STRATEGIC FOREST PLANTATION ESTABLISHMENT IN MALAYSIA FOR FUTURE PRODUCT DEVELOPMENT AND UTILISATION

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ABSTRACT

Forest plantations in Malaysia are geared towards supplementing timber produced from natural forests for downstream industrial manufacturing. Owing to relatively short rotation and high productivity, planted forests are capable of yielding timber of specific quality within a period of 3 - 30 years. The launching of large scale reforestation programmes (e.g. Compensatory Forest Plantation) in the past and the current development of government-assisted private forest plantations throughout the country are the indicative of this conventional strategy. However, the expected change in the role of natural forests, from timber production to environmental services and biodiversity conservation in the future would emphasise the mission of forest plantations as a main wood and non-wood producers. Moreover, forest-based products of the future would be very diverse, short-lived and technology driven. Environmental friendly products in the forms of bioenergy, pulp and paper, wood composite products, and plant-based cosmetics, nutraceuticals and medicinal products would dominate the market. Nevertheless, availability of suitable land for forest plantation establishment is rather limited, except for the degraded and infertile idle lands. Under of this probable setting, strategic move has to be formulated to establish forest plantations using various approaches in order to transform forest plantations into a sustainable land use option for timber and non-timber production. Several approaches including establishment of short rotation woody crop (SRWC) plantation, intermediate rotation forest plantation, long rotation, high quality forest plantation, mixed-species forest plantation and agroforestry are proposed. The prospects of these plantation forestry approaches in Malaysia are discussed in the light of the future scenario of products development and utilisation.

Key words: Forest plantation models, Reforestation programme, Degraded lands, Forest products, Agroforestry.

Introduction

The global demand and supply of wood from forest plantations is projected to continuously increase in the decades to come (Elias & Boucher 2014). In 1995, the global area of forest plantations was about 123.7 million hectares, or approximately 3.5 percent of the global forest area (Brown 2000). Even though forest plantations constitute less than 5 per cent of the world's forest resources, they would produce 35 per cent of the world's demand for industrial round wood and 10 per cent of fuelwood (Ogle & Miller 2000, Dyck 2003). It has been projected that the highest increase of planted forests area in the future will be in Asia – from 0.9 million ha to 1.9 million ha per year, which equals to approximately 55% of global increase (Carle and Holmgren 2008). The surge in the global and regional total forest plantation areas indicates the importance and increasing role of forest plantation in supplying timber for various downstream processing of forest industries (ITTO 2009). Indeed, planted forests have become a major component of the productive and protective forest resources in many tropical countries.

Compared to natural forests, plantation forestry can produce far greater quantity of wood and non-wood produces (NWFP) within a relatively shorter period of time, from 3-30 years (Hashim *et al*. 2011). Short rotation coupled with high yielding species and varieties of forest plantation enable a sustainable supply of timber and non-timber products from smaller areas of land. Various advantages of forest plantations over the native forests have been exhaustively discussed by Evans (1992) and others (e.g. Hashim *et al*. 1989, Dyck 2003). In a nutshell, plantation forestry not only offers opportunities in supplementing wood

demands and thus reducing the resource exploitation of natural forests, but also restores degraded lands and enhances biodiversity conservation (Parrotta 1992, 1995) for the benefit of future generations.

By establishing forest plantation, natural forests can be conserved from further degradation and being restored to their climax conditions while serving for other intangible and environmental benefits, including wildlife habitats and biodiversity conservation, watershed protection, landscape integrity, buffer against atmospheric calamities and climate change mitigation, to name a few. Thus, forest plantation complements natural forests in sustainable management of Malaysian forest resource for the present and future needs, not only in terms of timber and non-timber forest produces, but also in providing vital environmental services and intangible products.

History of Forest Plantations in Malaysia

Forest plantations in Malaysia began before the turn of 20th century with the establishment of selected commercial timber trees such as Nyatoh taban (*Palaquium gutta*), Rambung (*Ficus elastica*), teak (*Tectona grandis*) and mahogany (*Swietenia macrophylla*) plantations at several locations in Selangor, Malacca, Perak and Kedah (Appanah & Weinland 1993; Krishnapillay 1998). However, systematic research and development (R&D) activities on forest plantation only start with the formation of Afforestation Research Branch at the Forest Research Institute Malaysia, in 1925 in Kepong, Selangor. The main objective was to rehabilitate and to restore degraded forest areas caused by tin mining and farming activities. Both native and exotic forest tree species had been trial planted at Kepong and other locations in Peninsular Malaysia from 1920s until 1970s (Selvaraj & Muhammad 1980).

