CHAPTER-2

REVIEW OF LITERATURE
Aquilaria malaccensis is one of the 15 tree species in the Indonesian genus *Aquilaria*, family Thymelaeaceae. It is a large, evergreen tree growing up to 40m tall and 1.5-2.5 m in diameter, found typically in mixed forest habitats at altitudes between 0 and 1000 m above sea-level. This species has a wide distribution, being found in Bangladesh, Bhutan, India, Indonesia, Malaysia, Myanmar, Philippines, Singapore and Thailand. *A. malaccensis* and other species in the genus *Aquilaria* sometimes produces resin impregnated heartwood that is fragrant and highly valuable.

*A. malaccensis* starts to flower and produce fruit at the age of 7-9 years. The species is shade tolerant when young and may regenerate in almost pure patches underneath mother trees (Beniwal, 1989). Ding Hou (1960) records *A. malaccensis* as a tree that grows to 40m in height with a 60cm diameter trunk. Gianno (1986 cited in La Frankie 1994) suggested that only 10% of mature *Aquilaria* trees above 20 cm diameter at breast height (dbh) produce agarwood.

*Aquilaria* species have adapted to live various habitats, including those that are rocky, sandy or calcareous, well drained slopes and ridges and land near swamps. They typically grow between altitude of 0-850 m , and upto 1000 m in location with average daily temperature of 20-22°C. (Ding Hou, 1960, Keller and Sidijasa, 1994; Wiriadinata, 1995).

Oldfield et al., (1998) listed 10 countries as range states for *A. malaccensis*, Bangladesh, Bhutan, India, Indonesia, Iran, Malaysia, Myanmar, Philippine, Singapore and Thailand. This review has confirmed that Iran has no records of the species occurring in that country. In India, *Aquilaria malaccensis* occurs mostly in the foothills of the North-Eastern region (Assam, Meghalaya, Nagaland, Manipur, Mizoram, Arunachal Pradesh and Tripura) and West-Bengal up to an altitude of 1000 m. In Assam, it occurs in the districts of Sibsagar, Sadiya, Nowgong, Darrang, Goalpara and Cachar (Atal and Kapoor, 1982).
Aquilaria malaccensis is included in the World List of Threatened Trees (Oldfield et al., 1998). The IUCN Red list classifies this species as vulnerable. The export of native A. malaccensis products, except oil, is currently banned in India. At present, species are becoming increasingly scarce due to forest degradation and other harvesting. As scarcity leads to higher value, these products tend to attract greater outside attention and investment. This, in turn, reinforces the trend toward the alienation of local population from their traditional resources. Many NWFPs in the Asia-Pacific region are becoming scarce or are being harvested destructively due to increasing commercialization. These products include dammar resin, gaharu trees (A. malaccensis) containing fragrant heartwood, an assortment of barks, roots, stems and leaves used as medicines (Giano 1990 cited in Peters 1996).

In view of evidence of unsustainable harvest and trade, inter-governmental action has been taken to bring the international trade in one of these species, A. malaccensis, within sustainable levels. A. malaccensis was listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) with effect from Feb 1995.

The CITES Plants Committee considered it a priority to review the implementation of the CITES listing for Aquilaria malaccensis during the 1998-2000 triennium. TRAFFIC was contracted by the CITES Secretariat to undertake such a review in 1998. The results of TRAFFIC’s research are reported in the traffic network report Heart of the Matter: Agarwood Use and Trade and CITES Implementation for Aquilaria malaccensis. Some of the key findings of this report are summarized below:

The international trade in agarwood involves wood, wood chips, powder, oil and although not identified in available trade data, almost certainly finished products such as perfumes, incense and medicines.

Based on available trade data, Indonesia and Malaysia appear to be the main sources of agarwood (from all species) in international trade.
Aquilaria malaccensis leaves are used as antioxidants. In Mizoram this species is commonly used as effective herbal plant. It is endangered because of over-exploitation. E.B Hardiyanto and M. Na’iem found in their study that in Indonesia, Aquilaria malaccensis is mildly threatened and the cause of this is clearing and felling.

Agar wood also known as eaglewood or gaharu is a valuable non-timber forest product of genus Aquilaria occur mainly in South and Southeast Asia. Efforts have been undertaken to increase the production of the infected wood by deliberately wounding the trees. A variety of methods is towards this end. Some recently developed techniques have proven to be most effective. This resulted is planting of Aquilaria trees by small holders as well as large industrial size plantations. (G.A. Persoon, 2008 and H Heuveling van Beek, 1999)

Donovan and Puri (2004) in their research compared the traditional and scientific knowledge of the Penan Benalui and other forest products collectors of Indonesian Borneo. This study was concerned with the resin formation in the genus Aquilaria, a tropical forest tree of South and South-East Asia. The aromatic resin gaharu the product increasing under threat as the trees are overexploited and forest is cleared. Although limited management of wildings failed to bring the resin producing species. Under cultivation, they found that the Penan recognize the complex ecology of resin formation involving two or may be three, living organism the tree, one or more fungi, and possibly an insect intermediary.

