bamboo slats, pressed together with glue in combinations of horizontal and/or vertical orientation to form a solid piece of flooring or panel. This can be produced either in "pure" bamboo or combination with MDF or other wooden layers. The key characteristic is that the bamboo used is from highly regular slats at their original density.
- ***Laminated woven bamboo board***: This product is made of several layers of woven bamboo mats pressed together with glue, most similar to plywood. Each mat is typically made from thin, rough, flat bamboo strips. Each layer of strips runs in a direction perpendicular to the one beneath. The surface layers are typically a single mat of interwoven strip running in perpendicular directions within a single sheet. Bamboo is in thin rough strips at its original density.
- ***Strand Woven bamboo (SWB) block:*** A hardwood lumber equivalent that is a highly compressed block of bamboo and glue, with the bamboo compressed to approximately 3 times its natural density. It is made from thin, rough, flat bamboo strips dipped in glue and roughly aligned lengthways before being compressed. The block lumber can then be further processed into anything that hardwood can, from floors to furniture, window frames to doors and much more.

Further descriptions of conventional bamboo flooring and strand woven block are included in Annex A.

Why has industrial bamboo not yet become more widespread?

There is no single reason why industrial bamboo manufacturing has not yet been extensively replicated outside China. Obstacles exist at the industry, business and product level, often interacting to increase the challenges faced. Practical experience from working with businesses involved in the industrial bamboo sector, both outside and within China, suggests the following five factors have been influential:

1. China's significant economies of scope and scale, combining efficiencies with low cost labour have made it hugely competitive in export markets and difficult for new entrants to compete - sometimes called economies of agglomeration. China's large domestic demand combined with growing export markets add to its strength. Few other countries are so lucky.

2. The most competitive modern industrial bamboo industries have developed relatively complex supply chains to produce quality bamboo timber substitute products in volume and make an acceptable return on investment;
3. Early processed bamboo hardwood products were dogged by inconsistent quality and did not live up to the considerable hype and market expectations. This problems appears to be continuing in some regions and businesses;
4. Technology transfer and adaptation to varying conditions has not always been as successful as expected.

In addition to these five systemic factors, the current economic contractions have provided further insights in to the opportunities and challenges for the bamboo industry in the future. Further discussion of each of these factors is provided below.

China's economies of scope and scale

The challenge for those outside China (countries and regions as well as private enterprises) has been how to make the transition from traditional, often small scale, processing industries to the efficiencies and scale needed to compete in the world market against China.

China's leading bamboo regions have achieved remarkable efficiencies in utilising every part of the bamboo that leaves the forest – with raw material conversion rates often exceeding 95%, including branches and leaves as well as the main culms themselves.

With every part of the bamboo being used somewhere in the industry, individual businesses are able to buy only the exact part of the bamboo they require for their particular product and achieve low unit costs of production despite some of the world's highest farm-gate prices for raw bamboo. The efficiency in material utilisation has been made possible by the development of relatively complex and geographically concentred supply chains. This is discussed in more detail below.

The strong competition for raw material among businesses means that every part of the bamboo is used for the products of greatest added value and businesses constantly strive to find ways to increase their efficiency and value addition to the bamboo.

The Chinese industry has also been relentless in its innovations in processing and machinery. These have allowed it to achieve increasing labour productivity to off-set the rising cost of workers.

For those outside of China, the efficiencies of the Chinese industry have made it very difficult to compete with in export markets. Emerging industries elsewhere often struggle with raw material utilisation rates for added value products of perhaps 15%-25%. The dramatically higher efficiencies in China mean that the sales prices of Chinese bamboo products are often lower than the cost of production of similar products elsewhere where, despite big differences in the cost of raw materials and labour.

This can be illustrated by the example of the cost of a semi-processed bamboo slat for conventional bamboo flooring in June 2008:

- In Anji County, Zhejiang China, raw bamboo cost close to USD100/ tonne delivered to the gate of the primary processing factory who processes it into to slats and a range of other semi-processed products to be sold to secondary processing businesses. The flooring factory that bought the slat paid 6.5 US Cents per slat (RMB 0.45).
- In Thanh Hoa Province, Viet Nam, raw bamboo cost close to USD35/ tonne deliver to the gate of the primary processing factory. The flooring factory who bought the slat paid 6.8 US Cents per slat (VND 1160).

So, despite an almost 3:1 cost advantage on raw material, the inefficiencies of the industry mean that the flooring company in Vietnam is actually facing higher production costs than its competitors in China. Indeed, another similar company in Vietnam actually began importing semi processed slats from China in the same year in an effort to reduce its costs while at the same time local primary processing business were struggling to find buyers for their products. This is not a problem unique to the bamboo industry – as illustrated Box 1, below.

This cannot simply be explained by a lack of reliable supply. In north western Vietnam there are around 80 primary processing bamboo businesses[3] making various semi-finished products. However, of these 80 businesses, 65% make and sell just one or two products as this is all they can find markets for. In contrast, primary processing business in Anji can make and sell 4, 5 or more products – depending on which is most profitable at the time.