In 1960s, in relation to the federal government proposal to establish a pulp and paper mill in Peninsular Malaysia, R&D activities had been emphasized on the establishment of softwood plantations using fast growing tropical pines and araucarias. Thereafter, pilot scale forest plantations have been initiated at several strategic locations in Pahang, Negeri Sembilan, Johor and Selangor, with the assistance of FAO/UNDP (Table 1). In addition, sites in Perlis (Mata Ayer), Kedah (Langkawi & Gunung Jerai) and Pahang (Bukit Tinggi) were chosen to establish clonal seed orchards of *Pinus caribaea* (Selvaraj & Muhammad 1980) for seed production.

Table 1. Pine plantations in Peninsular Malaysia

State	Location	Species	Hectares	Year of Establishment
Pahang	Lentang, Bukit Tinggi, Kemasul	*Pinus caribaea*	2,285	1964-1982
Johore	Ulu Sedili	*P. caribaea*	1,932	1975-1983
Selangor	Rantau Panjang (Batu Arang), Sungai Buloh	*P. caribaea*	903	1950-1974
	Kepong	*P. caribaea,* *P. insularis* *P. merkusii*	66	
N. Sembilan	Setul Galah Lenggeng	*P. caribaea* *P. oocarpa*	669	1966-1980
Kedah	Gunung Bongsu Sengkup Bukit Perak	*P. caribaea* *P. oocarpa* *P. insularis* *P. merkusii*	20	1953-1964
Total			**5,875**	

Source: Adapted from Krishnapillay (1998), FAO (2002)

The imminent timber shortage in Peninsular Malaysia for domestic timber industries in 1980s has urged government to launch the Compensatory Forest Plantation in 1985. A total area of 188,000 ha had been proposed for forest plantation development and planted with fast growing hardwood species. Several exotic tree species have been identified for this large scale reforestation project, including *Acacia mangium, Eucalyptus* spp., *Gmelina arborea* , *Maesopsis eminii* and *Paraserianthes falcataria*). Due to better site adaptability and growth performance, more than 85% of the project area had been planted with *A. mangium.* However, this reforestation project was terminated in 1996, after a moratorium due to incidence of heart rot infection of main stem (Hashim *et al*. 1991; Lee *et al*. 1993). A total of 64,630 ha of *A. mangium* had been established, mainly in the states of Johore, Negeri Sembilan, Pahang and Selangor (Table 2).

Table 2. The Compensatory Forest Plantations in Peninsular Malaysia

Location	*A. mangium*	*G. arborea*	*P. falcataria*	Total
Pahang				
Kemasul F.R	19,569	426	1,426	21,421
Johore				
Ulu Sedili F.R	20,254	-	-	20,254
Selangor				
Rantau Panjang F.R. (Batu Arang)	4,305	-	-	4,305
Bukit Tarek F.R	5,896	-	-	5,896
N. Sembilan				
Setul F.R	1,809	89	4	1,902
Gemas F.R	2,441	-	-	2,441
Perak				
Chikus F.R	925	-	-	925
Besut	3,553	-	-	3,553
Kelantan				
Relai	3,417	-	-	3,417
Terengganu				
Merchang	2,461	-	100	2,561
Total	**64,630**	**515**	**1,530**	**67,325**

Source: Adapted from Krishnapillay (1998), FAO (2002)

In Sabah, Sabah Forest Development Authority (SAFODA) and Sabah Softwood Sdn Bhd have dominated the reforestation programme since 1970s. Two other companies, Sabah Forest Industries (SFI) and Innoprise Corporation (ICSB) have joined in to develop forest plantations in other parts of Sabah in 1980s. Similar exotic species have been planted in these plantations as in the Peninsular Malaysia. In 1999, about 138,000 ha of forest plantation have been established in Sabah. By 2004, more than 200,000 ha of forest plantations (including rattan plantations) had been established in Sabah (Anon 2004). Both fast growing hardwoods and high quality timbers of native and exotic species (Table 3) were planted.