The occurrence of the tree itself does not guarantee the presence of the resin. Scientists estimate that only 10% of the Aquilaria trees in the forest may contain gaharu (Gibson 1977). The resin forms in response to wounding and subsequent fungal infection, and is found in many parts of the tree, according to some sources in the bark and the roots as well as the heartwood (Jalaluddin 1977)

Jalaluddin (1977) found in his study that a fungus known as Cytosphaera manganiferae was isolated for the first time from the diseased tissues of standing trees of Aquilaria
*agallocha* Roxb. The fungus colonized wood blocks of *A. agallocha* when these were inoculated artificially and there is a possibility of commercial exploitation for the production of diseased wood by artificial infection.

Distributed broadly through South-East Asia, the genus *Aquilaria* has been found for Bhutan and Northeastern India across to Southern China and then south as far as the islands of New Guinea (Burkill 1966, Whitmore 1972). Little detailed information exists, however, on its distribution, exploitations, or use in the Southeastern edge of its range. In some exploited areas several species are thought to be extremely rare if not extinct in the wild, for example in Bangladesh and Java (Chakraborty *et al.*, 1994).

Soehartono *et al.*, (2001) studied the impact of gaharu harvesting in Indonesia. Gaharu harvesting generally involved felling the tree, with 31-92% of trees encountered being felled. Their study comprised the field assessment of two populations of *A*. species using a matrix model, to predict the impact of different harvesting regimes on population dynamics of the species. Their study revealed that both populations *A. malaccensis* and *A. microcarpa* are self-sustaining in the absence of harvesting. The study also concluded that *A. malaccensis* population expansion will continue if harvesting is set at a minimum diameter at breast height (dbh) of above 10 cm, but for *A. microcarpa*, a population will occur if trees with a dbh of less than 30 cm are harvested. It was also found that the gaharu was not being sustainably harvested at that times.

Kalita, *et al.*, (2002) studied the pest attack on leaves of *A. malaccensis* plants.

Gunn, et al., (2004) reported that to date, only one species of eaglewood, *Gyrinops ledermannii*, is known to occur in Papua New Guinea. The lack of information and awareness of eaglewood is creating major problems exacerbated by the remoteness of producers and landowners who harvest the resin wood. They found an urgent need to develop practical plan for scientifically-based biological conservation and management of eaglewood.
Tamuli et al., (2004) reported biochemical changes in agarwood trees. They found that during pathogenesis, changes occurred in sugar, ascorbic acid, phenol and protein contents of *A. malaccensis*. In healthy trees, the biochemical constituents increased. In infected trees, a decrease in the biochemical constituents was observed after inoculation with the fungi.

Donovon and Puri (2004) reported from their study that traditional knowledge of Penan could help fill gaps in the information base and identify promising areas for future research and play a greater role for ethnobiological research towards sustainable management for this traditional resource and its natural habitat.

*A. malaccensis* first came to the attention of the Plants Committee in the late 1960s, when the committee determined that a review of the implementation of the CITES Appendix II TRAFFIC was hired as the consultant to prepare a review of CITES implementation for the species, and an interim report was submitted to the 9th Meeting of the Plants Committee (Darwin, June 1999).

Soehartono, Newton and Mardiastuti (2002) studied the influence of various factors on the survival and growth of *Aquilaria malaccensis* found that height growth of *A. malaccensis* seedlings were positively related to light availability, but unrelated to distance to the nearest mature tree or seedling density. By the end of the observation period, they found fewer than 20% of seedlings surveyed were still alive. Trampling and cutting being one of the main causes of mortality.

Subeham et al., (2005) performed a field survey in Indonesia and reported from their study that agarwood had been extracted from natural habitats for its high economic value by the peoples living nearby forest areas to increase family income. Over exploitation of the natural resource makes the stock becoming exhausted. They initiated a cultivation programme which was also supported by the Indonesian government through research and training to the collector who cultivate agarwood. *Fusarium laseritum* is the faster
fungus infecting *Aquilaria* sp. tree can be isolated and inoculated easily into the medium. Thus, this fungus was inoculated into the holes in the trunk for production of agar.

The positive relationship recorded between seedling height growth and irradiance indicates the importance of light availability to the early growth of *Aquilaria malaccensis*, a finding supported by results from the shadehouse experiment (Soehartono, T. et al., 2002). The results from the shadehouse experiment suggest that *A. malaccensis* is at least moderately shade tolerant as a young seedlings.

Agarwood plantations had been raised in the past in Assam for experimental purpose and later on discontinued. Professional agar-wood traders have also planted seedlings mostly in their backyards with the hope that one day they may get some agar-wood from these trees. Experimental plots have also been planted at Seijusa (Arunachal Pradesh) during 1982 and 1985. Regular plantations of agar-wood are not raised due to scarcity of seeds, uncertainty of formation of agar-wood and lack of perfect method for developing agar. (Beniwal, 1989).

