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Establishment Of Rattan Plantations

A Publication of the INBAR Task Force on Rattan Uses and Development

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INTERNATIONAL BAMBOO AND RATTAN ORGANISATION

The International Bamboo and Rattan Organisation

The International Bamboo and Rattan Organisation, INBAR, is an intergovernmental organisation dedicated to the promotion of bamboo and rattan for sustainable development.

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Cover page image

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FOREWORD

Rattans are among the most important non-wood forest products of tropical forests. These climbing palms play a significant role in the livelihoods of several rural communities that are engaged in their collection from the forests and their utilisation for the manufacture of products and also as edible shoots. Significant quantities of rattan continue to be extracted from natural forests in an unregulated manner, which has resulted in the loss of genetic diversity and depletion of stocks. To achieve sustainability, it is essential that scientific management of the rattan resources that permits the regeneration of stocks and rational harvesting levels be implemented. Rattan cultivation, which has been practised to a limited extent in countries like Indonesia, Malaysia and the Philippines with varying levels of success, must now be undertaken on a larger scale with respect to key species to cater to the increasing demand for high-quality raw material.

The establishment of a scientific basis for plantations, right from the selection of species and production of planting stock and the identification of best practice for the establishment and management of plantations, is expected to contribute to enhancing rattan resources and ensuring sustainability. In the context of climate change resilience and the ecosystem functions of healthy forests and tree plantations, rattan cultivation, if accomplished sustainably, may also yield commercial benefits.

This publication has been prepared by the experts of the INBAR Task Force on Rattan Uses and Development with the objective of bringing together the collective experience of decades of rattan research in several countries around the world. It examines the entire gamut of activities that are involved in the scientific management of plantations, including the criteria for selecting suitable species, appropriate propagation and planting methods and cost-benefit analysis. It also examines how policy influences the management of rattan resources and how stakeholders respond.

It is hoped that this report will kindle interest in commercial rattan plantations of different types and will also encourage further research aimed at bridging the gap in our understanding of various factors that influence optimum rattan growth and quality.

Rene Kaam and E.M. Muralidharan

1. Rattan species and plantations

Rattans are spiny climbing palms that belong to the subfamily Calamoideae of the palm family Arecaceae. The genera concerned are *Calamus, Eremospatha, Korthalsia, Laccosperma, Myrialepis, Oncocalamus, Plectocomia* and *Plectocomiopsis. Eremospatha, Laccosperma* and *Oncocalamus* are restricted to Africa, while the remaining genera are distributed throughout the Asia-Pacific region (except one African species of *Calamus*) (Vorontsova et al., 2016). Rattans' mature stems have unique properties that make them amenable to various uses with few alternatives. The rattan cane that is extracted from the mature stem following removal of the leaves and the immature shoot tip consists of a long (up to 150 metres), solid, flexible material that can be bent with heat to forms suitable for furniture or baskets and peeled to yield a strip that can be woven into mats, wickerwork and webbing etc.

Rattans are important components of the forests in which they are found and are indicators of the integrity of the ecosystem when present in adequate numbers, indicating regeneration.

Rattans have been collected as an important non-timber forest product from time immemorial, and the extent of harvesting was—until recently—sustainable, since adequate natural regeneration occurred. It is becoming increasingly clear that most of the world's rattan resources are already under threat due to unsustainable harvesting practices and deforestation, leading to a loss of germplasm and even the threat of extinction of some species. This state of affairs has resulted from the absence of rattan resource inventories and overexploitation due to the on-demand granting of cutting permissions rather than an assessment of sustainable harvesting levels.

The world trade of rattan raw materials and woven rattan alone amounted to USD 0.38 billion (INBAR, 2019). A significant share of the USD 0.63 billion world trade in bamboo and rattan furniture is contributed by rattan. The report acknowledges that the figures could be grossly underestimated due to misclassification with other timber products. It is estimated that approximately 20% of all rattan species are used commercially in the furniture industry or for matting and basketry, and during the 1970s, Indonesia fulfilled about 90% of the world's rattan requirements (Dransfield and Manokaran, 1994).

