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AGARWOOD PLANTATION AND PRODUCTS AS LIVELIHOOD STRATEGY: A CASE STUDY FROM BAN KHLONG SAI VILLAGE, NORTHEAST THAILAND

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Abstract: *Agarwood products are sought after commodities in the international cosmetics market. On account of the depletion of raw materials at a faster pace and the ban on their extraction from the forest, Agarwood planting and induction of oil formation at early age was adopted by the villagers. This had a substantial impact on the livelihood of the farmers. In this background Ban Khlong Sai village was chosen as a case study to find out whether this was a plausible strategy. Common methods of qualitative and quantitative research, like questionnaire survey, interview, participatory rural appraisal, informal talk, case study, soil testing, biometric measurements etc. were adopted. The various livelihood strategies adopted by the villagers were compared with Agarwood activities. The economical, ecological and social opportunities and constraints gleaned from this are discussed in this paper. It was concluded that opportunities weighed heavier than constraints and Agarwood plantation appeared as a genuine livelihood opportunity.*

Keywords*:* *Agarwood product, Constraints and Opportunities, Ecology, Economics, Sociology*

INTRODUCTION

Agarwood is a dark coloured, fragrant resin embedded in the otherwise whitish wood of *Aquillaraia* species. It is accumulated in the roots and the trunk of the tree as nodules of varying age, shape, size and commercial quality, and is formed as a result of injury and fungal infection (Blanchette, 2007; Jensen, 2009; Nobuchi and Somkid, 1991). Agarwood product is very common in many religious rituals. Wooden pieces and sculptures, beads and bracelets are highly appreciated goods in South and Southeast Asia. However, the major use of agar wood is in the form of extracted essential oil as perfumes, other cosmetic products and in the incense industry. Agar oil is also used in traditional medicines and wine in China and Korea and in ayurvedic medicine in India (Barden *et al.*, 2000; Chen *et al.*, 2011; Gunn *et al.*, 2003; Persoon, 2007). The popularity of Agarwood products in the international market offers the opportunity for a high earning livelihood.

Though different species of agarwood are found in several south and southeast Asian countries, *A. malaccensis* is indigenous to Thailand. Presently, natural Agarwood is available in few places, such as Khao Yai National Park. The overexploitation of natural crop has

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resulted in a scarcity of Agarwood products. To ameliorate this, large scale plantation was adopted by villagers and private companies in Thailand, especially in the Nakhon Ratchasima Province. Ban Khlong Sai (BKS) village, the study area of this Province, had a large area under Agarwood plantation in the form of home gardens and farm plantations. As different livelihood systems, cultivation of Cassava and Maize and a mixed cultivation of timber tree, vegetable and seasonal fruit such as Custard apple, Litchi, Longan, and Banana were practiced.

The main goal of the study was to find out the contribution of Agarwood plantation and products to people's livelihood in BKS in comparison to other systems. Therefore, people's preference of different livelihood activities, quantum of, per hectare production, the opportunities and constraints of Agarwood plantation and the economical, social and ecological factors were identified and assessed.

MATERIALS AND METHODS

Both quantitative and qualitative research methods, as described, in brief, in following paragraphs, were used in March 2008.

A questionnaire survey was conducted in randomly selected 32 households out of total 129 households of BKS to find out the average number of Agarwood trees per household and how they compared with other neighbouring villages. This method was also used to know the importance of plantations as compared to off-farm work and landscape relationship with the type of crops and trees grown in the area.

Semi-structured interviews were conducted in six households, selected on the basis of the information gathered during a questionnaire survey, to get more information about Agarwood based activities, covering economical, ecological and social issues.

The informal talks which were the perfect complements to the interviews were performed with key persons to collect the missing data collected during questionnaire survey and semi-structured interviews.

Participatory Rural Appraisal meetings were held with the villagers to find out their various sources of income and to gauge which ones were the most profitable. Along with this, a preference rankings exercise was conducted regarding major sources of income and opportunities and constrains for Agarwood activities.

Soil sample analysis was done using field testing kit developed by Kasetsart University, Thailand. Soil samples were collected from three different types of vegetation systems like Agarwood plantation, mixed plantation and annual crops from high slope, intermediate slope and flat land. Nitrogen, Phosphorus, Potassium content and pH were assessed in these samples by adopting rapid field analysis method of colour comparison chart.

For plantation inventory and productivity analysis age series plantations (5, 6, 7 and twelve year old) were selected. Tree girth and height were measured in representative sample

plots of 10m by 10m. These two parameters were used to calculate basal area, wood volume, wood mass and oil content with the help of some secondary data like, form factor in USEPA (2008b), wood density in Chakrabarty *et al.* (1994), oil content in Chamling (1999), and price of Agarwood oil in Anon (2008). Basal area was calculated by the standard formula $g2/4\pi$. Volume was estimated as basal area times height times form factor. Dry wood mass was obtained by wood density multiplied by volume. Wood mass was converted to oil content as percent of wood. Per hectare income was derived simply from prevailing oil price and production quantity.

A General survey for home garden selection was conducted during the questionnaire survey to assess the role of home gardens in livelihood. Afterwards, three households were selected randomly for case studies. During this study the home garden owners were interviewed to gather production and utilisation information on their garden. An inventory of different species planted by them was prepared to know the role of different crops in their livelihood sustenance.

