Agar (*Aquilaria malaccensis* Lam.): a promising crop in the homegardens of Upper Assam, northeastern India

P. Saikia* and M.L. Khan

Department of Forestry, North Eastern Regional Institute of Science and Technology, Nirjuli 791109, Arunachal Pradesh, India

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Abstract

One hundred and thirty five randomly selected homegardens were surveyed in the Golaghat and Jorhat districts of Upper Assam to assess the economic prospects of agar (*Aquilaria malaccensis* Lam.) cultivation and the socioeconomic background of the growers. Almost 50% of the households had agriculture as the main vocation and all households practiced homegardening, despite variability in garden size based on socioeconomic factors. Homegarden products including agar and tea contributed to 1 to 45% (mean 14% ±1.15) of the total annual income of the family. Returns from agar to an individual family ranged from Rs 3,000 (US$ 60: from 10 trees after 10 years) to 9,00,000 (US$ 18,000: from 500 trees after 20 years) with an average of Rs 1,14,393 (US$ 2,288: from 106 trees after 13 years). Low input needs and flexibility in site requirements as well as suitability for intercropping make agar a preferred cash crop in the homegardens of Upper Assam.

Keywords: Economic returns; Agar oil; Socioeconomic status

Introduction

Several plant species grow together in the homegardens and their occurrence and abundance largely depend on local demand for the plant product, ecological conditions of the region, and the scope and economic potential of the species (Kumar et al., 1994). Agarwood is one of the most promising commercial products of the world and it has considerable economic importance. It is traded in several forms, from roundwood to processed products such as incense and perfume. In the past few years, the price of agarwood increased tremendously. *Aquilaria malaccensis* Lam. is the best known species of agarwood and its large-scale harvesting has caused rapid depletion of the stock in the natural forests. Consequently, it is listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1994) to ensure sustainable harvesting. The species is globally *vulnerable* according to the IUCN red list, and has been included in The World List of Threatened Trees (Oldfield et al., 1998). This species is considered *critically endangered* in India (IUCN, 2009) and almost *extinct in the wild* in Assam (Anonymous, 2003).

Sustainable agarwood production to support socioeconomic development and conservation of the species in its natural habitat is possible only through domestication of the wild species (Kumar 2008). The economy of Upper Assam is agriculture-based and homegardens are a prominent land use system of the state (Devi and Das, 2010). Although rice (*Oryza sativa* L.), sugarcane (*Saccharum officinarum* L.) and tea (*Camellia sinensis* (L.) O.

*Author for correspondences (Present address): Department of Environmental Science, Tezpur University, Napaam-784028, Tezpur, Assam, India; Cell +91-94360-93716; Email <purabi.saikia83@gmail.com>.

Kuntze) are the major crops of the region, of late, many homegardeners have started growing agar for greater returns and the species has become an important plantation crop of Upper Assam. The origin of agarwood business in Assam dates back to the 1930's when a few enterprising families from the then Sylhet district (now in Bangladesh) adjoining the Golaghat district (Nahoroni area) of Assam (Padma Konwar, pers. comm. March 2008) started its trade. The business then slowly got shifted to Golaghat, parts of Jorhat and Hojai of Nagaon districts (Assam), and presently these districts have become important loci for small-scale agarwood chip preparation and oil extraction. The business is most popular among the Muslim community and has become a major source of income in Naharani, Kabarugaon (Golaghat), Kakojan (Jorhat), and Hojai (Nagaon). Growers generally sell standing trees to the local traders, who in turn, sell the wood and wood-chips to the agar oil extraction industries. These local and small-scale traders generally sell agar oil or perfume either in the local markets or to the Ajmal Group of Companies, the largest exporter of agarwood oil to the Middle East.