What is missing in emerging industries, like the one in north western Viet Nam, is the necessary range of higher value added bamboo processing business capable of utilising all parts of the bamboo culm. The industry in Viet Nam has raw material utilisation rates for value added products of less than 25% and most primary processors struggle to find reliable buyers for their products. For example, the lack of added-value processing of bamboo sawdust means that primary processors can rarely secure any income for this major by-product stream.

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[3] Figures based on a comprehensive survey of bamboo businesses in Viet Nam in 2008 – see www.mekongbamboo.org for a searchable directory of businesses. Of the 80 or so small bamboo businesses, 26% sell just one product and 39% sell two products.

Box 1: Competing with China

Paul Collier[4], in his influential 2008 book: "The Bottom Billion: Why the Poorest Countries are Failing and What Can Be Done About It", makes the follow observation regarding the economies of agglomeration.

In the 1970's when developed economies dominated manufacturing, and just before the big manufacturing shift to Asia, the cost gap between Asia and developed countries was 40:1.

Today that costs gap between China and Vietnam in the case of the bamboo industry is 3:1 which indicates that despite the lower cost bases the chances of success are still limited if history is a guide.

To avoid this during initial stages of an industries development it is wise not to try and compete in industries that benefit from scale and complex processes / steps and go direct to industries that are more stand alone, with simpler supply chains so individual business can be more efficient and competitive from the outset (See Structure B in Figure 1).

Furthermore, an equal focus on domestic markets as well as exports can reduce the need to compete head on with highly efficient manufacturing industries, such as those in China. As local industries develop over time and raise their efficiency they can then begin to take advantage of their lower cost structure to compete effectively in export markets.

Indeed, one of the remedies suggested by Paul Collier is to provide a degree of temporary protection for emerging manufacturing industries in developing countries to allow them to improve their own efficiencies without the corrosive pressure of direct competition with manufacturers in China and other major Asian manufacturers.

So, for emerging industries, any major gaps in this industrial mix of the bamboo value chain and every other business in the local industry struggles to be profitable as the competitive advantage of lower raw material and labour costs is dispersed. This has made it hard to start industries in new locations, even where there is an abundant bamboo resource, comparative cheap labour and markets with good potential.

An important further lesson from Vietnam is that individual businesses do not possess the scale to tackle these problems alone within conventional industrial bamboo supply chains. While at the same time the challenge of orchestrating a coordinated industry level response has proved beyond the means of most governments or industry associations.

The adage "you are only as strong as your weakest link" has applied to the industrial bamboo sector.

[4] Prof. Paul Collier is the former Director of the Development Research Group of the World Bank and is currently Director for the Centre for the Study of African Economies at The University of Oxford, UK

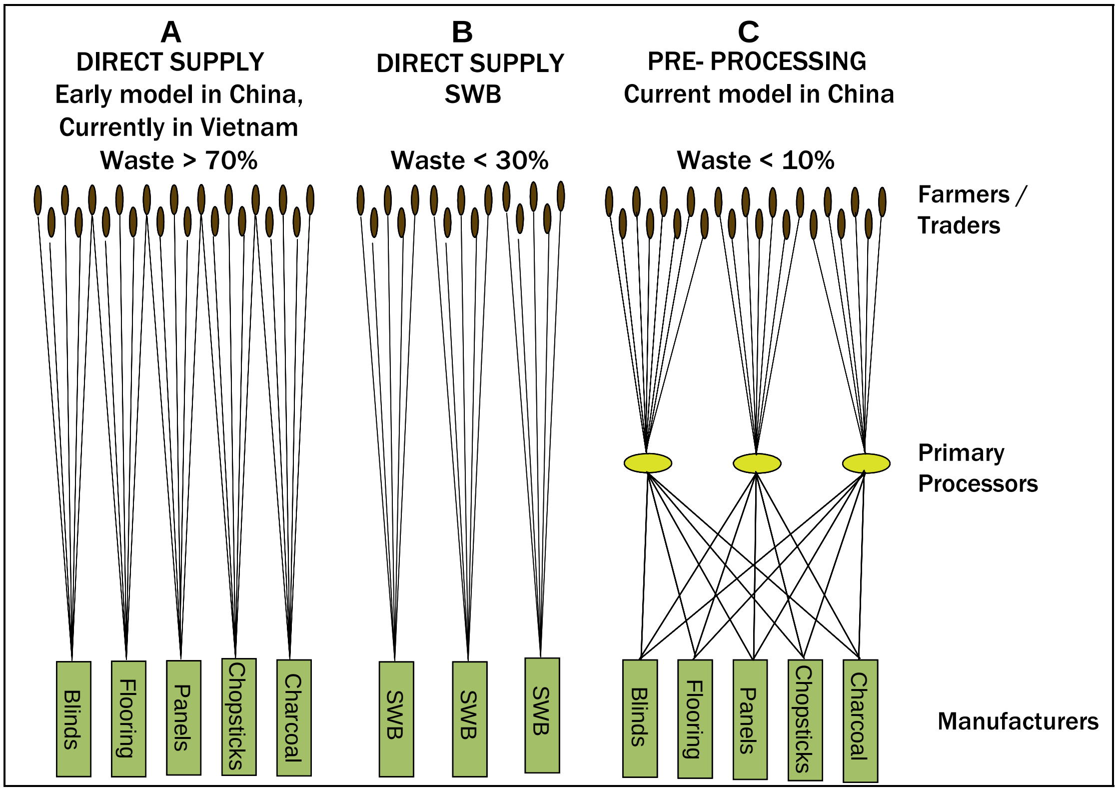

Figure 1: Industry structures

Supply Chain Complexities

The basis for China's competitiveness has been the efficiency of the industry overall rather than of any individual business, as outlined above. This has been made possible by the evolution of relatively complex but geographically concentrated supply chains.