RESULTS AND DISCUSSION

Livelihood Strategies in BKS

It was evident from the reconnaissance survey and interaction with the villagers that BKS had all the capital (natural, social, human, physical and financial) as household wealth in varying degrees to pursue different livelihood activities (Sherbinin *et al.*, 2008). BKS had undulating topography with mostly high slopey terrain, non-fertile soil, and almost non-existent irrigation infrastructure (location map along with neighbouring villages in Fig. 1). This was one of the reasons for having lower proportion of agriculture but the highest mean number of Agarwood trees per household (158) as compared to other villages like, (Ban) Khlong I Phaeo, (Ban) Pho Tong Pattana, (Ban) Khlong Bong Pattana and (Ban) Khlong Tu Rian (Fig. 2) and other sources of income were plausible to make a living from the inferior quality of land (Steimann, 2005). It is interesting to note that almost each household had a minimum of three Agarwood trees in their compound, indicating that the villagers had easy access to seedlings and a good knowledge of silviculture and of the uses of this species. It was likely that a change agent, a successful Agarwood entrepreneur, had created the initial awareness about Agarwood planting in this village (Knowler and Lovett, 1996).

Agarwood products were seen as an important strategy to earn a high income by virtue of being expensive and therefore, many villagers were attracted to this livelihood activity (Persoon, 2007). It was found that there was higher number of households (38%) getting cash from Agarwood than any of the fruit trees (Fig. 3)like Banana, Papaya, Coconut, Thai-apple and others (Jack-fruit, Custard apple, Plum, Mangoes, Wood apple, Longan, Litchi, and Guavas). However, domestic consumption was high in these cases except jackfruit which was a cash earner to only one household. Since this household had plenty of jackfruit trees it had initiated jackfruit processing but the income was very low as compared to Agarwood.

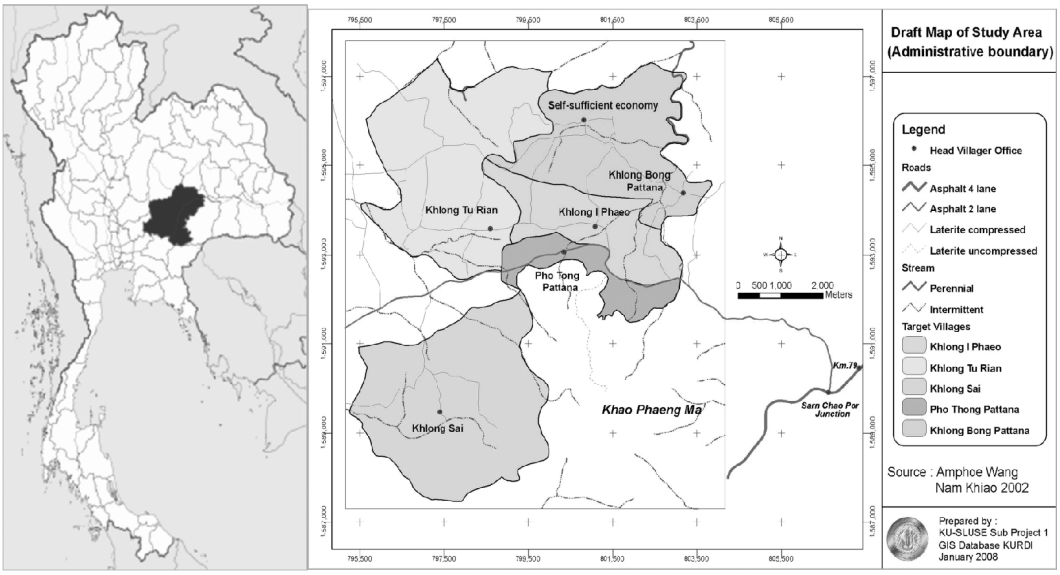

Figure 1: Location of Nakhon Ratchasima Province in Thailand and the Village Map of Study Area Ban Khlong Sai (green) and Neighbouring Villages: Ban Khlong Tu Rian (yellow), Ban Khlong Bong Pattana (blue), Ban Khlong I Phaco (purple) and Ban Pho Tong Pattana (orange)

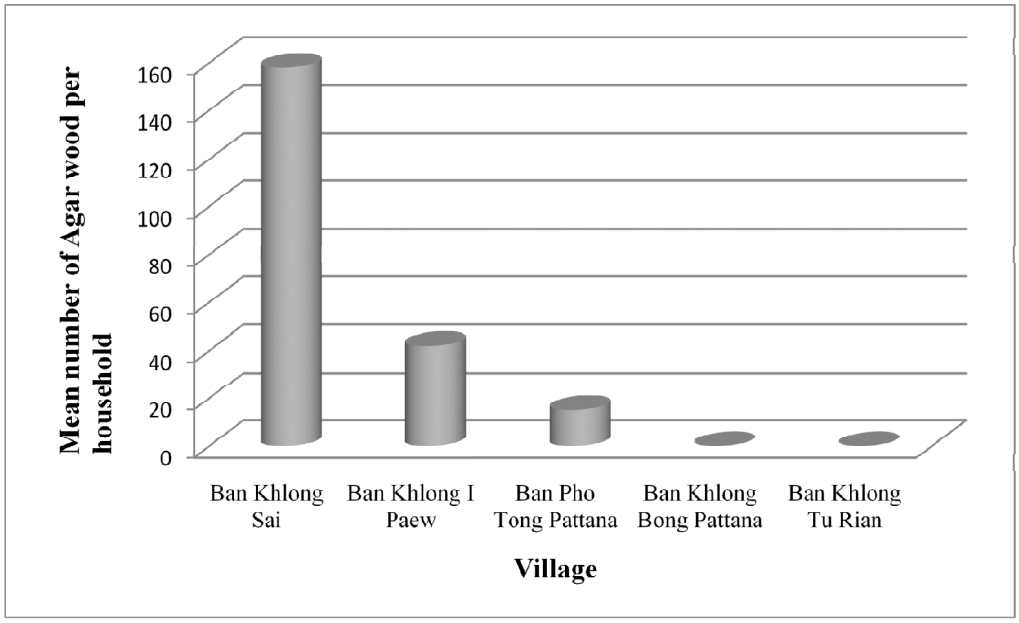

Figure 2: Mean Number of Agar Wood Trees Per Household in each of the Five Villages Studied in Nakhon Ratchasima Province

Another source of household income was agriculture, in which cassava and maize were grown on bigger farms, since these two crops were comparatively high yielding and relatively more tolerant to water stress than others. Apart from these, wage labour and town jobs were important strategies of the people in BKS.