Agar oil popularly known as 'Attar' is an essential oil extracted from the infected woody parts of *Aquilaria* trees. Although, the process of oil formation is not yet fully understood, it is perceived to be formed by the reaction of the trees against fungal infection or injuries caused by boring insects, or even manmade wounds. Artificial wounding of tree trunk by nails or by cutting is common in Upper Assam, especially among the traditional growers, which may accelerate the oil forming processes. Factors such as tree age, seasonal variations in growth, and environmental and genetic factors may also play an important role in oil formation (Ng et al., 1997). Very few studies have been undertaken on the socioeconomic aspects of agar production in the world. Uddin et al. (2008) explored the production, marketing, and industry problems of agar (*A. malaccensis*)-based enterprises and their potential contribution to socioeconomic development in Maulvibazar district of Bangladesh. They reported that a sustainable source of raw material, availability of technical and financial assistance, and opportunity for expansion of market facilities are essential to secure maximum benefits. Soehartono and Newton (2001), however, noted that agarwood trade in Indonesia is non-sustainable. A similar study by Chakrabarty et al. (1994) showed that overexploitation is a problem for *A. malaccensis* in India and it is highly threatened. Studies on socioeconomic aspects of agarwood production in India are rare. This may be because of the restricted distribution of the species and lack of attention. Other difficulties in studying the socioeconomic impacts of agar trade are problems in quantifying the volume traded, lack of respondents' knowledge about previous income levels, and reluctance of the respondents for information sharing. Considering the paucity of information on agarwood production in the homegardens of Upper Assam, we assessed the socioeconomic status of homegardeners with special reference to their economic returns from agarwood cultivation and analysed the potential of homegardens as a loci for domestication of agarwood.

Materials and Methods

Study sites

The study was conducted in selected homegardens of Golaghat and Jorhat districts of Upper Assam in north-eastern India (25°48' to 27°10' N; 93°17' to 94°36' E; Fig. 1). The sites are situated in the central part of Brahmaputra valley surrounded by Sibsagar and Dibrugarh districts on the east, Nagaon and Karbi Anglong districts on the west, Lakhimpur and Sonitpur districts on the north, and the state of Nagaland on the south. Climate of the region is tropical having a hot and humid summer (averaging 39.0°C during June-July) and a cool winter (averaging 9.0°C during December-January). Average annual rainfall of Golaghat and Jorhat districts is 1300 mm and 2244 mm respectively, most of which is received during June and July. The prominent indigenous communities of this area are *Konch, Kalita, Keot, Ahom, Sut, Mising, Chutia,*

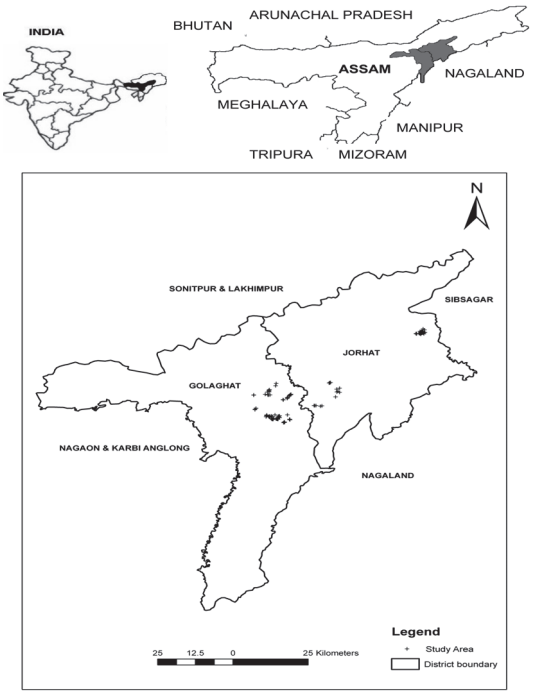

Figure 1. Map of the study site (Golaghat and Jorhat districts of Upper Assam) showing the locations of studied homehardens.

Kachari, Bodo, and the teagarden workers. The population comprises predominantly of Hindus; Muslims and Christians constitute the other segments of the society. Population densities of Golaghat and Jorhat districts are 302 and 383 per km^2 respectively (Census of India, 2011).

Methodology

The villages were selected based on informal knowledge about the areas where agar cultivation is widely practiced. Interviews were conducted in 135 randomly selected homegardens of Jorhat and Golaghat districts as well as with selected local traders during 2007 to 2010. Socioeconomic information was collected by interactive questionnaires focusing on years of agar cultivation, number of harvested trees, price of individual tree, and returns from it. Besides, information on the principal plantation crops, labour and fertilizer inputs, family size, literacy rate, main and subsidiary sources of income, and the number of individuals employed were gathered. Vegetation was studied using 10 x 10 m quadrats laid out in the fields covering a minimum of 30% area in each homegarden. Plant species were identified on the basis of vernacular names, published field inventories, floras, and by referring to the regional herbaria. Herbarium specimens were collected and deposited in the Department of Forestry, North Eastern Regional Institute of Science and Technology, Arunachal Pradesh. Standard error and correlation were worked out in MS-excel.