Modern bamboo supply chains, such as in Anji, typically have three distinct layers (see Structure C, Figure 1 above)

1. Farmers sell their raw bamboo to primary processing factories.
2. Primary processing factories covert the entire culm in to a range of semi-finished products, which they sell to secondary manufacturing businesses. They are able to easily change the mix of semi-finished products in response to market demand to maximise their profit from the entire culm. Each primary processor will have several different customers, often making different end products.

3. Secondary manufacturers buy the specific type of semi-finished bamboo products they need to manufacture finished goods for sale to the market. Depending on the size of the business, each secondary manufacturer may buy semi-finished products from several primary processing factories.

It is the emergence of the middle layer – the primary processing factories – that has made possible the achievement of such high material utilisation rates. By doing the bulk of the initial processing of the bamboo in a single factory, all the various products and by-product streams can be economically collected and then sold to secondary manufacturers. Because the primary processing businesses do not need to make finished goods from all the bamboo they are able to operate profitably at a small scale with low capital investment. So they are easier to set-up and operate profitably.

In addition, the larger, more capital intensive secondary manufacturing businesses can drive down their unit costs of raw material as they only buy the precise part of the bamboo culm they need. They do not have to find alternative markets for large amounts of unwanted processing waste or invest in additional product lines to achieve the efficiencies within their own business.

Together this means that it is much easier, from a commercial perspective, to set-up and operate a bamboo business in an industry that has this structure of primary processing factories – capital investment requirements are smaller and cost of production are lower.

However, in reality these supply chain structures are complex and difficult to establish. In Anji, primary processors emerged only after there were already a large number of competing manufacturing businesses. Primary processors were able to offer immediate savings to these businesses due to their greater efficiency and so they were able to quickly restructure the industry to everyone's benefit.

The most common structure during the early stages of industry development has been a direct supply mode (see Structure A in Figure 1). Indeed, this was the early industry structure in Anji, China, and is still the most widespread structure in the industry in north western Viet Nam. This has led to emerging industries having large inefficiencies compared to the modern Chinese industry (Structure C).

So emerging industries face a major dilemma – they must adopt these complex supply chains to achieve the efficiencies needed to compete and survive yet the complexity and interdependence needed makes them especially hard to establish in an open market..

The complexity of the supply chains also creates very real problems for quality control for the manufacturers of finished goods. The quality of the end product is heavily dependent on the quality and consistency of the raw material, especially the age and species of the raw bamboo. Yet after the raw material has gone through its initial primary processing it is very difficult to have effective quality controls to indentify any problems. The secondary manufacturers therefore rely on their suppliers – the primary processors – for a major part of their quality control.

Many of the quality problems associated with some conventional industrial bamboo products have stemmed from poor supply chain management that fosters below standard raw bamboo materials, including inappropriate glues, lack of supply at critical times and bad storage techniques to name a few issues. Bringing the supply chain under better control is usually difficult as production steps are out of the control of the end processor and price signals are often not passed down the supply chain to the farmer, trader or even the primary processer (See Structure C, Figure 1). Although a seemingly simple process this inherently complex supply chain management has hampered replication of the process in developing regions due to greater risk and lower profits. Some of these issues, if not all, have lead to failure of infant businesses.

Bamboo Hardwood Quality

Despite that fact that bamboo slat flooring and block timbers make environmental, social and commercial sense and thus have found reasonable appeal, problems with bamboo products have been encountered and too often not lived up to customer expectations. Examples of these issues include, but are not limited to:

- Failures to provide a consistence quality of raw materials, e.g. bamboo culms ages and varieties have been mixed;
- Usually linked to the previous point, failure by some manufacturers to produce consistent quality finished product, leading to variable perceptions of product
- Poor product knowledge at the point of sale, e.g. end users using bamboo products for purposes for which it is not suited and a lack of knowledge of bamboo
- A lack of independent research made publically available on bamboo product attributes and associated accreditation.
- Substandard adhesives.[5]

In general, many bamboo products have still to find widespread acceptance as reliable, value for money products but progress is undoubtedly being made.

Technology Transfer Outside China

In theory, emerging industries should be easily able to obtain the necessary processing technologies from China, Taiwan and elsewhere, especially since the emergence of specialist bamboo equipment manufacturers.