Out of the above options Agarwood production and wage labour were considered the most important occupation in the village (Fig. 4). This was supported by the fact that wage employment often improved the standard of living. Combining plantation or farm activities with wage labour provided a temporary financial relief especially in times when the demand for cash was high for example, paying school fees and expenditure of customary ceremonies (Koczberski *et al*., 2001).

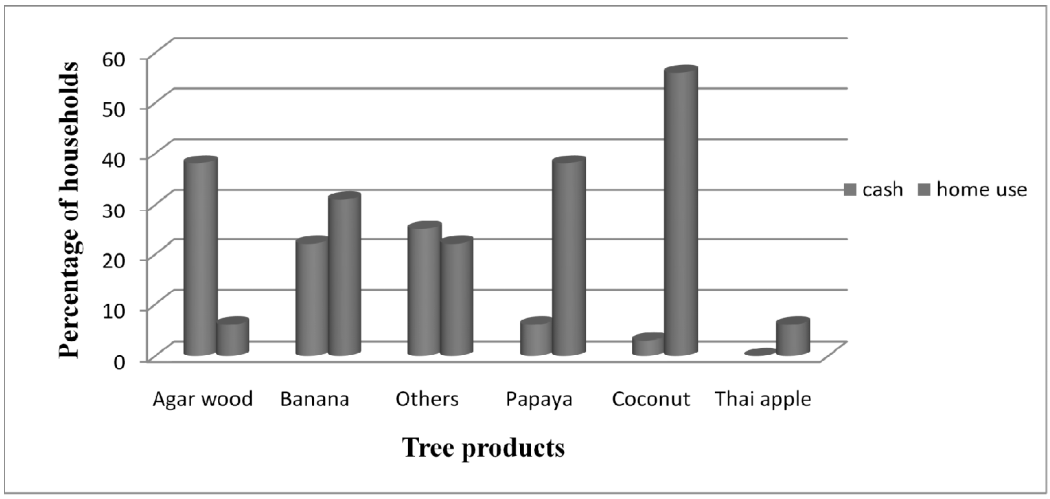

Figure 3: Shows Percentage of Households that used Different Trees Products for Income and or Home Consumption

The farmers having bigger Agarwood plantations or nurseries did not engage in wage labour activities but those having smaller plantations or trees in a home garden were found engaged in wage labour. The latter also worked at construction sites, tourist camps, someone else's farm/plantation and petty engagement in the nearby city . There was a higher number of people working either on their own plantation or off-farm than those working on others' farms (Fig. 5).

Very few households had pigs, chicken and ducks but none had cattle, goats or sheep. A possible reason for this was the non-affordability of stall feeding material, to which was added the scarcity of outdoor fodder. It was also observed that most of the grass, whatever little growing in the field, was dry. All this was linked to water scarcity and frequent occurrence of drought reported by the majority of the respondents (66%).

Agarwood was grown in BKS in two distinct ways: (i) small scale plantations and (ii) large scale monoculture or, in a few cases, mixed with other species. A majority of households

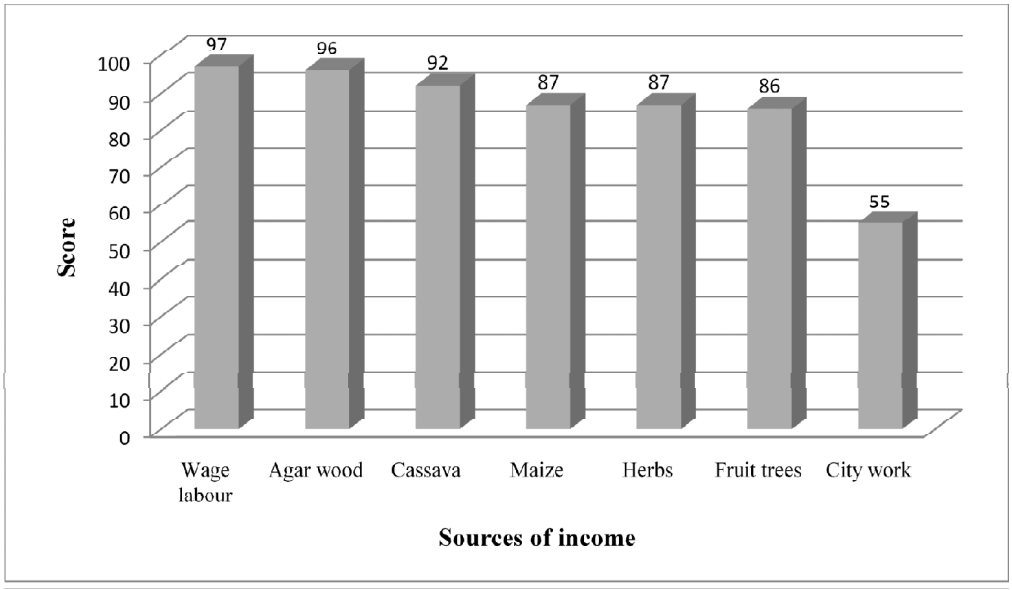

Figure 4: Preference Ranking Scores of the Different Income Sources used by Villagers in Ban Khlong Sai

grew this species in limited number in their home gardens along with other trees, predominantly fruit-yielding species. This strategy was evolved in the village, possibly because home gardens are believed to produce a number of benefits to families, ranging from improving nutrition to providing a source of additional income (FAO 2008). Large scale planting was adopted by a limited number of rich households in contrast to small scale plantation holders who were plenty in number. Due to these contrasting systems, the number of Agarwood trees per household varied from 2 to two thousand. However, irrespective of the number of Agarwood trees almost all the owners resided in the village and there was almost no evidence of absentee landlordism, except in one case of a big plantation owner living in another province.