Since rattans contribute substantially to the livelihood and economic status of local communities in many countries worldwide, it is important to establish rattan plantations to ensure sustainable availability and sufficient economic returns. Although several studies have been undertaken on rattan systematics, propagation techniques and plantations, it is important to gather the pertinent information into a document that will serve those interested in establishing economically viable rattan plantations to sustain the raw material production and the industry that supports the livelihoods of numerous people. This is in the face of competitive land-use options that might seem attractive to potential famers in the short term but are in reality damaging to the environment and unsustainable in the long term.

Globally, the furniture and handicraft industry mainly depend on resources from the secondary and virgin forests for rattan supply. Deforestation, overexploitation and habitat modification have caused the supply of raw rattans for the furniture industry to dwindle, and most rattan industries are experiencing setbacks. The only way to overcome this issue is to ensure the identification of commercially important species, the establishment of high-quality plantations and the continuous supply of high-quality rattan poles. This, in turn, is expected to help uplift the socio-economic status of the communities engaged in rattan production, processing and trade. In addition, since rattans require support trees for their growth and development, the establishment of rattan plantations will inevitably contribute to the care, protection and conservation of trees as well as the improvement of ecosystem services.

1.1 Rattan species selection - commercial species

Rattans have been used for a wide variety of domestic, non-market purposes by rural communities for centuries, and they have become one of the world's most valuable non-timber forest products. It is estimated that approximately 20% of all rattan species are used commercially in the furniture industry or for matting and basketry (Dransfield and Manokaran, 1994). With approximately 600 species worldwide, rural communities depend on rattans for numerous uses, particularly flexible canes for furniture, fibres, edible shoots, thatch and many more diverse handicraft products. The rattan stems (canes) are both strong and flexible, with diameters ranging between 2 and 10 mm, and are either solitary or clustering with respect to their growth. The canes can be bent and woven into products such as furniture, handicrafts and mats. The most popular rattan product is furniture, but additional products include carpets, walking sticks, ropes, birdcages, matting and baskets. Some communities use the fruits and leaves of rattan in traditional medicine (Dransfield and Manokaran, 1994; Renuka, 2001; Meijaard, 2014). The resin from rattan fruits can also be used as a natural dye and as medicine (Dransfield and Manokaran, 1994). Details of species-specific rattan uses and their distributions are provided in Table 1 below (Sunderland & Dransfied, 2002; Vorontsova et al., 2016).

Table 1. Uses of rattan species in different countries

Product / Use	Important rattan species	Countries
Edible fruits	*Calamus conirostris* Becc.	Borneo, Peninsular Malaysia, Sumatra.
	C. calospathus (Ridl.) W. J. Baker & J. Dransf.	Peninsular Malaysia.
	C. longisetus Griff.	India (Andaman and Nicobar Islands), Bangladesh, Myanmar, Thailand, northern Peninsular Malaysia.
	C. manillensis (Mart.) H. Wendl.	Philippines.
	C. merrillii Becc.	Philippines.
	C. ornatus Blume	Southern Thailand, Sumatra, Java, Borneo, Sulawesi, Philippines
	C. paspalanthus Becc.	Borneo, Brunei, Peninsular Malaysia
	C. subinermis H. Wendl. ex Becc.	Malaysia, Indonesia, Philippines, Sulawesi
	C. viminalis Willd.	Bangladesh, Cambodia, India, Indonesia, Laos, Peninsular Malaysia, Myanmar, Thailand, Vietnam
	C. rotang L.	Bangladesh, India, Myanmar Sri Lanka.
	C. ingens (J. Dransf.) W. J. Baker	Borneo
	C. periacanthus (Miq.) Miq.	Borneo, Malaysia, Sumatra
	C. ruptilis (Becc.) W. J. Baker	Borneo
	C. tenuis Roxb.	Bangladesh, India, Nepal, Myanmar, Thailand, Sumatra, Laos, Vietnam
Palm heart eaten/ Edible shoots	*C. deerratus* G. Mann & H. Wendl.	Africa, Angola, Senegal, southern Sudan and Uganda Zambia.
	C. egregius Burret	Hainan (China)