Gianno (1986, cited in La Frankie, 1994) suggested that only one-tenth of mature trees above 20 cm diameter at breast height (dbh) produce agarwood. According to Chakrabarty *et al.*, (1994), infected trees produce resin from the age of 20 years onwards.

Two types of *Aquilaria malaccensis* are found in India: *A. khasiana* and *A. malaccensis*, although a third, *A. macrophylla* Miq. (found in Nicobar islands) is also thought to produce agarwood (G.S. Giri, Joint Director, Indian Botanic Garden, *in litt.* To TRAFFIC Southeast Asia, 2003).

For conservation and management purpose individual states within India have established various harvest control measures, including complete banes on harvests, harvests allowed under lease (Agar Mahal) and restricted to private lands.
Regarding production of agar-wood, research continues, Gianno (1986, cited in LaFrankie, 1994) suggested that only 10% of mature *Aquilaria* trees produce agarwood. Chakrabarty *et al.* (1994) stated that infected trees produce resin from the age of 20 years onwards, while Sadgopal (1960, cited in Soehartono and Mardiastuti, 1997) suggested that trees aged 50 years and over produce the best yields of agarwood. Hilton-Taylor (2002) stated that the classification of *A. malaccensis* as vulnerable according to IUCN Red List 2002, based on a population reduction of at least 20% over the last three generations caused by actual or potential level of exploitation, as well as a decline in the area of occupancy, extent of occurrence and/or quality of habitat. (CITES, 2003)

A report by Chakrabarty *et al.* (1994) documenting India’s trade in agarwood concluded that *Aquilaria malaccensis* is highly threatened in the country due to exploitation of the species for commercial purposes. *A. malaccensis* is threatened in its natural habitat because of overexploitation. In the North-Eastern region, continued existence of the species in the wild can only be substantiated in Nagaland.

CITES (2003) “Review of significant trade in *Aquilaria malaccensis*”, stated that wild agarwood (known locally as ‘agar’) was heavily extracted from Arunachal Pradesh between the late 1950s and early 1980s, virtually exhausting the natural stock. Wild *A. malaccensis* is now considered almost extinct in Assam. *A. malaccensis* in Nagaland and Manipur is so depleted that a large population of the raw agarwood used by processing units in these two states is sourced from neighbouring countries (Gupta, 1999)

Domestication can takes place in several ways:-

1) Enrichment planting in forest areas.
2) Smallholder cultivation and
3) Commercial or community plantations (Wickans, 1991)

The range of combinations allows communities to adapt a domestication strategy to suit their needs and preferences.
Domestication helps to improve the NWFP resource in qualitative and quantitative terms. It is to be noted, however, that domestication calls for certain research issues to be addressed and information generated and analysed before it can be widely adopted: can the species desired be domesticated? If so, what are the specific characteristics? If it exists, is this variation genetic in nature or caused by environmental factors?; can improvement in desirable characteristics be best achieved by genetic (phenotypic) selection, by silvicultural interventions, and/or by a combination of both?; in such improvement economically practical and feasible?

Dayak communities in Indonesia believe that dying seedlings and saplings (indicated by yellowish leaves) of Agar tree testify to infection of the mother tree. They appear to be able to identify infected trees by differentiating between the sound made by knocking an infected trunks and the sound made by knocking an non-infected trunks.

Harvesting of *Aquilaria* for agarwood is destructive, with no management as trees are felled with a small axe and often the roots are dug up. Agarwood has cultural, historic and religious significance in Arab and far Eastern countries, and the trade dates back several thousand years (Barden et al. 2000; Yamada 1995).

International demand for agarwood rose sharply in the wake of the oil crisis in 1973, after which agarwood became affordable to many consumers in Arab countries.

*Aquilaria malaccensis* had been listed in rare and endangered plants in Arunachal Pradesh. Shifting cultivation, over exploitation of medicinal and other useful plants, rapid development of infrastructure such as new townships, roads, industries, clearing of forest lands for permanent agriculture have led to decline of many plants populations and degradation of their habitats.

Both govt.-owned and private agarwood plantations have been established in Arunachal Pradesh. The Silvicultural Division of Arunachal Pradesh has converted large areas of degraded forests into commercial agarwood plantations. The upper Assam climate provides particularly suitable growing conditions and large scale plantations exist in this
state. Owners of private plantations in Assam have also attempted artificial fungal inoculation of two-to-three year old *Aquilaria malaccensis* plants, but it is not known how effective this has been at stimulating agarwood production. CITES Management Authority surveyed in Tripura and estimated that approximately 450-500 ha of private agarwood plantations exist in the north district.

Uddin, *et al.* (2008) revealed from their study that agar is used as one ingredient in the cosmetics and pharmaceuticals sector, and therefore the global trade in agar based products is growing rapidly. They surveyed 30 randomly selected agar-based factories during Dec 2005 - April 2006, and found that majority of the factories of the area were depend on local sources of raw materials to produce agar-based products. The study was carried out in Maulvíbazar district of Bangladesh and it was observed that the socio-economic development is to a certain extent depend on these agar-based enterprises.