Several useful species were, randomly, planted in home gardens to meet the need for food (fruit trees), medicine (herbs), spices, vegetables, floss (Kapok), fibre (*Agave*) and ornamental plants. Almost all the species were for home consumption, except Agarwood which was meant for cash income. Sometimes fruit products were gifted to relatives or friends or neighbors when production was higher than self consumption. Chicken, duck and pig rearing formed a part of the home garden and was also aimed at home consumption hence not for sale. Seedlings for Agarwood planting were procured from the market or the locally raised nurseries, but not collected from the forest since it was prohibited by law. Drought condition was a general problem in the village especially for home garden owners. It had caused mortality at young stage of Agarwood plantation, in one instance as high as 80 percent. Trees are almost maintenance free after establishment and did not require irrigation

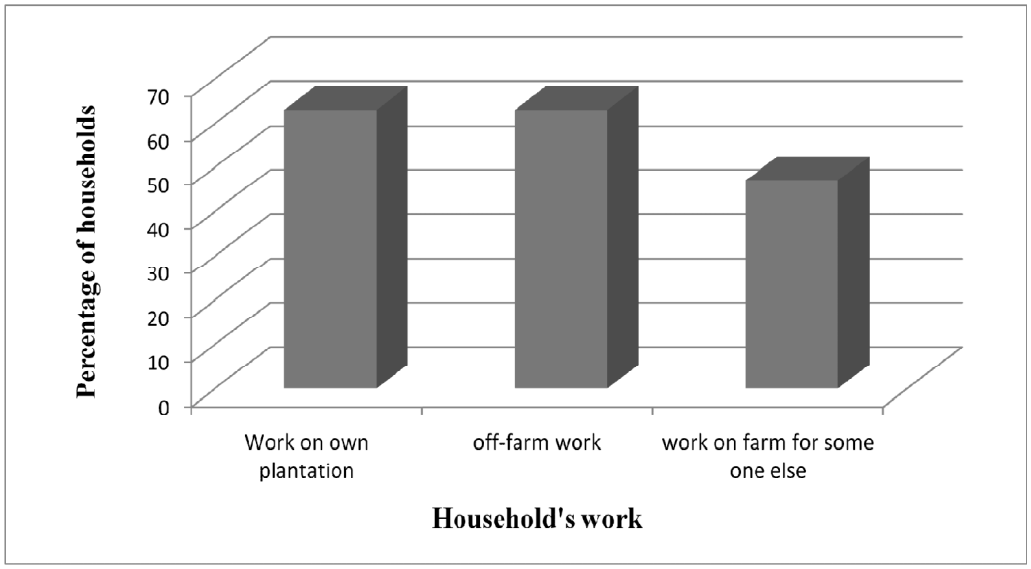

Figure 5: Percentage of Households that Worked on their Own Plantation, off-farm (Construction Sites, town Jobs and others) or on some one else's Farm

after initial couple of years. Therefore, shortage of water for irrigation might also be the reason behind why mainly the trees formed the largest part of home gardens. The growing of vegetables or annuals in home gardens was limited to a few plants. Large scale sowing was not done because it would require irrigation facility. However, tap water was used for irrigating seasonals and annuals in home gardens during very dry period. Fertilizers were not used and pruning was not done in order to minimize costs.

It was also discovered that many households depended on various combined means of living like, Agarwood trees and fruit trees, agricultural crops and at the same time some members were doing off-farm work. This confirms earlier reports according to which in many countries, especially in the developing world, local people in rural areas combine both subsistence and income generating activities in various ways to meet their basic needs (Leach *et al*., 1997; Margolius and Salafsky, 1998 in Walker *et al*., 2001). Walker *et al.*, (2001) discussed this further to illustrate that livelihood decisions are strategic and dynamic, based on changing relationships among people, their opportunities for access to, and control over, use of local resources, and their capacity to make use of those opportunities for subsistence and/or income generating purposes. However, the main goal of livelihood strategies is to ensure the household's economic and social security (Koczberski *et al.*, 2001) by combining together different options in the village.

Agarwood as Livelihood Option in BKS

To asses or evaluate the sustainability of a livelihood option one should look into the opportunities it offers and it's constraints in terms of economic, ecological and social aspects

(Sneddon, 2000; Vierikko *et al*., 2008). A host of such opportunities and constraints were encountered by the people engaged in Agarwood activities in BKS, which could be categorised into economic, social and ecological aspects. These are discussed in following paragraphs.

Economic Aspect

The most important driving force for Agarwood planting was the high income from its products like bark, leaves, core, eyes, trunk, wood chips, wood peels, seedlings, oil etc. Raw material availability of such high value products in BKS attracted the attention of potential investors from a number of countries (Persoon, 2007) giving a further boost to Agarwood planting in the area. The data presented in Table 1 suggested that the range of oil production could be 0.8 to 13.76 kg per hectare from the plantations aged between 5 to 12 years and can generate very high income. This was substantiated by Sidik (2008) that agar oil sells at very high prices as the traders quoted it as high as US $30,000 per kilogram of highest quality agar oil. Lower grade oil was quoted at US $5,000 to 10,000. However, the word of caution is that the income estimated in the present study was based on many assumptions, and some factors like natural calamities, diseases, fire, market risks etc. were not discounted. Nevertheless, the opinion of a household head, who narrated that Agarwood planting, was an excellent economic opportunity and helpful in uplifting the economy of the village, was significant. This was supported by Blanchette (2007) to the extent that production of fine quality Agarwood material in young plantations and home gardens could provide improved economic status to rural farmers throughout the world wherever *Aquilaria* is grown.