Results and Discussion

Socioeconomic background of the growers

Altogether 759 individuals, with an average family size of six were recorded from the 135 households surveyed. Of these, 50.6% were male and rest were female. Age distribution showed that 11% of total individuals were above 60 years, 43% between 25 to 60 years, 40% between 5 to 24 years, and the rest 6% were of less than 5 years of age. Literacy rate was 92.75% and it was highest among the 5 to 60 years age group. Major income sources included service (government and private sectors, including pensioners), business (including agar business) and agriculture (including homegardening). Agar-based homegardens were also identified as a potential income source of Upper Assam as agar on an average contributed 4% ± 0.46 of the total annual income of the family. Almost 50% households considered agriculture as the main income generating activity followed by service (37%) and business (13%). All the households practiced homegardening albeit the size of the homegardens were variable (range: 0.05 to 0.40 ha; mean 0.17 ha ± 0.01). In general, the homegardeners maintained their gardens for meeting the household requirements of fruits, timber, vegetable, ornamentals, and fuelwood; market-oriented production was of secondary importance. Animal husbandry, fishery, poultry and weaving

were also common as additional sources of income for some families.

Homegardening provides diverse products and benefits as well as space for working and socializing. In the present study, most of the homegarden products were used for household consumption and the surplus available was sold in the local markets. The most dominant and frequently occurring species were, however, the cash crops followed by fruit and timber trees (Table 1), cultivated for both domestic consumption and for sustaining the household economy. Agar and tea were the most commonly cultivated cash crops, found in 100% and 30% of the studied homegardens respectively. Besides, sugarcane, betel vine (*Piper betle* L.), black pepper (*P. nigrum* L.), *Citrus reticulata* Blanco., *Citrus* spp., timber yielding trees, and vegetables were also used for income generation by several garden owners. Consistent with the observations of Peyre et al. (2006), a shift from subsistence-oriented agriculture to market economy in many homegardens of the region was discernible in the study locations. High frequency and density of cash crops like agar, tea, bamboos (*Bambusa* spp) and betel nut exemplifies this phenomenon. The degree of dependence on the homegarden as a source of income was influenced by the plant species present. Homegarden products including agar and tea contributed a good amount of subsidiary income – 1 to 45 % of the total annual income of the family with a mean of 14% ±1.15, which is higher than the reported 7% average annual gross income per household of Meghalaya, Northeast India (Tynsong and Tiwari, 2011). Our results clearly highlight the potential of homegardens in Upper Assam to supplement income levels. Easy maintenance of homegarden plants by low input of organic manures and utilization of cow dung made homegardens an ecologically sustainable ecosystem, as well.

Economic potential of agar

Agar was the most common tree species (34% of the total tree density) in the studied homegardens of Upper Assam with highest density (1443 individuals ha^{-1}) and frequency (98%). Tree density of agar per homegarden ranged from 260 to 7913 individuals ha^{-1} with a mean of 1466± 86.98 individuals ha^{-1} (Table 2), which reflect a good stocking level of agar in the studied homegardens of Upper Assam. Agar contributed significantly to the economy of the local people and generated substantial income. The reasons for the high returns from agar are the high

Table 1. List of ten most dominant tree (>10cm GBH) species found in homegardens (HGs) of upper Assam, Northeast India.

Species	Density (individuals ha^{-1})	Frequency	Abundance (%)	IVI	HGs of occurrence (%)	Uses
Aquilaria malaccensis Lam.	1443	98	14.72	49.50	100	Cash crop
Areca catechu L.	554	74	7.45	24.94	97	Masticator, Cash crop
Artocarpus heterophyllus Lam.	35	25	1.42	5.49	73	Fruit, Timber
Bambusa spp.	1426	15	95.51	35.84	53	Cash crop, Miscellaneous use
Carica papaya L.	35	19	1.85	3.95	59	Fruit, Vegetable
Cocos nucifera L.	26	18	1.44	4.39	56	Fruit, Cash crop
Mangifera indica L.	63	36	1.75	7.79	85	Fruit, Timber
Musa spp.	287	55	5.22	15.62	85	Fruit, Vegetable, Cash crop
Psidium guyava L.	17	1	2.50	12.42	47	Fruit
Tectona grandis L.	25	10	2.59	2.84	30	Timber

cost of the product and lower inputs in terms of labour and fertilizer for its management. Garrity and Mercado (1993) also suggested that smallholder-based reforestation approaches have advantages over large-scale, estate-based schemes, due to savings in variable costs, mostly labour. Density of agar in the homegarden was not related to size, but was dependent on the owner's preference. On the whole, agar is a species with great economic prospects in Upper Assam. The tree is harvested based on its age, size, infection, and product and harvesting may provide employment to the rural people.