Table 3. Species planted in Sabah in 1995 and 2004

Species	**1995**	**2004**
Acacia mangium	55,595	75,120
Paraserianthes falcataria	12,049	8,642
Gmelina arborea	10,142	4,463
Eucalyptus deglupta	5,728	1,767
Eucalyptus grandis	-	9,962
Tectona grandis	1,704	6,047
Eucalyptus spp.	786	1,503
Hevea brasiliensis (Timber clones)	-	68,070
Pinus caribaea	695	154
Other spp. *(Dipterocarpus, Swietenia, Pterocarpus, Araucaria, Pinus)*	3,095	4,598
Total	**89,758**	**180,326**

Source: Adapted from Krishnapillay (1998), FAO (2002), Anon. (2004)

In Sarawak, reforestation of degraded lands due to logging and shifting cultivation activities had been initiated since 1984. The State Forest Department of Sarawak has issued reforestation licences (LPF) to investors to establish forest plantations of greater than 1,000 ha on state land or alienated land. Kollert *et al.* (1994) estimated that there were 6.9 million ha of degraded areas available in Sarawak for forest plantation development. Prior to 2000, about 20,873 ha of degraded forests have been reforested mainly with native timber species (Vincent 2002).

Shortage of timber in Peninsular Malaysia becomes a reality in the following decades. Wood-based industries, particularly primary processing industries (sawmilling & plywood milling) were severely affected (Woon & Norini 2002). The shortage of logs has resulted in the increased raw material cost to wood processing industries. Rubberwood, an agricultural waste from the felling of old rubber plantations, has been used primarily in the furniture industries, due to its abundance and low price. The export value of wooden furniture increased from a mere RM 120 million in 1988 to more than RM 4 billion in 2002 (Norini *et al.* 2001) due to utilisation of rubberwood. In meantime, increased environmental awareness, social pressures and the rapidly diminishing forest resource has affected the yield of timber from natural forests. The existing natural forest seems unable to meet the increasing demand of timber for domestic wood processing industries.

In an effort to reduce reliance on natural forest as the main source of timber, the Government is encouraging the development of large-scale commercial forest plantations. Unlike the previous reforestation programmes, the current programme should involve the full participation of private sector. In line with this policy, the Cabinet, in March 2005 gave an important task to the Ministry of Plantation Industries and Commodities (MPIC) to initiate a forest plantation development programme in Malaysia. Under this programme, a total area of 375,000 hectares of forest plantation will be established, with a targeted annual planting rate of 25,000 hectares per year within 15-year period. The reforestation programme is mainly focused on two major species, namely Rubberwood (Timber Latex Clone) and Acacia spp. (*Acacia mangium* /*Acacia* hybrid). Other additional timber species include *Tectona grandis* (Teak), *Azadirachta excelsa* (Sentang), *Khaya ivorensis, K. senegalensis, Neolamarckia cadamba* (Kelempayan/Laran); *Paraserianthes falcataria* (Batai) and *Octomeles sumatrana* (Binuang).

Owing to long gestation period and high risk of forest plantations (Woon & Lim 2003), banks and financial institutions foist high interest rate on loans for developing land into forest plantations. This situation has dreaded the private sector participation in the forest plantation programme. Except for the state corporations and companies, no private sector company in Malaysia was willing to invest in forest plantation development, even though there were certain incentives (e.g. Pioneer status & Investment tax allowance) provided by government (Menon 2000, Woon & Lim 2003). To overcome this deadlock, the federal government has allocated a special fund in 2006 for soft loans amounting to RM1.045 billion. The soft loans would allow local investors to establish commercial forest plantations and encourage government subsidiary companies to be involved in forest plantations projects (Zuhaidi *et al.* 2007). The Malaysian Timber Industry Board (MTIB) through its subsidiary company, Forest Plantation Development Sdn. Bhd., is responsible in the disbursement of soft loans, carry out auditing process of the plantation as well as to provide technical support and training for the reforestation programme.