Table 1
Plantation Attributes, Productivity Assessment and Estimated Income from Agar Oil

Age of the plantation (years)	*Spacing (m^2)*	*Number of Trees (ha^{-1})*	*Basal area (m^2ha^{-1})*	*Volume (m^3ha^{-1})*	*Bole wood mass (ton ha^{-1})*	*Oil content ($kgha^{-1}$)*	*Estimated income in US $, base year 2008*
Five	1.5x1.5	4444	7.65	14.3	4.01	0.80	19200
Six	1.3x1.3	5917	13.98	24.9	6.99	1.39	33360
Seven	2 X 1.5	3333	28.28	80.1	22.42	4.48	107520
Twelve	3m row	1111	59.6	245.7	68.80	13.76	330240

By comparing the annual income from Agarwood with other trees and crops growing in BKS and nearby areas (Jackfruit, Cassava, Tomato and Maize), as narrated by the villagers, it was evident that income from the former was much higher. This was the main reason the villagers went after it. Another incentive was the availability of credit facility with the Bank of Agriculture and Agriculture Cooperative and the access to loans to make an initial investment in Agarwood plantation by the villagers.

The impediments to the advancement of the Agarwood industry included the non-availability of an oil distillation factory in the village or a close by area which resulted in the

long distance transport of Agarwood to the neighbouring province of Prachin Buri for oil extraction. This constraint resulted in the entry of middlemen or commission agents who exploited the farmers. The Role of middlemen in minor forest products business was also confirmed by te Velde (2006). Furthermore, low investment capacity of the villagers was a limiting factor towards increasing the scale of Agarwood production and the quality of products. Another important issue was the availability of credit of small amounts, that too, sometimes, with restriction of use on agriculture activities only.

Ecological Aspect

Afforestation activity is known to sequester carbon and in turn reduce the impact of green house gases in the environment or global warming (Andrasko, 1990; Kyrklund 1990). Carbon sequestration rates vary from species to species and depend upon the age of plantations. A Twelve year old plantation of Agarwood stored more than 7 ton C per acre per year. This is higher than a *Pinus* plantation (one ton C per acre per year, Birdsey 1996 quoted in USEPA, 2008a). Reduction in frequency and intensity of tillage operation required in agriculture reduces carbon emission; therefore, planting of Agarwood trees in an agriculture land of low productivity could be useful from this angle.

Trees and native vegetation improve the soil beneath them as organic matter, nitrogen and other nutrient content are comparatively higher (Nair, 1993; Roy *et al*., 2010) in the plantation area. The soil sample data in the present study was not adequate enough to clearly indicate the trend in tree covered land versus annual cropping land as nitrogen, phosphorus and potassium level was similar in both types of land use. Young age plantations are reported to have no impact on phosphorus content of the soil (Zeng *et al*., 2010). However, it was indicated in the present study that the pH level was less acidic in tree covered land as compared to cassava and maize cultivated land.

Another ecological opportunity was the automatic conservation of the natural stock of Agarwood trees and associated biodiversity in the bordering National Park since the supply of raw materials to the Agarwood business was met from the plantations raised in the village outside the Park boundary. It was confirmed by the functionary of the National Park during an interview that there had been almost negligible illegal activities like tree felling and seedling theft in the forest for the past several years.

Yet another favourable ecological aspect of Agarwood planting was the lower requirement of water and nutrients than maize and other crops. Since the villagers experienced frequent drought and had nutrient poor soil they adopted tree planting strategy on their land, at least in small numbers, in anticipation of ecological suitability and as a new income source. Some farmers also informed that they were abandoning traditional cultivation of cassava and maize in favour of Agarwood.

Although in the long run Agarwood was less water demanding than maize, nursery seedlings and young plantings needed a lot of water during initial 2-3 years, otherwise, the survival rate would be generally affected. In BKS, only the big producers had access

to artificial ponds and irrigation systems but small holders were simply dependent on the rain.

Yet another concern was the risk from monoculture, which might get enhanced if the Agarwood business developed extensively in BKS. However, during the study it was noticed that the practice of mixing banana and other crops with Agarwood was adopted to make the crop as diversified plantation system.

Social Aspect

There were a number of social aspects in the promotion of Agarwood, like low labour requirement in planting and non-intensive care after establishment. This opened the opportunity of diverting the labour resource of the family to other activities that could earn more income to the household in addition to managing Agarwood trees. It was learnt that experts and researchers from Kasetsart University, Bangkok were involved in attending Agarwood problems and were conducting research on different aspects of improvement. This was useful in the sense that the villagers were getting proper management input.

Another positive issue in the Agarwood industry included the presence of the Agarwood Union engaged in the identification of good markets, lobbying for funding from national and international organizations, and advocating changes in Agarwood related policies. It was reported by the villagers that powerful stakeholders (the people's representative) were engaged in the amendment of a law to get rid of restrictions imposed upon farmers for cutting, transporting and selling of Agarwood products, and to make the business hassle-free.

Once the plantation was done the villagers had to wait for few years until revenue started flowing in. However, this gap was filled by a few villagers by raising an Agarwood nursery for seedling sale in order to get a regular income. The most positive social impact of Agarwood business was that it created more work and new income source in the village resulting in the villagers staying home instead of moving to Bangkok and other cities.

The Villagers used to see the long harvesting cycle of Agarwood plantation as an incentive to help them claim tenure ship on PBT-5 category of land on account of long time use - which otherwise could not have been owned by the villagers. In other words, the possibility to acquire landowner status was limited except if one could prove its long term use. This way PBT-5 could be upgraded to NS-3, another kind of land tenure, which was a more secure land title and could be sold and bought and used to take loans from the bank. Otherwise also tree plantation helped an absentee landlord to maintain their claim on the land.