Product / Use	Important rattan species	Countries
Palm heart eaten/ Edible shoots	*C. javensis* Blume	Borneo, Java, Sumatra, Peninsular Malaysia, S. Thailand and Palawan
	C. muricatus Becc.	Borneo
	C. paspalanthus Becc.	Peninsular Malaysia and Borneo
	C. siamensis Becc.	Laos (South), Myanmar, Thailand, Peninsular Malaysia
	C. viminalis Willd.	Bangladesh, Cambodia, India, Indonesia, Laos, Myanmar, Peninsular Malaysia, Thailand, Vietnam
	C. simplicifolius C. F. Wei	Hainan (China)
	C. subinermis H. Wendl. ex Becc	Borneo, Philippines, Sulawesi
	C. tenuis Roxb.	Bangladesh, Cambodia, Myanmar, Laos, India, Bhutan, Laos, Nepal, Thailand, Vietnam, Java, Sumatra.
	C. fissus (Blume) Miq.	Borneo.
	C. longibracteatus W. J. Baker	Borneo.
	C. jenkinsianus Griff.	China, Myanmar, Laos, Philippines, Thailand, Vietnam,
	C. melanochaetes (Blume) Miq.	Java, Malaya, Sumatra, Thailand.
	C. nambariensis Becc.	Bangladesh, India, Laos, Myanmar, Thailand, Vietnam
	C. periacanthus (Miq.) Miq.	Borneo, Malaysia, Sumatra.
	C. scapigerus (Becc.) W. J. Baker	Borneo, Malaysia, Sumatra.
	C. sparsiflorus (Becc.) W. J. Baker	Borneo.
	C. walkeri Hance	Vietnam.
	C. applanata (A. J. Henderson & N. Q. Dung) W. J. Baker	Vietnam.
	Laccosperma secundiflorum (P. Beauv.) Kuntze	Benin, Cabinda, Cameroon, Central African Republic, Gabon, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Niger, Nigeria, Senegal, Sierra Leone, Togo, Zaire.
Fruit used in traditional medicine	*C. castaneus* Griff.	Thailand, Malaysia, Sumatra.
	C. longispathus Ridl.	Malaysia.
	C. didymophyllus (Becc.) Ridl.	Borneo, Malaysia, Sumatra.
Palm heart in traditional medicine	*C. exilis* Griff.	Thailand, Malaysia, Sumatra.
	C. javensis Blume	Borneo, Java, Sumatra, Peninsular Malaysia, S. Thailand and Palawan.
	C. ornatus Blume	Southern Thailand, Sumatra, Java, Borneo, Sulawesi, Philippines.
	C. grandis Griff.	Thailand, Malaysia.
	Korthalsia rigida Blume	Borneo, Thailand, Malaysia, Philippines, Sumatra.