In practice, however, this has not proved as straightforward as expected. Chinese bamboo equipment has been imported into many countries, but with varying results. Considerable adaptations have often been needed to make these machines optimal with other species. In some countries, such as some in Africa, little success has yet

[5] Adhesives are the most expensive material in the SWB process. Urea Formaldehyde (UF) and Phenol Formaldehyde (PF) are glues in common use, although different types of glue apply for different product groups. UF is more suitable to indoor products while PF is for outdoor ones. Overseas markets require strict technical criteria, aimed at limiting formaldehyde evaporating from the product. Depending on the amount of formaldehyde emission the cost of glue may vary and so does the final cost of the product.

been achieved while in others such a Vietnam, progress has been made through trial and error. However, further work continues to be needed to refine practices and machinery to make it regionally specific and thus ensure profitability. This however may not be within the resources of a new investor trying to introduce the bamboo industry to his home country but with no prior experience of bamboo manufacturing.

For some more recent processing technologies, such as SWB, the processing techniques are still at a very early stage and while good products can now be reliably produced, few businesses have practical experience in applying this technology on a commercial scale.

The Current Economic Contraction

With a worldwide economic recession the demand for some bamboo products has found some resistance compared to the rapid growth of recent years. But the impact has not been uniform, with part of the industry actually seeing a growth in demand.

Products which have emerged stronger from the current economic storm are those with clear price or performance advantages over competing products – these include strand woven bamboo block, bamboo mat board and particle board. Indeed many of these have seen demand grow as buyers search for better value and reduced costs.

In contrast, products that have less clear cost or performance advantages over alternatives have seen orders and margins decline sharply, such as conventional laminated flooring or window blinds.

This may give some indication of the true competitiveness of different industrial bamboo products and should be an important consideration for new investors in emerging bamboo industries.

Over recent year many of the more successful bamboo businesses in Anji and elsewhere have expanded their operations into new locations, in search of lower costs and higher profits. Of the more advanced and largest Chinese bamboo businesses, some were considering Initial Public Offerings (IPO) in 2008 and potential investments overseas. While these more ambitious overseas investments may still be under consideration, the market uncertainty and financial pressures in the current recession mean that it may be some time before any of these plans come to fruition. For those aspiring to build their own local industry, they will therefore need to look for investors closer to home, and seek savings inside their business, for some time to come.

Conclusions

We may conclude from these observations that, despite the apparent simplicity of the process adopted by the Chinese industry for achieving such high levels of efficiency and competitiveness, the challenges for emerging industries in replicating this are enormous.

Specifically, the need to simultaneously develop the right mix of secondary manufacturers, linked together within an efficient but complex supply chain has proved beyond the means of most individual businesses or government agencies.

However, the commercialisation of second generation processing technologies and changing patterns in market demand for different bamboo products may be changing the industry and, at the same time, creating new opportunities for emerging industries.

Identifying a Lead Industry Candidate – The Case for SWB

Having considered the reality of the challenges facing emerging industries, we may envision what might be the ideal characteristics for a business to act as a lead industry to kick start the growth of the industrial bamboo sector in a new location.

Experience to-date suggests that, although there are some sound lessons to be absorbed, simply trying to copy the route taken by Anji and other Chinese industries is unlikely to succeed.

Any lead industry must try and achieve the same efficiencies and competitiveness while avoiding the need for the complex supply chains that have proved so difficult to recreate.

With this in mind, the following characteristics are proposed for an ideal lead industry:

Market Demand

- A highly saleable product that competes well with substitutes - as perceived by the customers. As bamboo is a relatively new material in many markets, a clear advantage in terms of value, price and/ or quality would be needed to claim market share.
- A viable domestic market can help new businesses develop scale and improved manufacturing before going on to compete in export markets.
- Accessible export markets, without significant entry barriers, are important to underpin a larger and growing industry and allow progression into increasingly high value markets.

Supply and production

- Manufacturing process uses >50% of raw material in primary high value products - greatly reducing reliance on other markets or successful businesses nearby using by-products
- Simple supply chains enabling control of quality of materials and costs, essential factors in long term profitability and reputation
- Minimum efficient scale for production is low with later incremental expansion technically and commercially feasible. This allows managed investment but with reduced pressure in investment and cash flow during the early year while the businesses become established.

For sustained longer term success (in addition to the above)

- Diversified end markets, with growth potential,
- Some key markets in close proximity, to increase competitiveness via lower transport costs.
- Opportunities for downstream value addition, for example through further processing
- Sustainable, diversified, supported and expandable, raw material supply

To build a wider industry with strong local impact, in addition to the above the following characteristics are desirable:

- A sufficiently large lead industry to act as an anchor for future industry growth
- For the bamboo to be mostly owned by smallholders
- An increasingly supportive sector enabling environment for businesses and farmers alike.

Comparing three nominally similar industrial bamboo products illustrates important underlying differences against these ideal characteristics.