In order to encourage greater participation in the forest plantation programme, three categories of forest plantation are made available to potential investors: the large scale Forest Plantation Development scheme involving 2,500 ha and above, the medium scale scheme involving 41 to 2,499 ha and the small scale scheme involving 4 to 40 ha. By 2011, a total area of 187,805 ha of forest reserve has been designated for forest plantation establishment in Peninsular Malaysia (FDPM 2011). Presently, a total of about 200,000 ha forest plantation have been developed in Sabah, mainly located within forest reserves. In Sarawak, by 2009 a total of 312,525 ha had been planted, from 2.8 million ha of approved areas under the licence for planted forest (Yap 2012). By 2020, Sarawak is committed to establish 1 million ha of planted forest (Anon. 2009).

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A New Forest Plantation Strategy

As previously mentioned, the importance of forest plantations in providing sustainable supply of timber in Malaysia cannot be refuted. Presently, wood based industries, particularly furniture and panel board manufacturers need the support of the federal, state and local governments in ensuring sustainable supply of raw materials. The growth of Malaysia's wood-based exports might be stalled if strategic measures to circumvent the supply of raw materials are not implemented. Malaysian wood-based industries would encounter an increasing competition from low-cost neighbouring countries (Thailand, Indonesia & Vietnam) with ample supply of cheap raw materials. Forest plantation development is considered a strategic vehicle in supplementing sustainable timber supply for the wood-based industries in Malaysia. Indeed, the National Timber Industry Policy 2009-2020 (NATIP) clearly indicates that forest plantation sector to yield 16.7 million cubic metres of logs per year within a period of 2016-2020. Natural forests are expected to produce only 14 million cubic metres of logs annually during the same period. One of the major obstacles in the establishment of large scale forest plantation in Malaysia is availability of suitable land. In general, forest plantations in Malaysia are established on low quality soils compared to soils used for agricultural plantations. This is mainly due to the fact that most of the fertile soils in Malaysia have been allocated to commercial tree crops and food crops, while the poorer soils are reserved for forest trees

Furthermore, land in Malaysia is a state matter and each state has its own procedure and legislation regarding the land ownership and tenure. This factor can be a problem under certain circumstances. Fortunately, Malaysia has large stretches of idle and degraded lands which can be recovered for plantation forestry purpose. There are about 200,000 ha of BRIS soils in the east coast of Peninsular Malaysia and Sabah and more than 100,000 ha of ex-mining areas mainly in the states of Johor, Perak and Selangor (Ang 2002, Zakaria & Ang 1992, Chan 1990), that can be restored and converted into forest plantations, using appropriate site amelioration approaches. In Sabah and Sarawak, large areas of abandoned shifting cultivation areas remain unproductive. In Sarawak, an estimate of 3 million ha of land was affected by shifting cultivation (Lee 2004). Reforestation of these degraded areas is needed to restore forest productivity. These types of lands are less suitable for agricultural purposes due to high input requirements. Plantation forestry, owing to its flexibility and restorative in nature is considered more appropriate land use system. Thus, new strategic approach has to be devised for forest plantation development in order to transform the barren and low productivity lands into sustainable forest plantations, geared for timber and non-timber production, in view of future demand and end uses. Conservation need has to be balanced with the increasing demand of woody and non-woody industrial raw materials for end-product processing, in such a way that environmental degradation is minimised, while socio-economic and environmental benefits are maximised in the long run, in accordance with the sustainable development concept. Issues of monoculture, use of exotic species and 'fast-wood' in the plantation forestry need to be seriously thought, in the light of current and future socio-economic needs, environmental awareness, sustainable supply of wood and non-wood products and international trade mechanisms.

The following forest plantation models are proposed for short, medium and long term strategies. It should be cautious that monoculture system *per se* should be avoided as it is ecologically unstable, has low biodiversity and more susceptible to pests and diseases.

i. Very short rotation plantation (VSR) – selected fast growing species trees, shrubs and bamboos such as *Acacia mangium, Leucaena leucocephala, Sesbania grandiflora, Macaranga* spp., *Mallotus* spp., *Gliricidia sepium* , *Piper aduncum,* can be grown at very high density (10,000- 12,000 trees/ha) and managed on coppice system of 2-5 years (Hashim *et al*. 2008b, 2009a). Bamboos such as *Bambusa spp., Gigantochloa spp.* can be established in on degraded land. The wood and bamboo culms can be used in manufacturing of engineered wood, bio-composite products and as bioenergy feedstock (Hashim *et al.* 2009b). New crop can be established using improved genetic materials, nursery practices, site preparation, establishment, tending, and other improved silvicultural treatments in the new forest stands (Varmola *et al.* 2005).