Product / Use	Important rattan species	Countries
Fruit as source of red resin, used medicinally and as a dye (source of "dragon's blood")	*C. didymophyllus* (Becc.) Ridl.	Borneo, Malaysia, Sumatra.
	C. draco Willd.	Thailand, Borneo, Malaysia, Sumatra.
	C. maculatus (J.Dransf.) W.J.Baker	Borneo
	C. micracanthus Griff.	Borneo, Malaysia
	C. ruber Reinw. ex Mart.	Java.
Leaves for thatching	*C. andamanicus* Kurz.	India (Andaman and Nicobar Islands)
	C. castaneus Griff.	Thailand, Malaysia, Sumatra.
	C. longisetus Griff.	India (Andaman and Nicobar Islands), Bangladesh, Myanmar, Thailand, northern Peninsular Malaysia.
	C. calicarpus Griff.	Malaysia, Sumatra.
	C. elongatus (Blume) Miq.	Borneo.
	C. grandis Griff.	Thailand, Malaysia.
	C. ingens (J.Dransf.) W.J.Baker	Borneo
	C. manii (Becc.) W.J.Baker	Andaman and Nicobar Islands
Leaflet as cigarette paper	*C. longispathus* Ridl.	Malaysia
	C. leptopus Griff.	Malaysia
Chewed as narcotic (with betel nut)	*C. erectus* Roxb.	Bangladesh, India, Myanmar
Leaves chewed as vermifuge	*L. secundiflorum* (P.Beauv.) Kuntze	Benin, Cabinda, Cameroon, Central African Republic, Gabon, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Niger, Nigeria, Senegal, Sierra Leone, Togo, Zaire.
Roots used as treatment for syphilis	*Eremospatha macrocarpa* Schaedtler	Benin, Central African Republic, Equatorial Guinea, Ghana, Guinea, Ivory Coast, Ivory Coast, Liberia, Nigeria, Sierra Leone, Zaire
Leaf sheath used as toothbrush	*E. wendlandiana* Dammer ex Becc.	Angola, Cameroon, Central African Republic, Equatorial Guinea, Gabon, Nigeria, Gabon, Nigeria
	Oncocalamus wrightianus Hutch.	Benin and southern Nigeria
Leaves used as broom	*C. tenuis* Roxb.	Nepal, Myanmar, India, Bhutan
Rachis for fishing pole	*C. grandis* Griff.	Peninsula Thailand to Peninsula Malaysia
	L. secundiflorum (P.Beauv.) Kuntze	Benin, Cabinda, Cameroon, Central African Republic, Gabon, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Niger, Nigeria, Senegal, Sierra Leone, Togo, Zaire.
For cane (Furniture and Handicrafts)	*C. acanthospathus* Griff. (clustering moderate-sized rattan)	China, India, Nepal, Laos, Thailand, Vietnam
	C. caesius Blume (clustering moderate-sized rattan)	Peninsular Malaysia, Sumatra, Borneo, Thailand, Philippines; introduced to China and south Pacific

Product / Use	Important rattan species	Countries
For cane (Furniture and Handicrafts)	*C. centralis* A. J. Hend., N. K. Ban & N. Q. Dung (clustering medium-sized rattan)	Vietnam
	C. cinereus A. J. Henderson & N. Q. Dung	Vietnam
	C. dioicus Lour. (slender, clustering rattan)	Vietnam
	C. egregius Burret (clustering)	Hainan island, China, introduced to southern China for cultivation
	C. exilis Griff. (slender solitary or clustering small-diameter rattan)	Thailand, Malaysia, Sumatra
	C. javensis Blume (slender clustering rattan)	Borneo, Java, Sumatra, Peninsular Malaysia, S. Thailand and Palawan
	C. jenkinsianus Griff. (clustering rattan)	Bangladesh, China, Myanmar, Laos, Philippines, Thailand, Vietnam,
	C. latifolius Roxb. (medium-sized clustering rattan)	India, Bangladesh, Myanmar, Nepal
	C. longisetus Griff. (clustering large-diameter rattan)	Andaman and Nicobar Islands, Bangladesh, Myanmar, Thailand, northern Peninsular Malaysia
	C. manan Miq. (solitary large-diameter rattan)	Borneo, Malaysia, Sumatra Thailand
	C. nambariensis Becc. (clustering moderate-sized rattan)	Bangladesh, India, Laos, Myanmar, Thailand, Vietnam
	C. merrillii Becc. (clustering large-diameter rattan)	Philippines
	C. mindorensis Becc. (solitary large-diameter rattan)	Philippines
	C. nagbettai R.R.Fernald & Dey (clustering large-diameter rattan)	India
	C. optimus Becc. (clustering medium-size diameter rattan)	Borneo
	C. ornatus Blume (clustering rattan)	Southern Thailand, Sumatra, Java, Borneo, Sulawesi, Philippines
	C. ovoideus Thwaites ex Trimen (clustering large-diameter rattan)	Sri Lanka
	C. palustris Griff. (clustering large-diameter rattan)	Andaman Islands, Myanmar, China, Laos, Vietnam, Malaysia
	C. parvulus A. J. Hend. & N. Q. Dung (clustering, very small-diameter rattan)	Vietnam
	C. pogonacanthus Becc. ex H.J.P.Winkl. (clustering, moderate-sized rattan)	Borneo