Characteristic	Conventional laminated bamboo flooring	Strand woven bamboo lumber	Laminated woven bamboo board
Market Demand			
• Highly saleable product	?	✓✓	✓✓
• Viable domestic market	✗	✓✓	✓
• Accessible export markets	✓	✓✓	✗
Supply and production			
• Uses >50% of raw material	✗✗	✓✓	✓
• Simple supply chain	✗✗	✓✓	✓✓
• Low minimum scale needed	✓	✓	✓
Sustained longer term success			
• Diversified end markets	✗	✓✓	✗
• Opportunities for downstream processing	✓	✓✓	✗
• Sustainable raw material supply	✓	✓✓	✓✓
Summary	✗	✓✓	✓

Conclusions

The evidence of the last four years of the industries development in Viet Nam and China, as summarised above, strongly supports the conclusion that strand woven bamboo, or similar products such as laminated woven bamboo board, are likely to be the most suitable lead industries for helping industrial bamboo sectors succeed in new locations around the world.

The Opportunity for the Future

The situation in the industrial bamboo sector is now changing. As outlined, a second generation of processing innovations are opening the door to more widespread growth of the bamboo industry. These high value-added manufacturing processes, such as a SWB and laminated woven bamboo board, are beginning to change the economics of the industry, to the benefit of all those who have struggled to copy China's.

The business model for SWB production has a number of unique features. It is becoming clear that the SWB manufacturing process lends itself to being a potential entry point for starting a host of new commercial bamboo industries around the world.

The reasons for this include:

- High material recovery rates into high-value products – 60-80% of a bamboo culm can be converted into the final product – compared to less than 15% for traditional layered bamboo flooring.
- The finished product(s) is a strong, durable substitute to hard woods, yet can be sold on the market at 20-30% less than comparable timber and still provide acceptable returns. As a direct hardwood substitute, the market is opening to sub sectors such as window frames, doors, furniture as well as normal engineered bamboo markets of flooring and panels – there is often a strong domestic market for these general construction items, making it easier for the businesses to start incrementally and exploit the price advantage over hardwoods to gain market share. (See Box 2)
- If the bamboo is owned and sold by smallholders then they could quickly benefit from the rising price and demand for their bamboo. Additionally small holders can benefit from very basic first stage processing requirements in the village thus providing additional value add labour requirements at the point of sale.
- The available investment model analysis shows that these SWB processing factories can remain profitable and highly competitive against hardwoods with bamboo prices of over USD 50 / tonne – a price which most farmers outside of China rarely benefit. This is equivalent to an income of around USD650-750 per hectare per annum from only around 50-60 days labour. Often in mountainous areas this compares extremely favourably even compared to cash crops in respect of price / production risk and sustainability.
- At current market prices, a new factory with a capacity of 5000 m3 p.a. would need an investment of around USD1.5 million (excluding land) - of which working capital is around USD200,000-300,000[6].

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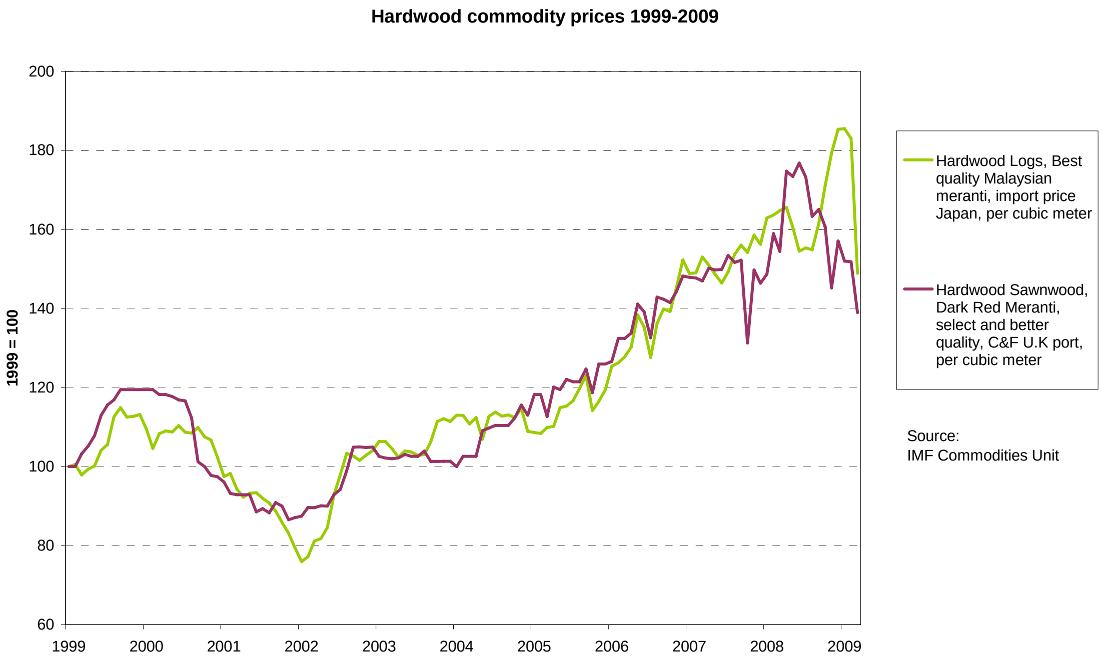
[6] Priced June 2009

Such a factory would generate revenue of over USD2.4 million per annum and annual operating profits (EBIT) of over USD700,000 per annum. Refer to Annex 2 for summarised calculations.