Another incentive to Agarwood production was the partial support from the government which promoted Agarwood, in particular, and tree plantations in general, as a part of their reforestation policy in the villages.

The constraints identified were: a lack of well defined protocol of oil induction in healthy trees, Thai Factory Act 2535 legislation prohibiting transport of Agarwood without permission by the government, ban on direct sale of uncertified products etc. Another impediment was the uncertain future, since the business was young and there was lack of research input to commercial scale plantations.

An additional issue was the restriction on exploitation and export or import due to endangered status of *Aquillaria malaccensis*, attracting the provisions of an international agreement, CITES. However, indigenous activities also, like tree felling and local transport, were suffering from middleman wageries of burdening the villagers with reduced profit in lieu of the favour offered by them.

The most important opportunities and constraints considered by the villagers while doing the preference ranking are presented in Fig. 6 and Fig. 7. Despite some of the constraints Agarwood production was a promising and attractive intervention to many people in the area. The relative advantage of Agarwood cultivation over agriculture listed in Fig. 8 was the guiding force for change in an age old system of livelihood. For example, farmers needed to invest every year in sowing and harvesting agriculture crop, while in the case of Agarwood there was a gap of several years between plantation establishment and harvesting. Meanwhile, the households strategically deployed their human capital across locations and economic sectors to increase income, access financial capital and minimize risks (Sherbinin *et al.*, 2008).