Product / Use	Important rattan species	Countries
For cane (Furniture and Handicrafts)	*C. poilanei* Conrard (solitary large-diameter rattan)	Cambodia Laos, Vietnam,
	C. salicifolius Becc. (clustering rattan)	Cambodia, Vietnam
	C. scipionum Lour. (clustering rattan)	Thailand, Borneo, Malaysia, Sumatra, Philippines
	C. simplicifolius C.F.Wei (clustering moderate-sized rattan)	Hainan; introduced to southern China for cultivation
	C. sabut (Becc.) W.J.Baker (clustering rattan)	Peninsula Malaysia and Borneo
	C. subinermis H.Wendl. ex Becc. (solitary or clustering robust rattan)	Borneo, Philippines, Sulawesi
	C. tetradactylus Hance (clustering slender rattan)	China. Introduced to Malaysia Vietnam (natural and cultivated)
	C. trachycoleus Becc. (clustering slender rattan)	Borneo; introduced into Malaysia for cultivation
	C. tumidus Furtado (solitary rattan)	Malaysia, Sumatra
	C. validus W. J.Baker	Malaysia
	C. viminalis Willd. (clustering large-diameter rattan)	Bangladesh,Cambodia, Laos, India, Myanmar, Thailand, Vietnam
	C. wailong S.J.Pei & S.Y.Chen (clustering large-diameter)	China, Laos, Thailand
	C. walkeri Hance (clustering large-diameter)	Thailand, Laos Vietnam
	C. zollingeri Becc. (clustering rattan)	Sulawesi, Moluccas
	E. macrocarpa Schaedtler (clustering moderate-sized rattan)	Tropical Africa from Sierra Leone to Angola
	E. haullevilleana De Wild. (clustering moderate-sized rattan)	Congo Basin to East Africa
	L. robustum (Burret) J.Dransf. (clustering rattan)	Cameroon to Congo Basin
	L. secundiflorum (P.Beauv.) Kuntze (clustering rattan)	Benin, Cabinda, Cameroon, Central African Republic, Gabon, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Niger, Nigeria, Senegal, Sierra Leone, Togo, Zaire

The selection of species for establishing plantations depends on their uses and forest types in addition to several other parameters, such as growth form (solitary/clustering) and diameter class (small, medium and large). Generally, in natural forests, the distribution and abundance of rattans are influenced by various biotic and abiotic factors, including predation, disease, inter- and intra-specific competition altitude, light availability, canopy, and soil factors. In Borneo, species such as *C. optimus* have been found in lowland dipterocarp forests and alluvial forests at elevations up to 170 m above sea level whereas in India, commercially important species, such as *C. gamblei*, have also been reported in high-elevation montane forests or shola grasslands. In the case of *C. viminalis*, this species forms thickets in lowland forests or deciduous forests, persisting in cleared areas and is often seen planted near villages.

It has been concluded that, in general, rattan abundance increases in moderate- to high-light conditions (Siebert, 2012) and in well-drained soils (Dransfield, 1992; Siebert, 2012) and peaks in abundance at mid-elevations (~1000 m) (Putz and Chai, 1987; Stiegel et al., 2011). However, species-specific rattan responses have been identified with respect to light availability, soil type, elevation and soil moisture (Siebert, 1993; Siebert, 2012; Thonhofer, 2015), some of which are contradictory. Some rattan species exhibit a positive relationship to light intensity whereas, in others, abundance appears negatively related to light intensity. Determining which environmental variables positively relate to rattan abundance and whether synergisms exist would facilitate improved conservation of wild rattan populations.

Selection of species for plantations is based on a range of factors, of which the following are most critical:

1. Suitability to the existing site (ecophysiological) conditions
2. Growth rate and productivity
3. Appropriate products to be made and availability of skills locally
4. Market demand and marketability of products
5. Preference of local communities
6. Potential for sustaining a livelihood for the local community
7. Resistance to pest and diseases
8. Cultural factors, if any