Box 2: Favourable Market Conditions for SWB in Viet Nam

Global hardwood prices have continued to rise in recent years in the face of limited natural wood resources and growing concerns over sustainability (see chart). This bodes well for the long term outlook for SWM in export markets.

In domestic markets, Viet Nam's demand for imported wood has been increasing during the economic development and growth of the wood processing industry. The total net domestic demand for wood products reached almost USD3.5 billion in 2008 – dominated by furniture, windows, doors and other construction materials (excluding imported timber for processing and re-export which account for a further USD+2 billion per annum).



In the domestic marketplace, studies have shown that the acceptable price for SWB lumber could range from USD 455 to USD 685 per m^3. In Vietnam, SWB will compete directly with balau ("cho chi"), a local species in medium grade hardwood in the segment of doors and window frames. The quotation for cut "Cho Chi" wood ranges from USD 570 per m^3 (origin - Lao PDR), USD 685 per m^3 (origin - Viet Nam) to USD 800 per m^3 (origin - Indonesia).

Investment modeling predicts a basic cost of goods produced of USD360-440 per m^3 for the first year from a capacity of 5000 m^3 of product per year (based on current input prices). If sold on the market at USD 540 per m^3 this would give Earning Before Interest and Tax (EBIT) of USD100-180 per m^3.- a margin of 18%-33% on sales revenue.

- A wide range of species appear to be suitable, although current estimates suggest larger diameter species (larger biomass species with thick walls), such as D Barbatus, D Asper, D. Giganteus, may be more commercially competitive as they can achieve higher material utilisation rates. In China, the most popular species used for SWB is Moso (*Phyllostachys pubescens*). In Viet Nam for example, Luong (*Dendrocalamus barbatus)*, Buong (*Dedrocalamus* sp.nov.), Lo O (*Bambusa sp.*) or Tre gai (*Bambusa blumeana Schultes.*) all suit the SWB process, whereas for the traditional slat process only Luong fit the quality requirements.
- Some species with a course fibre structure may also have commercial advantages due to better glue uptake and bonding thus reducing costs of goods produced. But certainly more research and market development is required.

From a Poverty Reduction Perspective

In terms of local economic development and poverty reduction in remote and mountainous areas, the industrial bamboo sector can be especially valuable. Bamboo handicrafts can create significant employment opportunities and can be a valuable part of household livelihoods - most of the value of the product is in the labour. Yet in remote locations, the fact that finished goods are bulky and light means that transport costs are high and market access is limited, so household income opportunities are poor. Most large scale bamboo handicraft production has therefore grown up in rural areas relatively close to urban centres, with only the raw bamboo coming from more rural areas. Thus in more remote rural areas handicraft production is often limited to local markets and household use and so offers few opportunities for local growth.

In contrast, industrial bamboo manufacturing consumes large quantities of bamboo which is typically found in remote and mountainous areas. Much of the value of the finished product is in the bamboo itself. The industries also benefits from processing the bamboo reasonably close to the forest to either semi-finished or finished goods. If farmers in remote areas own the bamboo they can benefit from the growth of a local industrial bamboo sub-sector through higher prices and stronger demand for their bamboo.

The simple supply chains and commercial competitiveness of SWB offer considerable promise in enabling new industrial bamboo sectors to be established in new rural areas and thus help drive local economic development and poverty reduction.

From a commercial perspective

The current opportunity for an investment in SWB production is it is at the frontier of the industrial development cycle but technologies and markets are now proven. Margins will remain strong for many years as little competition exists for the raw material and the market demand is strong and large. Over time it is expected that these margins will come under pressure but could be maintained through careful supply chain management, the development of preferred suppliers, a continued refinement of the process, new technologies, potential accredited ethical supply chains and most importantly moving down stream into finished products of the SW material, such as furniture, doors, window frames, shipping boxes etc..

The Next Steps: Stages to launch a competitive industrial bamboo sector

If a region has significant resources of bamboo stands with culms that measure over 5 cm in diameter at the base, has reasonable access to markets and a has a domestic demand for timber then a SWB investment is a distinct possibility. The SWB process overcomes many of the country specific issues of a conventional industrial bamboo sector based on slat laminate flooring or other similar products.

A SWB investment model would be developed in three main phases, with investment review points between each:

Phase 1. Prefeasibility or Preparation Phase: initial scoping and assessment of proposed site / region.

Phase 2. Study and Analysis Phase: investment and feasibility study.

Phase 3. Investment or Partnership Phase: Ongoing and as required.

Specifically, as Phase 1 is the most logical point of initial engagement, the following detailed tasks should ideally be followed:

- Review the existing data on the bamboo natural resource and physically assess local varieties and their growth densities.
- Pilot test the bamboo culm physical properties across a range of tests to identify specific properties.
- Understand smallholders access and tenure/access rights to land and forest resources.
- Ascertain current bamboo business value chains and related activities in all subsectors.
- Assess the local business and the broader sector enabling environment for potential first stage processing SMEs or traders in the local area.
- Assess infrastructure and access to markets in the province, in relation to international and domestic markets.
- Provide a functional / generic, investment model.
- Assess human resources capacity in local area through meetings with other businesses, especially those in forestry or other similar sectors.