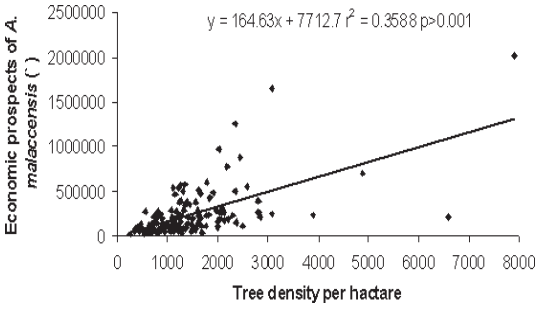

Figure 2. Relation between the tree density and economic prospects of *Aquilaria malaccensisnm* in Golaghat and Jorhat districts of Upper Assam.

Returns from agar were dependent on the abundance and density of trees in the homegardens (Fig. 2). Indeed, tree density had significant effect on earnings ($r^2 = 0.3588$, $p < 0.001$) and with increase in agar tree density, earnings increased. Agar starts resin formation by about five years of age and resin accumulation increases with age. Although harvesting time generally ranges from 5 to 50 years and the value of the product increases with the age of the tree, in Upper Assam, agar is harvested from 5 to 30 years. According feedback from the respondents, price of a single tree varied from Rs 150 (UD$ 3) to 40,000 (US$ 800) to Rs 1,00,000 (US$ 2,000) based on resin yield. During the study period, a total of 107 (79%) sampled homegardens generated income from agar and it varied greatly based on the number of harvested trees, age of the trees, and resin recovery.

The incentives from agar by individual family depend mainly on its rate of infection, abundance, density, and age of tree. Therefore, homegardens having high abundance of mature agar with high quality products gave higher incomes than newly established ones with less abundance and low infection rates. Although, larger homegarden is economically sustainable and signifies better economic and social status of the owners, in our study, size of homegarden *per se* did not affect the population density of agar. Most of the owners were not economically sound and they sold agar during

Table 2. Details on income generation and future economic prospects of agar cultivation in homegardens of upper Assam, Northeast India.

Parameter	Range	Mean (± SE)
Homegarden size (ha)	0.05 – 0.40	0.17 ± 0.01
Cultivation of agar in homegardens (year)	5 – 30	12 ± 0.59
Harvested trees (number) by 79% owners	6 – 500	106 ± 9.24
Total money earned (Rs) by 79% owners	3,000 – 9,00,000	1,14,393 ± 14,896
Price of individual tree (Rs)	270 – 2,000	950 ± 43
No. of trees yet to be harvest (number)	34 – 2,117	251 ± 19.63
Density of agar (>10cm GBH) in homegarden (individuals ha^{-1})	260 – 7,913	1,466 ± 86.98
Approximate amount of money to be earned (Rs)	28,986 – 20,08,238	2,49,090 ± 23,908
Total annual income contributed by agar (%)	0– 20	4 ± 0.46
Total Annual income contributed by homegarden products including agar and tea (%)	1– 45	14 ± 1.15

a financial crisis without considering its actual market value (distress sale). Therefore, incentives derived from agar fluctuated among families and it ranged from Rs 3,000 (US$ 600; from 10 trees after 10 years) to 9,00,000 (US$ 18,000; from 500 trees after 20 years) with an average of Rs 1,14,393 (US$ 2,287.86; from 106 trees after 13 years).

This variability in returns from agar in different homegardens is the result of complex interactions among many factors including yield, cost, age of the tree or year of cultivation, transport, bargaining capability, and control over markets. Experienced traders generally estimate the rate of infection and resin recovery even in standing trees with ease and determine the prices. The average cost of individual tree varied in different homesteads from Rs 270 (US$ 5.4) to 2,000 (US$ 40) with an average of Rs 950 (US$ 19). Economic prospects of agar in homegardens of upper Assam is calculated from the total number of trees present per homegarden and the average cost of a mature tree, which ranged from Rs 28,986 (US$ 580) to 20,08,238 (US$ 40,165) with an average of Rs 2,49,090 (US$ 4,982). It shows that agar based homegardens in upper Assam are financially rewarding and can generate significant amount of money for sustaining the economy of the region. Agar has been traded from the homegardens of Upper Assam for the past 30 years suggesting that populations of agar have been able to tolerate high harvesting pressure over long term. However, it appears that the extent of the agar trade has increased markedly in recent years.