1.2 Purpose of rattan plantations

It is estimated that more than 700 million people worldwide trade in or use rattan for a variety of purposes, and the global trade (domestic and export) and subsistence value of rattan and its products exceeds USD 7,000 million per annum (Pabuayon, 2000; Sastry, 2000; Soedarto, 1999). The FAO-INBAR-SIDA Expert Consultation on Rattan Development (FAO, 2001) confirmed that the raw materials used to meet the global demand for rattans for the furniture and handicraft industries are harvested from unmanaged, wild rattan resources, and only a small percentage (10%) is sourced from plantations. In most countries, the rattan and handicraft industries are experiencing setbacks due to raw material shortages as a result of regulations limiting rattan harvesting in the wild. This has resulted in the use of lower-quality cane from alternate species as well as rattan material of lower quality. Although approximately 600 rattan species are known globally, only a small proportion are used for commercial purposes, and several underutilised rattans species have the potential for development as plantation crops. It is reported that in Malaysia, Sumatra, India and the Philippines, most important commercial rattan species are already under threat (Sunderland and Dransfield 2002). Establishment of rattan plantations along with support trees will inevitably contribute to the restoration of many important ecosystem services in areas with a degraded vegetation cover or none at all. Moreover, the establishment of rattan plantations will augment the supply of high-quality rattan for industry, which, in turn, will help to uplift the socio-economic status of communities engaged in rattan production, processing and trade.

1.3 Size/type of rattan plantation

Plantation sizes can range from small home gardens (for edible shoots) to plantations of greater than 30,000 ha (for commercially important species). For edible shoots, even very small plantations are seen in agro-ecosystems in Assam, India, particularly for *C. tenuis.* The average size of such rattan gardens in Indonesia is 1.4 ha, and the density of rattan clumps ranges from about 50 per hectare to 350 per hectare, with a mean of around 170 per hectare (Garcia-Fernandez, 2001). In Nepal, the average size of *C. tenuis* plantations in community forests is 0.5 to 3 hectares, particularly for edible shoots.

1.4 Land use/tenure

Throughout their natural distribution, rattan species are found in a wide range of forest and soil types. As such, rattans can be planted in degraded secondary forests, agro forestry systems, home gardens, etc. Most commercially important rattans are components of the evergreen forest understorey, while some rely on good light penetration for their development; hence, several species are found in gap vegetation and respond very well to canopy manipulation, particularly that caused by selective logging. Other species grow in swamps (*C. rotang* and *C.tenuis*) and seasonally inundated forests, while others are more commonly found on dry ridge tops (*C.viminalis*).

In general, natural forests are not recommended for rattan plantations, while logged forests (newly logged or old logged forest) and existing plantations (tree forest, abandoned rubber or commercial rubber plantations and oil palm plantations) are ideal.

1.5 Site-species matching

Rattan growth for cane production requires specific conditions, of which the most important are the availability of:

1. Suitable support trees
2. Optimum light (50–60 percent of full sunlight)
3. Soil moisture
4. Relative humidity of around 70 percent or more.

These requirements are typically met in 1. forest fringes, 2. rubber plantations, 3. fruit orchards, 4. swamps along the riverbanks, 5. paddy field dikes and 6. tree plantations.

As several factors affect the habitat requirements of rattan, site-species matching should be considered an important criterion in establishing plantations. Site-specific factors, such as physiography, soils, climate and vegetation (PCARRD, 1991; Razal and Palijon, 2009), play a key role in rattan cultivation. For example, some species prefer to grow in low elevations, including *C. merrillii, C. rotang* and *C. rivalis*, whereas *C. brandisii* and *C. ornatus* var. *ornatus* are vigorous and robust at high altitudes. Rattans prefer areas with abundant and well-distributed rainfall, where the soil is fine clay and rich in humus. They also prefer strong to medium acidic, dark-coloured loamy soils with moderate water-holding capacity and high moisture content. In the Philippines, the species *Calamus merrillii* is particularly widely distributed and is considered one of the species with the highest climatic adaptability characteristics. *C. tenuis* is found in lowland forests in silty soils subject to flooding and also in scrub and degraded land (Evans and Sengdal, 2002). Alluvial soils that are swampy in nature and located close to perennial water sources are particularly suitable for *C. tenuis*. *C. viminalis* prefers drier areas and can also tolerate open sunlight. These two species, which are commonly used as edible shoots in Laos and Thailand, are suitable for cultivation in open land with no support trees. Rattan grows faster and produces larger shoots under such conditions.