However, the major disadvantages to using tropical soils for short rotation tree crops are due to their inherent low nutrient reserves and poor nutrient retention ability. In order to overcome these problems, selection of suitable species and the use of leguminous tree species are essential as hardy species can tolerate inferior soils, while leguminous species are capable in enriching the site fertility through biological nitrogen fixation (BNF). The foliage of leguminous species can be pruned and incorporated into soil as green manure.

It has been found that wood and non-wood materials from short rotation plantation is suitable for medium density fibreboard (Hashim *et al.* 2008b), plybamboo (or pulp and paper. Other light hardwood species have been found

to yield good quality cement bonded composite boards (Nor Azrieda *et al*. 2009) and gypsum –bonded board, wood polimer composite (Rahim 2010). Moreover smaller size stemwood and branches of less than 5 cm diameter can be used to produce charcoal and wood vinegar (Chong *et al.* 2009) and bio-based wood adhesives (Tohmura 2010). Large and medium scale reforestation model are appropriate for this VSR model.

ii. Short rotation plantation (SRP) – fast growing, general utility hardwoods can be planted at high density of 1111-2500 trees/ha. Species such as Berembang bukit (*Duabanga grandiflora*), Sesenduk (*Endospermum diadenum*), Batai (*Paraserianthes falcataria*), Melembu (*Pterocymbium javanicum*), Mentalun (*Terminalia bellirica*), Yemane (*Gmelina arborea*), Binuang (*Octomeles sumatrana*), *Eucalyptus* hybrids, Kekabu (*Ceiba pentandra*), Kelampayan (*Neolamarckia cadamba*), Kelumpang (*Sterculia* spp.), Saga (*Adenanthera pavonina*), Sentul (*Sandoricum koetjape*) and *Maesopsis eminii* can be established and managed within a rotation age of 15 to 25 years. Thinning is optional and recommended to be conducted once or twice at age 4 - 6 years and 15 years. The thinning materials can be utilised as chipwood for bio-composite products or as bioenergy feedstock. Degraded forests and marginal lands can be used for mixed species plantation of using 2-3 compatible species. For example, Sesenduk can be mixed with Batai, Berembang bukit, Binuang, Kelempayan, Yemane, Neem (*Azadirachta indica*), Maesopsis and Melembu. In case of rubber (*Hevea brasiliensis*) forest plantation, trees are planted at final stocking (625 t/ha) without the need for thinning, as conventionally done in forest plantation. The timber is suitable for general utility purposes. Large and medium scale reforestation model should be appropriate for this SRP model.

iii. Medium rotation plantation (MRP) – high quality timber species are grown either in the open (full light: for light demanding species) or under partial shade (line planting: shade tolerant species) under secondary forests or established stands of pioneer nurse trees such as Petai belalang (*L. leucocephala*) or other light canopy tree species. Mixing of two or more tree species can be made by using alternate row planting or a "checkerboard" mixed planting, where every other tree in each row alternates each species. Woody nurse trees are planted among high quality timber trees to help their growth and improve their timber quality through side limb shading and forcing the trees to grow taller and straighter. Rotation age of 45- 60 is suggested to allow the trees to grow to peeler size for rotary peeling or solid wood production. Thinning should be conducted twice or thrice, at age 5-7 years and 15-18 years and 25-30 years by removing 40%, 30% and 20% of the growing stock respectively. Species such as Ara (*Ficus* spp.), Damar minyak (*Agathis borneensis*), Bungor (*Lagerstroemia* spp.), Durian (*Durio zibethinus*), Engkabang (*Shorea* spp.), Jelutong (*Dyera costulata*), Kayu malam (*Diospyros* spp.), Kekabu hutan (*Bombax ceiba*), Kempas (*Koompasia malaccensis*), Keruing (*Dipterocarpus* spp), Mahogany (*Swietenia macrophylla*), Malabera (*Fagrea crenulata*), Merawan siput jantan (*Hopea odorata*), Meranti sarang punai (*Shorea parvifolia*), Meranti temak nipis (*Shorea roxburghii*), Meranti tembaga (*Shorea leprosula*), Mersawa (*Anisoptera* spp.), Minyak beruk (*Xanthophyllum* spp.), Nyatoh (*Palaquium* spp, *Pouteria* spp.), Pelong (*Pentaspadon motleyi*), Podo (*Podocarpus* spp.), Sentang (*Azadirachta excelsa*), Sena (*Pterocarpus indicus*), Surian (*Toona* spp.), Surian batu (*Chukrasia tabularis*) and Teak (*Tectona grandis*) are recommended for this MRP model. The timber of MRP can be used for solid wood furniture, building construction, doors, flooring, decking, staircases, wall panelling, joinery, cabinet work, interior panelling, etc. Large and medium scale reforestation model seems appropriate for this MRP model.