If required, further work should be undertaken to establish the efficiency and efficacy of linking investments in bamboo to pro-poor outcomes. This would require a review of the existing data on the local poverty rates, poverty gap and poverty headcount, and ascertaining the location of the poor in relation to the bamboo resource.

Further audits would be required to ensure that social, environmental and cultural issues were also being addressed and could be linked to additional studies such as for the accreditation of ethical supply chains and even carbon trading benefits. Another consideration might be linking any project with Reducing Emissions from

Deforestation in Developing Countries (REDD) under the United Nations Framework Convention on Climate Change. Many synergetic avenues certainly exist and need to be prioritised.

Findings from Phase 1, would be detailed in a brief report with recommendations. If positive, the Phase 1 report would also include information related to the next stage of any detailed and specific demand-focused investment study.

The main output for Phase 2 would be a work plan for developing the bamboo sector. This would be targeted around creating a triple-bottom-line business investment plan, as a process to identify and address all key issues for launching the sector anchored around a particular location while drawing on a wider value chain. It would begin the process of screening potential investors and looking for the best approach to see the local industry commence.

Conclusions

Many have recognised the great potential of bamboo as an industry, yet few countries have been able to develop their bamboo industries on a large scale. A second generation of bamboo processing technologies are now offering new opportunities to overcome the technical and commercial obstacles faced by many emerging industrial bamboo sectors.

Experience from the emerging industrial bamboo sector in Vietnam, Lao and Cambodia suggests despite the apparent simplicity of the process adopted by the Chinese industry for achieving such high levels of efficiency and competitiveness, the challenges for emerging industries in replicating this are enormous.

Specifically, the need to simultaneously develop the right mix of secondary manufacturers, linked together within an efficient but complex supply chain has proved beyond the means of most individual businesses or government agencies.

However, the commercialisation of second generation processing technologies and changing patterns in market demand for bamboo products may be changing the industry and, at the same time, creating new opportunities for emerging industries. Some of the new generation of technologies have important differences in their manufacturing process and product qualities that may overcome the technical and commercial obstacles faced by emerging industries.

The evidence of the last four years of the industries development in Viet Nam and China, as outlined in the paper, strongly supports the conclusion that strand woven bamboo, or similar products such as laminated woven bamboo board, are likely to be the most suitable lead industries for helping industrial bamboo sectors succeed in new locations around the world.

ANNEX 1 - Fact Sheet: Strand Woven Bamboo

- Strand Woven Bamboo (SWB) is a relatively new product that was first marketed in China six years ago and is known by several names such as "re-constructed board", "Tiger Bamboo" and "Pressed Block Bamboo" to name a few. One of the most commonly used brand names that is currently copyright protected in the U.S. is "Strandwoven Bamboo"
- SWB hardwood products are created through the following summarised stages:
  - Cutting the culm from the forest or plantation;
  - Scrapping the outside green layer from the bamboo culms;
  - Cutting the culm to size and then a 2-stage splitting process of the bamboo strands;
  - Boiling the strands in a processing solution to remove any sugars and/or insects.
  - Kiln drying the strands to 10-12% moisture content.
  - Soaking the bamboo strands with glue whilst in bales, or billets,
  - Placing the bamboo strips in bales under very high pressure to compress the strands.
  - Baking the compressed bamboo in an oven until hard and dry and resin set.
  - Removing from the metal case the solid logs of bamboo and slicing them into boards and milling them like traditional hardwood.

The following pictures show the final stages of the production of the SWB block.