Most rattan species require 50% to 70% relative light intensity (Bravo and Andin, 1990), and the selected tree-vegetated areas should allow sufficient light illumination. If the canopy does not permit sufficient light transmission, then the vegetation type should allow silvicultural treatments, such as crown-thinning/modification to suit the rattan species' light requirements. In China, Bingshan et al. (2000) reported that climate is an important factor for the growth of rattans and that growth appears to be retarded in temperatures below 15°C and monthly precipitation under 25 mm. The ideal conditions for luxuriant rattan growth are tropical oceanic monsoon climate conditions, with annual average temperatures of more than 22°C, annual precipitation of more than 1500 mm, fewer dry months and absence of frost.

1.6 Ecosystem services from rattan plantations (cultural and ecological)

In Indonesia, rattan ecosystem services are well recognised, whereby rattan is extracted through primary forests and rattan gardens. Rattan gardens and cultivation are important cultural symbols, facilitating the maintenance of practices, beliefs and knowledge across generations (Afentina et al., 2017).

Developments in government policies for promoting industrial plantations, a ban on export, the reclassification of rattan webbing as a semi-finished product and changes in land-use practices have severely affected Indonesia's rattans gardens and associated services (Pambudhi et al., 2004). It is well known that the conservation of rattan itself contributes to the protection of biodiversity, including trees and shrubs, and that the presence of rattans in an evergreen forest ecosystem is indicative of its health status. The conversion of natural forest to monocultures of annual or perennial cash crops is certainly more damaging to the ecosystem services than the more benign interventions involved in planting and harvesting rattan without removal of trees and undergrowth.

1.7 Including multispecies and monoculture

Rattans can be planted in both single and mixed systems. When planted in mixed systems, a planting density of 50 to 170 rattan plants per hectare (depending on whether the growth form is solitary or clustering) is recommended. Two months after rattans have been planted under trees, food crop plants, such as rice, maize and cassava, can also be planted. In the first year, the young plants in the rattan crop require little maintenance and, one or two years later, leave the cultivated land for a new plot. In this way, the rattan crop is incorporated into the cycles of shifting cultivation. In the case of monoculture, the cropping pattern is 7 m x 3 m, or 476 plants per hectare, and planting holes should be 20 cm wide and 30 cm deep. In Indonesia, farmers plant rattan seeds, wildings or seedlings in newly created agricultural fields as part of this shifting cultivation system (swidden cycle), and the main agricultural crop is upland rice, along with maize, cassava and banana, among other food crops (Pambudhi et al., 2004). The young rattan plants are left in the field, and when the farmer shifts to a new swidden plot one to two years later, the rattan is left to grow with the secondary forest vegetation to create a *kebun ratan,* or rattan garden.

2. Normative references

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3. Justification for rattan plantations

Many examples of rattan cultivation in agroforestry systems in forest lands controlled by local communities are known (Weinstock, 1983; Connelly, 1985; Siebert and Belsky, 1985; Peluso, 1992), and a small proportion of cane from such systems supplies the formal markets. Commercial-scale plantations and silvicultural studies were initiated across Southeast Asia when it became clear that rattans were becoming scarce (Table 2). Most plantations, however, were under the control of forestry departments, and revenue was not flowing to the local communities. Commercial cultivation leads to the removal of a resource from the informal forest economy and into the formal forestry sector and results in inequity, as benefits do not accrue to local people (Belcher, 1999).