iv. Long rotation plantation (LRP) – Heavy hardwood species such as Belian (*Eusideroxylon zwageri*), Bitis (*Madhuca utilis*), Chengal (*Neobalanocarpus hemii*), Kekatong (*Cynometra ramiflora*), Merbau (*Intsia palembanica*), Resak (*Vatica* spp.), Tembusu (*Fagrea fragrans*) can be established using mixed planting concept, where species are distributed randomly or following specific patterns of planting. Various species mixtures and arrangements can be devised to fit the plantation objectives and preferences. Species such as Batai, Berembang bukit, Mahang, Neem (*Azadirachta indica*), Petai and Maesopsis can be interplanted as nurse trees between the rows of heavy hardwood species. Proper silviculture treatments and management practices such as pruning and thinning are important to enhance tree growth and optimise the wood quality and value of the end product. Thinning can be arranged at ages of 10, 20, 30 and 40 years. The rotation age is 60 to 90 years. The timber is potential to fill market niches for feature-grade, structural uses and decorative products. Due to long rotation, the plantation can be a reliable carbon sink reservoir. Small and medium scale reforestation schemes should be suitable for this type of forest plantation model.

Non-timber plantation (NTP) – None wood species such as Jatropha (*Jatropha curcas*), Mulberry (*Morus alba*), Bemban (*Donax canniformis*), Cengkih (*Syzygium aromaticum*), Cherry (*Muntingia calabura*), Karas (*Aquilaria crassna, A. malacensis, A. sinensis, A.subintegra*), Kayu manis (*Cinnamomum verum*), Mempari (*Pongamia pinnata*), Neem (*Azadirachta indica*), Roselle (*Hibiscus sabdariffa*), Kenaf (*Hibiscus cannabinus*), Nutmeg (*Myristica fragrans*), lemon grass (*Cymbopogon nardus.)*, Enau/Kabong (*Arenga pinnata*), and rattan (*Calamus* spp.) can be planted and managed for production of fruits, agarwood, syrup, fiber, canes, oils, shoots, rubber and/or resin production (Chin 1989; Wan Razali *et al*. 1992; David 1999; Lee 2004; Abd. Razak *et al.* 2008, 2009, 2012; Hashim & Zuhaidi 2012; Zuhaidi *et al*. 2009; Chetpattananondh 2012). Large, medium and small scale reforestation schemes can be fitted for this model.

v. Mixed wild fruit plantation (MWF) – selected wild fruits such as *Durio* spp (e.g. old *Durio zibethinus* varieties, *Durio dulcis*, *Durio graveolens*, *Durio oxleyanus*), *Artocarpus* spp. (Jackfruits, Chempedak, Breadfruits), *Garcinia* spp (Mangosteen, Asam gelugor, Kandis), *Scaphium macropodum* (Kembang semangkuk), *Dialium*

indum (Keranji), *Parkia* spp (Petai), *Bacaurea* spp (Rambai, Jentik-jentik, Rami, Tampoi), *Phyllanthus* sp. (Melaka), and *Mangifera* spp (Binjai, Mangoes, Bacang, Kuinin) and other suitable species (Hashim 1986; Lee 2004) can be planted in mixture with multi-strata canopies in accordance with traditional fruit orchard or homegarden structures (Hashim *et al.* 2004). Wild fruits are available in the local market and important in the diet of local people. They are a reliable source of nutrients and vitamins. The small and medium scale schemes are appropriate for this model.