1. Pressing- initial stage	**2. Pressing-final stage**
	
3. Near-finished logs	**4. Finished Products**
	

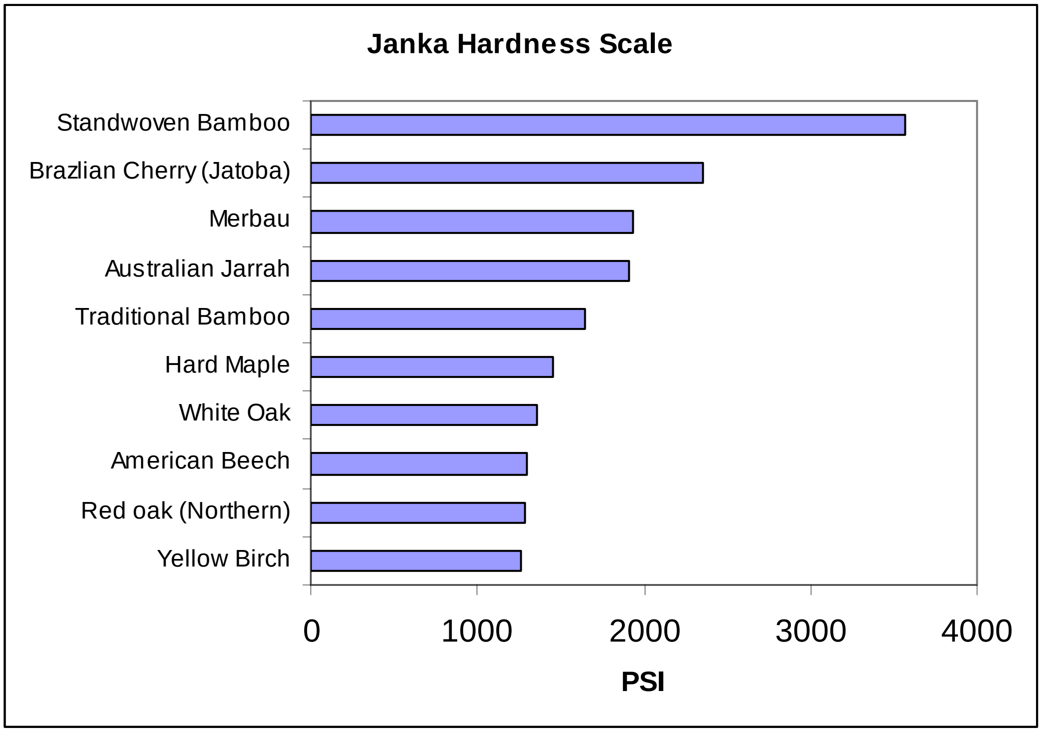
THE BENEFITS: STRAND WOVEN BAMBOO PRODUCTS AND PRODUCTION

Where the SWB is the one described above the tradition process of bamboo utilization is the lower part of the culm converted to slats for engineered board construction, the middle part into mats and / or blinds, the thinner section into chop sticks and in some instances the very top of the culm into tooth picks.

Table 1. SWB process versus the Traditional Process

	SWB Process	Traditional Process
Material cost-savings	Utilisation of the culm into higher value products: 60% - 85% of bamboo culm material	Low utilization of bamboo culm material, usually less than 25% into higher value products. Eg. conventional bamboo floorings only use 8%-10% of the culm.
Quality requirements to bamboo material	Material supplies may be various types of bamboo. It is believed that homogenous supplies of bamboo (age, variety, thickness) are important for qualities but more tests are required.	Selective to input of bamboo. Stringent demand for homogenous variety and age. E.g. In China, Moso and in Vietnam, Luong.
Market potential	SWB as a wood substitute, is open to mass market made-of-wood products and not a confined market segment of flooring, panels and furniture. Prices competition this is higher. Further testing of SWB in weigh bearing situations is required.	Conventional bamboo products, such as chopsticks, mats, and flooring are only sold to certain market segments. The growth rate therefore is limited relative to pressed bamboo.
Quality and application	SWB technical specification of hardness (2820 PSI) and dimensional stability is higher than most of iron woods and hardwoods in Group 1. SWB can be tailor formed to different dimensions as required.	Limited application. Product quality depends on various factors, including product type, material quality, processing ability and technical ability. Flooring hardness has been tested at 1450 PSI.
Financial efficiency	Estimated to be high. Net profit over turnover ratio may exceed 20%, with a payback period of 48 months maximum.	Known to be diminishing. Net profit over turnover ratio is in generally less than SWB. Eg. it is less than 5% for rough chopsticks and less than 10% for bamboo strips, etc.

Figure 2: Hardness (PSI) of SWB compared with other types of hardwood



Source: www.danskhardwood.com and www.jankahardnessscale.com; Note; The higher the PSI number the harder the surface. For additional test information (US, Europe and Australian independent test) regarding SWB please refer to www.danskhardwood.com, Dansk Fusion Manual pages 15 to 16.

ANNEX 2 Financial Analysis

Below is a summary of key variables that influence costs and returns.

Key Variables	**Unit**	**Variable**
SWB Price, Net Tax Year 1	*USD/m3*	*543*
Del. Factory Bamboo Price Year 1	*USD/kg*	*0.034*
Farm Gate Bamboo Price Year 1	*USD/kg*	*0.023*
Glue content (resin in solid form)	*%*	*10%*
Price for glue (UF)	*USD/kg*	*1.03*
Density	kg/m3	1080
Length	*mm*	*1900*
Strips length	*mm*	*2000*
Moisture content of raw bamboo	*%*	*50%*
Moisture content of SWB	*%*	8%
Utilisation of Culm	*%*	*65%*
Terminal growth rate	*%*	*-5%*
Currency Exchange	*USD/VND*	17,500

Revenue & Costs **USD 000/year**	**10 year average**	**%**
Total revenue	3,439	100.0%
Raw material cost	967	28.1%
Glue and chemical	886	25.8%
Electricity	85	2.5%
Direct labour	428	12.5%
Depreciation & maintenance	168	4.9%
Sales and marketing	138	4.0%
Other expenses	141	4.1%
EBIT (Earning before int. & tax)	627	18.2%

Key profitability indicators	**Unit**	**Quantity**
Total Initial Investment	USD 000	1,133
Equity	USD 000	675
Debt	USD 000	458
Modified Internal rate of return (MIRR)	%	26%
NPV (20% discount rate)	USD 000	1,128
ROE (10 yr average)	%	32%
Return on equity in year 10	%	21%
Net profit margin	%	17%
Payback period	Years	4