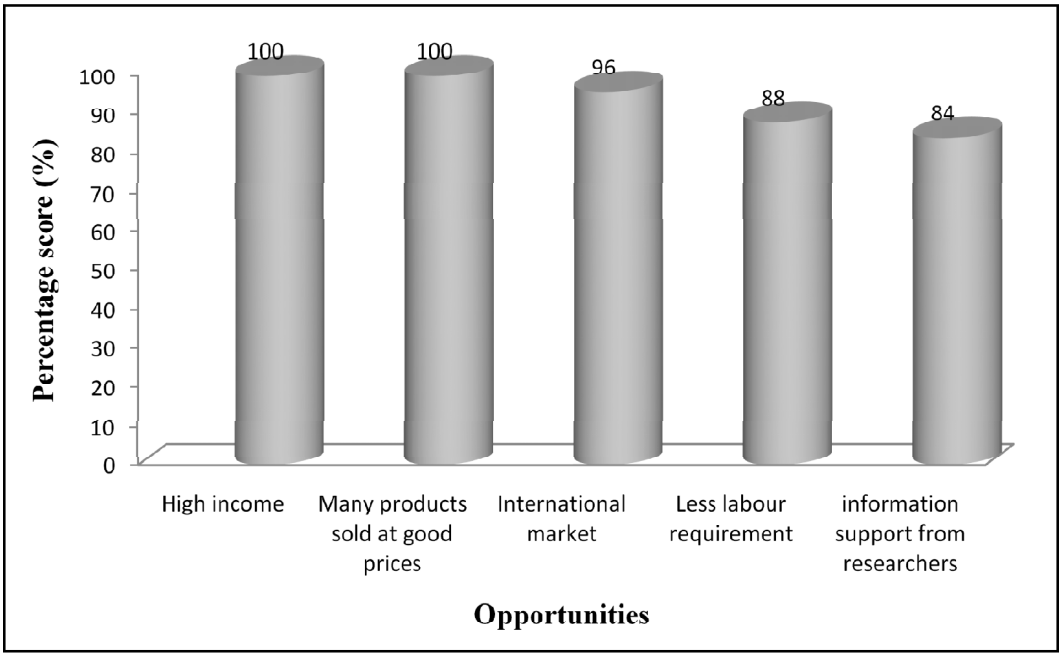

Figure 6: Ranking of Opportunities for Development of Agar Wood Plantation

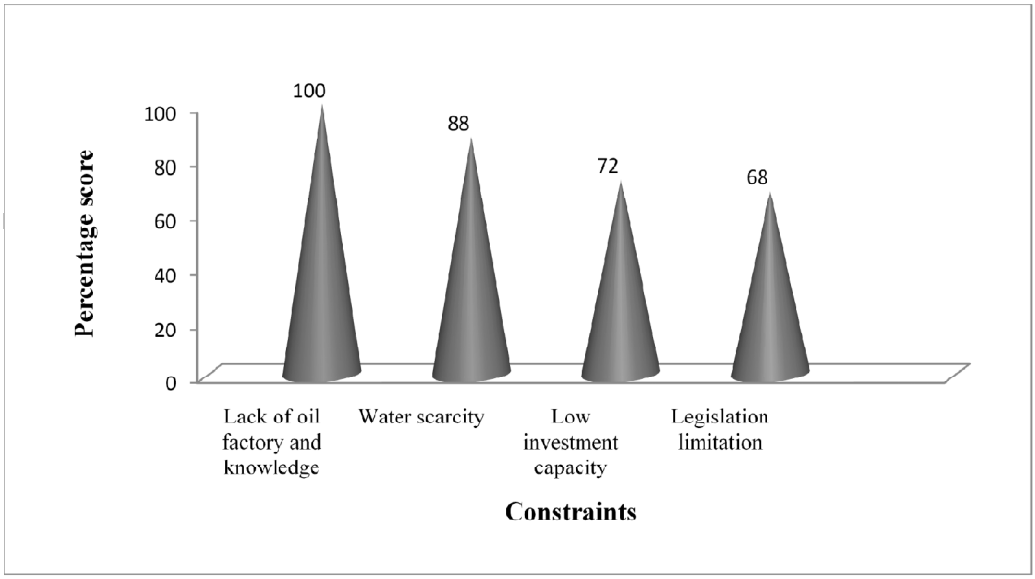

Figure 7: Ranking of Constraints for Agar Wood Plantation

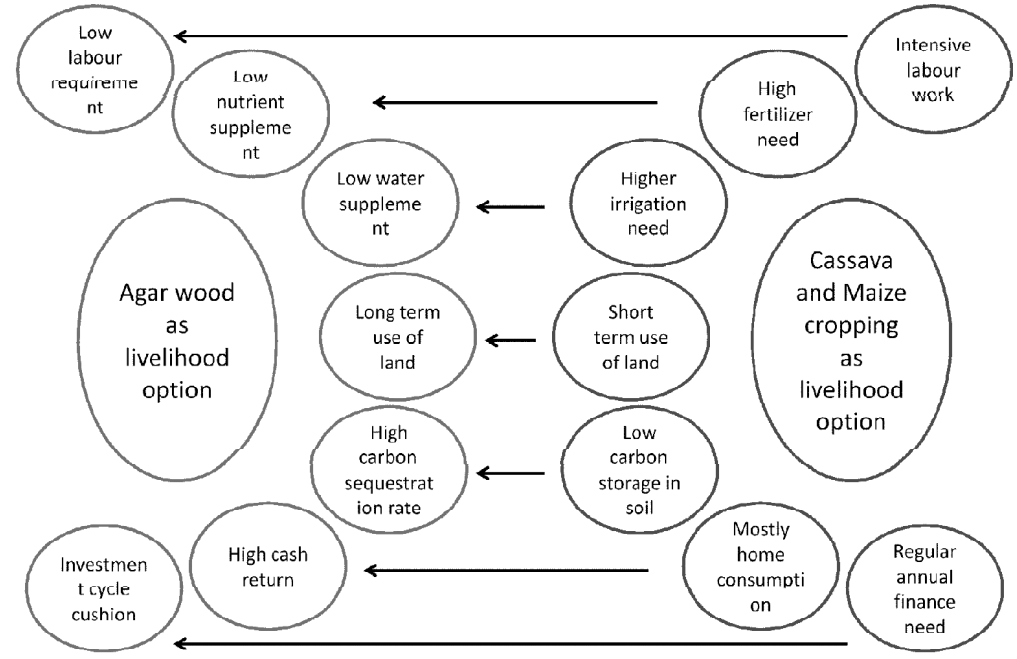

Figure 8: Relative Advantages or Disadvantages of Two Systems in BKS Indicating Shift from Agriculture to Agarwood Livelihood Option

CONCLUSION

Although commercial planting of Agarwood was a new venture in BKS it had already created an impact as a livelihood strategy. It was amply evident during the study that this was taking over the earlier strategies indicating the dynamism in the livelihood evolution process. This concurs with the theory of Rosen (1975), Shanin (1990) and Seneduangdeth (2005) that social activities of the peasants change over time in the process of developing their livelihood and social status.

Wage labour employment, Agarwood plantations, maize and cassava cropping, herbs production and work in the city were the main sources of income of the villagers. However, Agarwood planted in home gardens and large scale plantations in BKS was very important to them on account of economic, social and ecological benefits. The income from Agarwood was really significant and stable, especially to those who owned relatively big plantations and seedling nurseries. Among all the Agarwood products, oil was the most expensive. A high demand of the products in the international market made this enterprise very attractive. A high income from the planting endevour also attracted many people to adopt Agarwood planting coupled with the government's promotion of tree plantations, on-going research projects in the village and low labour requirement. More so, frequent occurrence of drought, water shortage and poor soil were the main environmental factors that encouraged people to adopt tree plantations, especially of Agarwood, in lieu of agriculture farming.

Besides the facts that make Agarwood plantation and its produce attractive, there were pressing factors which hinder further the development of this strategy. The most important ones included the lack of an oil factory in the nearby area and the lack of a standardized procedure to induce *Aquilaria* trees to pathogen infection to form Agarwood oil, low investment capacity of the villagers, water scarcity and stringent legislation in terms of transportation and certification to sell Agarwood products.

To sum it up, Agarwood was a genuine opportunity of diversification in order to uplift people's livelihood condition in BKS. The removal of constraints might have an added advantage in the further development of the venture.

References

Andrasko, K. (1990), Global Warming and Forest: An Overview of Current Knowledge. *Unasylva*: 41(163): 3-11.

Anon. (2008), *Agarwood/Aloeswood*, Viewed on 11 August 2013. *http://www.equitech.biz/equitech_Silviculture.asp?status=SubGroupData&SubMainId=7&SubGroupId=14&TypeTable=3*

Barden, A., Awang, A. N., Mulliken, T. and Song, M. (2000), Heart of the Matter: Agarwood Use and Trade, and CITES Implementation for *Aquilaria Malaccensis*. TRAFFIC Network Report 46: 17-18.

Blanchette, R. A. (2007), Successful Production of Cultivated Agarwood ; A New Economy for Poor Rural People using Green Technology. Abstract. Second International Agarwood Conference, Bangkok-Chantaburi-Trat Koh Chang. March 4-11, 2007, Kingdom of Thailand.

Chakrabarty, K., Kumar, A. and Menon, V. (1994), *Trade in Agarwood*, Viewed on 11 August 2013. Traffic India and WWF India, New Delhi 51p. *http://www.forest.sabah.my/download/2006/22i%20Gaharu.pdf*

Chamling, K. D. (1999), *Essential Oils*, Viewed on 11 August 2013. Traditional paper, essential oils, rosin and turpentine. Non-wood forest products of Bhutan. The Food and Agriculture Organization of the United Nations, Bangkok. *http://www.fao.org/docrep/X5335e/x5335e06htm#essential%20oils*.