Employment prospects and improved economic opportunities for rural people are usually regarded as the most important social benefits of agar plantation. From the present study, it can be concluded that cultivation of agar in the homegardens of upper Assam is beneficial. Owners get a subsidiary income from agar without much extra care and efforts. Furthermore, low input management, lack of site specificity, and intercropping opportunities are predisposing factors for agar cropping in the homegardens of the region. More than this, optimum densities of agar in homegardens commensurating with the farmers' socioeconomic status may improve conservation efficiency and the homegardens thus can act as biological corridors for the conservation of *A. malaccensis* genetic resource.

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References

Anonymous 2003. Review of Significant Trade *Aquilaria malaccensis*. Available at http://www.cites.org/eng/com/PC/14/E-PC14-09-02-02-A2.pdf; accessed 31 Jan 2012.

Census of India 20011. Provisional Population Data. Ministry of Home Affairs, Govt. of India, New Delhi.

Chakrabarty, K., Kumar, A., and Menon, V. 1994. Trade in agar. Traffic India and WWF-India, New Delhi, 51p.

CITES 1994. Resolution of the Conference of the Parties. Ninth meeting of the Conference of the Parties, Fort Lauderdale, USA, 7–18 November 1994.

Devi, N. L. and Das, A.K. 2010. Plant species diversity in the traditional homegardens of Meitei community: a case study from Barak Valley, Assam. J. Trop. Agric., 48: 45–48.

Garrity, D. and Mercado, A. 1993. Reforestation through agroforestry: market driven small-holder timber production on the frontier. In: Raintree, J.B. and Francisco, H.A. (eds), *Marketing of Multipurpose Tree Products in Asia*. Proceedings of an International Workshop, Philippines, pp. 265–268.

IUCN 2009. Asian Regional Workshop (Conservation & Sustainable Management of Trees, Viet Nam)

1998. *Aquilaria malaccensis*. In: IUCN 2009, *IUCN Red List of Threatened Species*, Version 2009.2. Available at www.iucnredlist.org; accessed 23 August 2009.

Kumar, B.M., George, S.J., and Chinnamani, S. 1994. Diversity, structure and standing stock of wood in the homegardens of Kerala in peninsular India. Agroforest. Syst., 25: 243–262.

Kumar, B.M. 2008. Homegarden-based indigenous fruit tree production in peninsular India. In: Akinnifesi, F.K., Leakey, R.R.B., Ajayi, O.C., Sileshi, G., Tchoundjeu, Z., Matakala, P., and Kwesiga, F.R. (eds), *Indigenous Fruit Trees in the Tropics: Domestication, Utilization and commercialization*. CAB International Publishing, Wallingford, UK, pp. 84–99.

Ng, L.T., Chang, Y.S., and Kadir, A.A. 1997. A review on agar (*gaharu*) producing *Aquilaria* species. J. Trop. For. Products, 2: 272–285.

Oldfield, S., Lusty, C. and Mackinven, A. 1998. The Word List of Threatened Trees. World Conservation Press, Cambridge, UK, 650p.

Peyre, A., Guidal, A., Wiersum, K.F., and Bongers, F. 2006. Dynamics of homegarden structure and function in Kerala, India. Agroforest. Syst., 66: 101–115.

Soehartono, T. and Newton, A.C. 2001. Conservation and sustainable use of tropical trees in the genus *Aquilaria* II: The impact of gaharu harvesting in Indonesia. Biological Conserv., 97: 29–41.

Tynsong, H. and Tiwari, B.K. 2010. Plant Diversity in the Homegardens and their Significance in the Livelihoods of *War Khasi* Community of Meghalaya, North-east India. J. Biodiversity, 1(1): 1–11.

Uddin, M.S., Mukul, S.A., Khan, M.A.S.A., Alamgir, M., Harun, M.Y. and Alam, M.S. 2008. Small-scale agar (*Aquilaria agallocha* Roxb.) based cottage enterprises in Maulvibazar district of Bangladesh: production, marketing and potential contribution to rural development. Small scale For., 7: 139–149.