vi. Agroforestry system (AFS) – Agrisilviculture or Agrisilvipasture models will be adopted where selected trees/shrubs such as Mahogany (*Swietenia* sp. and/or *Khaya* spp.), Merawan siput jantan, Meranti temak (*Shorea roxburghii*), Neem (*Azadirachta indica*), Cengkih, Kayu manis, Nutmeg, Keranji, Kembang semangkok, Sentang, Teak, *Eucalyptus* spp., *Leucaena leucocephala*, *Sesbania* spp., are planted using alley crop (hedge) system. The short term food crops such as groundnuts, sweet potatoes, maize, cassava, roselle, yam (*Diocorea* spp.), and perennial crops such as palas palm (*Licuala* sp.), coffee, citrus, vanilla (*Vanilla planifolia*), medicinal plants (e.g. Tongkat ali, Kacip Fatimah, Mas cotek) can be intercropped in the alley zone and between the tree rows (Hashim *et al*. 1984, Abdul Razak *et al*. 2006, Hashim *et al.* 2008a). The trees will provide timber, fuelwood, fruits, nectar for bee keeping, green manure and/or fodder for animals (cattle, goats, sheep, deer), while the food crops provide foods and cash to the farmers. The agroforestry system provides greater social benefits than other forest plantation models, but it is more labour intensive and requires local knowledge of agriculture and forestry (Hashim *et al.* 2012). This model should be targeted to small scale forest plantation scheme with area of 4 to 40 ha.

Issues & Challenges

Even though forest plantations have started for more than a century in Malaysia, the experience in forest plantation development is still at infancy stage, compared to India, Indonesia and China. There are several problems faced by the plantation forestry in Malaysia, which need to be solved in order to shift to the next phase of forest plantation development for commercialisation. Even though Malaysia is one of the mega diversity centres of plant species, its biodiversity richness is not reflected in the greater knowledge in biology, ecology and silvics of native species. As such, planters prefer exotic species over the native species. Species such as *Aquilaria crassna, Acacia mangium, Cymbopogon nardus, Eucalyptus deglupta, Gigantochloa levis, Gmelina arborea, Hevea brasiliensis, Hibiscus cannabinus, Jatropha curcas, Khaya ivorensis, K. senegalensis, Leucaena leucocephala, Maesopsis eminii, Paraserianthes falcataria,* and *Tectona grandis* which had been planted in the past in Malaysia are all exotic species. In Sabah and Sarawak, for example, the major species planted in reforestation programmes comprise of exotic species such as *Acacia mangium* while *Hevea brasiliensis* is the main timber tree species in Peninsular Malaysia.

The extensive use of exotic species has disadvantages from the ecological and biodiversity points of view. These drawbacks include decrease in plant and animal diversity, increase susceptibility to disease infection and insect outbreaks and potential to become invasive weeds beyond the plantation borders (Parrotta, 1997; Florence, 1996). Moreover, as most of the forest plantation species are classified as pioneers, they are light demanding species and generally thrive under a full light condition or in big forest gaps (Hashim 2003). Furthermore, pioneers are voracious in soil moisture and nutrients uptake, fix a substantial amount of soil nutrients in their biomass (Wan Rashidah *et al*. 1998), leaving the site almost exhausted. As most of tropical soils are deficient in essential soil nutrients, planting of invasive exotic species such as *A. mangium* would deplete the soil fertility. Moreover, the building up of soil seed bank can arrest the succession process and deprive the recruitment of native trees. Native species is seldom used in reforestation programme due to lack of information various silvicultural aspects of the species. Only a few native species have been selected, such as *Aquilaria malaccensis, Azadirachta excelsa , Chukrasia tabularis, Ficus* spp., *Neolamarckia cadamba* and *Octomeles sumatrana*. Other lesser known native species such *Alstonia scholaris, Duabanga* sp., *Dyera costulata, Endospermum diadenum , Hopea odorata, Lagerstroemia* spp., *Pentaspadon motley, Podocarpus* spp., *Pouteria* spp., *Pterocymbium tinctorium, Sterculia* spp. and *Toona* spp , to name a few, are potential for forest plantation establishment.