Chen, H., Yang, Y., Xue, J., Wei, J., Zhang, Z. and Chen, H. (2011), Comparison of Compositions and Antimicrobial Activities of Essential Oils from Chemically Stimulated Agarwood, Wild Agarwood and Healthy *Aquilaria Sinensis* (Lour.) Gilg trees. *Molecules*: 16:4884-4896.

FAO. (2007), *State of the World's Forest*, Viewed on 11 August 2013. Food and Agriculture Organization of the United Nations. Rome: Italy.

Gunn, B., Stevens, P., Singdan, M., Sunari, L. and Chatterton, P. (2003), *Eaglewood in Papua New Guinea*, Viewed on 15 March 2008. RMAP working paper no 51. Resource Management in Asia Pacific. Firat International Agarwood Conference TRP Vietnam. November 2003.*http://rspas.anu.edu.au/papers/rmap/Wpapers/rmap_wp51.pdf.*

http://umpir.ump.edu.my/659/1/Nurdiyana_Abu_Bakar_Sidik.pdf

http://www.fao.org/docrep/005/ac625e/ac625e10.htm

http://www.fao.org/docrep/009/a0773e/a0773e00.htm

http://www.iias.nl/nl/45/IIAS_NL45_2425.pdf.

Jensen, A. (2009), Valuation of Non-timber forest Products Value Chain. *Forest Policy and Economics:* 11: 34-41.

Knowler, D. and Lovett, J. (1996), *Training Manual for Environmental Assessment in Forestry*, Viewed on 15 March 2008. Department of Environmental Economics and Environmental Management, University of York, Heslington, York, U.K. Y01 5DD.

Koczberski, G., Curry, G.N. and Gibson, K. (2001), Improving Productivity of the Smallholder Oil Palm Sector in Papua New Guinea. RSPAS, Australian National University. pp. 41, 42 & 46.

Kyrklund, B. (1990), The Potential of Forests and Forest Industry in Reducing Excess Atmospheric Carbon Dioxide. *Unasylva :* 41(163) : 12-14.

Leach, M., Meams, R. and Scoones, I. (1997), Challenges to Community-based Sustainable Development. IDS Bulletin, 28(4).

Margoluis, R. and Salafsky, N. (1998), Measures of Success: Designing, Managing, and Monitoring Conservation and Development Projects. Island Press, Washington DC 362p.

Nair, P. K. R. (1993), *An Introduction to Agroforestry*. Kluwer Academic Publisher. London. 499p.

Persoon, G. A. (2007), *Agarwood: The Life of a Wounded Tree*, Viewed on 15 March 2008. IIAS News Letter no. 45. Autumn 2007. pp. 24-25.

Rosen, G. (1975), *Peasant Society in a Changing Economy: Comparative Development in Southeast Asia*. Urbana, University of Illinois Press 256p.

Roy, K., Samal, N. R., Roy, M.B. and Mazumdar, A. (2010), Soil Carbon and Nutrient Accumulation under Forest Plantations in Jharkhand state of India. *Clean - Soil, Air, Water:* 38: 706-712.

Seneduangdeth, D. (2009), Rural Development and Strategies for Sustainable Agrarian Livelihood: A case study of Ban Huaxieng Xaithain district, Vientiane capital, Lao PDR. *Development and Society:* 38:165-199.

Shanin, T. (1990), *Defining Peasants Essays Concerning Rural Society, Exploratory Economies and Learning from them in Contemporary World*. Oxford, UK: Basil, Blackwell.

Sherbinin, A., Wey, L.K.V., Mc Sweeney, K., Aggarwal, R., Barbieri, A., Henry, S., Hunter, L.M., Twine, W. and Walker, R. (2008), Rural Household Demographics, Livelihoods and the Environment. *Global Environmental Change*: 18: 38–53.

Sidik, N. B. A. B. (2008), *Comparison of Gaharu (Aquilaria Malaccensis) Essential Oil Composition between Each Country*, Viewed on 11 August 2013. Faculty of Chemical Engineering and Natural Resource, University Malaysia Pahang.

Sneddon, C. S. (2000), 'Sustainability' in Ecological Economics, Ecology and Livelihoods: A Review. *Progress in Human Geography:* 24: 521–549.

Steimann, B. (2005), Livelihood Strategies in North-West Pakistan. IP6 Working Paper No. 5. Development Study Group, Department of Geography, University of Zurich, Winterthurerstr. 190, CH-8057 Zurich, Switzerland te Velde, D.W., Rushton, J., Schreckenberg, K., Marshall, E., Edouard, F., Newton, A. and Arancbia, E. 2006. Entrepreneurship in value chains of non-timber forest products. *Forest Policy and Economics;* 8:725-741.

USEPA. (2008a), Carbon Sequestration in Agriculture and Forestry. Internet document. *http:// www.epa.gov/sequestration/faq.html*

USEPA. (2008b), Stem form and taper. *http://sresassociated.anu.edu.au/mensuration/ BrackandWood1998/SHAPE.HTM*

Vierikko, K., Vehkamaki, S., Niemela, J., Pellikka, J. and Linden, H. (2008), Meeting the Ecological, Social and Economic Needs of Sustainable Forest Management at a Regional Scale. *Scandinavian Journal of Forest Research:* 23: 431-444.

Walker, J., Mitchell, B., Wismer, S. (2001), Livelihood Strategy Approach to Community based Planning and Assessment: A Case Study of Molas, Indonesia: Impact Assessment and Project Appraisal, volume 19, number 4, Beech Tree Publishing, Guildford, Surrey GU1.

Zeng, D., Mao, R. and Li, L. (2010), Restoration Effects of Young Plantations on Magnesite Mine Spoil in North China. International Conference on Bioinformatics and Biomedical Engineering. 18-20 January 2010. Chinese Academy of Science, Shenyang China. pp 1-5.