Lack of silvicultural knowledge and insufficient growth and yield data have prevented the use of native species for large scale plantations. Hence, research & development programme should be intensified to determine and document the lacking aspects of silviculture and the growth and yield of selected species. Native pioneer species and fast growing species such as *Alstonia scholaris, Arenga pinnata, Duabanga grandiflora, Dyera costulata, Endospermum diadenum , Hopea odorata* and *Pterocymbium tinctorium* should be trial planted on different soil types and site conditions at various planting distances (spacing) and planting densities in order determine their growth and yield under different silvicultural regimes and site conditions. Propagation of planting materials through rooted stem cuttings and micro-propagation (e.g. tissue culture) should be initiated to increase availability of planting materials. Nutrient requirement of the native species need to be determined to enhance the growth and yield under plantation conditions. Growth model for a particular native species should be developed based on sample plot data and used as a management tool to predict the future growth and yield. Thinning study needs to be conducted to determine the age of the first thinning and subsequent thinning periods. Prior to large scale initiative, pilot scale plantation need to be established.

As the abovementioned silvicultural practices can affect quality of forest produces; wood obtained from forest plantation might be different from that of natural forests (Hashim *et al*. 1989; Zobel & Van Buijtenen 1989). Due to systematic nature of forest plantations, trees are grown under a similar environmental condition and management practice. Consequently, wood and non-wood produces from forest plantations should have less variation in quality compared to those of natural forests. Hence, the wood utilization of planted native species need to be explored for suitable value-added products. Many of the native tree species

have wood with strength and beauty that make them suitable for specific uses (Gan & Lim 2015). For instance, Forest Research Institute Malaysia (FRIM) has spearheaded the R&D in the cultivation and utilization of indigenous timber species such as *Endospermum diadenum* (Sesenduk). A superior clone of Sesenduk has been produced and being trial planted in different sites, to obtain growth and yield data. The wood of the species was tested for furniture making, either as solid wood or as engineered wood (Khairul *et al*. 2015, Mohd Noor *et al*. 2008). For future product development, innovation in the designs, machines and manufacturing processes have to be made, in line with the change in environmental awareness, consumer tastes, and the rising costs of energy, labour and raw materials, if Malaysian forest products are to remain competitive in the global market (Ratnasingam & Wagner 2010). Market research and marketing strategy are a must, to survive the competition with other well established manufacturers and designers.

Conclusions

The future is the beginning of a new era of forest plantations, as their roles in producing wood and non-wood products are becoming increasingly prominent, while providing social and environmental benefits, and would gradually replacing the economic functions of natural forests. The remaining natural forests would be conserved for biodiversity and wildlife conservation, while providing environmental services in the forms of forest recreation, watershed protection and climate change mitigation.

Forest plantations have a great potential in producing pre-determined biomaterials in accordance with targeted end uses and future market. Various types of wood and non-wood products can be derived from forest plantations owing to its flexibility and sustainability. In this respect, several models of forest plantations have been proposed for idle and degraded lands in Malaysia, to provide sustainable supply of raw materials, in line with the industrial requirements and as guided by the respective government policies (e.g., NATIP) and other relevant legislation at both Federal and State levels.

Species selection for forest plantations should be made based on reforestation objectives, availability of silvicultural and management information, planting site conditions, ease of establishment and management of species and the present and future end uses of forest products. Long term objectives should outweigh short term profits. The sustainable development concept should be upheld in all phases of plantation development. The rotation length could be adjusted to meet the market condition, species used and the management options. Equivalent native species should be given priority in any forest plantation development, for both short and long rotation forest plantations.

In the future, the type of wood and other forest based products, their manufacturing processes and the end product types and designs, to a certain degree, are determined by market demand, international regulation and green consumerism. Hence, the forest based products would be very diverse, short-lived and technology driven. Green materials from forest plantations would be more preferable by importers, manufacturers and builders. Consumers of the future would prefer green products that have been produced in such a way that the natural environment and natural forests are protected and conserved. Hence, environmental factors and sustainable development practices would be the important considerations in the forest plantation establishment and management practices and the manufacturing processes of end-use products derived from forest plantations. There is a big challenge lies ahead in translating this strategic plan of future forest plantations into actions in favour of sustainable forest management, environmental friendly utilisation of forest products and sustainable income generation from local forest-based industries.

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