Table 2. Cultivation of rattan in different countries

Country	Cultivation
Bangladesh	Trials of *Daemonorops jenkinsiana* (*Calamus jenkinsianus*) established in early 1980s; plantations of *C. tenuis* for the edible shoot industry are popular. Trail plantations of *C. jenkinsianus, C. viminalis* and *C. tenuis* were established in the early 1980s, and 2488.25 hectares of plantation were established during the period 1985–2002 in the first phase. In the second phase (2005–2014), another 2000 ha of rattan plantation were raised with the abovementioned three common species.
Cameroon	1 ha trial plot of *Laccosperma secundiflorum* under obsolete rubber near Limbe. 1998: 1 ha silvicultural trial under obsolete rubber 2000: 1 ha agroforestry trail in community-managed mixed forests 2000: 1 ha provenance trail of *E. macrocarpa* in community-managed mixed forests
China	1970s: 30,000 ha of enrichment planting of forest on Hainan Island with *Calamus tetradactylus* and *C. jenkinsianus* (as *D. margaritae)*; Plantations of *C. egregius* and *C. simplicifolius* in Guangdong Province; Plantations of *C. gracilis* and *C. nambariensis* in Yunnan Province since 2001; *Calamus rhabdocladus*, *C. nambariensis.* Cultivation trials of many species have been initiated since 1985.
Indonesia	1850: Rattan gardens established in the areas around Barito, Kapuas and Kaharjan in Kalimantan Trials of *C. manan* began in the 1980s in Java; 1988–1993 several thousand hectares of *C. caesius* planted by forestry department and, to a lesser extent, *C. trachycoleus*, in Java and East Kalimantan.
Kenya	Trial plot *C. latifolius* under *Gmelina arborea* near Lake Victoria
Malaysia	1960: *C. manan* planted in Ulu Langat Forest Reserve; 0.6 hectare plot *C. manan* trail - Sungai Buloh Forest Reserve, Selangor, in 1966. 1972: Cultivation trial of *C. manan* under pines initiated in Pehang 1975: Forest Research Institute Malaysia (FRIM) cultivation trials of *C. scipionum* and *C. caesius* planted under rubber, 1,100 ha in total; 1980–81, Sandakan area - 4,000 ha plantation in logged forest planted with *C. caesius* and *C. trachycoleus* and 2,000 ha of abandoned rubber, *Acacia mangium* and logged forest planted with *C. manan, C. caesius* and *C. merrillii*; 1982–1983: Two trial plots of *C. optimus* established in Sarawak; 1990: large-scale planting in Sarawak with *C. manan, C. caesius, C. optimus* and *C. trachycoleus*.

Country	Cultivation
The Philippines	Cultivation trials of *C. merrillii* and *C. ornatus* var. *ornatus* established in Quezon in 1977; 1989: 500 ha of *C. merrillii* and *C. ornatus* var *ornatus* planted under *Acacia mangium* in Ormoc Leyte. (Abasolo and Lomboy 2009). 5,000 ha plantation of *C. merrillii* established in Mindanao; Early 1990: 500 ha of *C. merrillii* and *C. ornatus* var. *ornatus* planted under *Endospermum peltatum* (matchwood tree plantation) in Mindanao
Sri Lanka	*C. ovoideus* and *C. thwaitesii* trials established in recent years
India	Plantations of *C.thwaitesii* and *C.hookerianus, C.rotang* by Forest Department in the period 1995–2000 period. Small-scale cultivation in northeast India for edible shoots (*C.tenuis*) No private plantations
Thailand	213 ha of *C. caesius* in Narathiwat Province, established by 1978; *C. caesius* trials established in 1979 in Ranong, Surathani and Chuporn Provinces; 1980–1987: *C. caesius* and *C. manan* trials established - 930 ha in Narathiwat Province
Laos	Cultivation for edible shoots: *C.tenuis*
Nepal	1990s: community-based rattan cultivation for furniture, biodiversity, and income generation of community people: 212 ha in community forest, *C.tenuis*
Vietnam	*C. tetradactylus* was planted for more than 100 years for domestic furniture; about 500 ha of commercial plantations by 2010. 1994 and 2005: *Calamus inermis* was planted experimentally in North Vietnam. 2005 to present: more than 1,000 ha of *Daemonorops applanata* planted in Central Vietnam.

4. Cost-benefit analysis

The collection and sale of canes and edible shoots is a major source of income for several communities in various nations in Southeast Asia. A large proportion of these communities are comprised of rural poor. Strategic development of this sector, therefore, has the potential to impact the livelihoods of several million people in the region, elevating them out of poverty and providing them with a sustainable means of income. This can be attained by adding value to raw rattan through the creation of innovative products, the implementation of quality control, the development of standards and improvement of market access while maintaining a sustainable resource base. Boosting private-sector investment in the industry will also help sustain it.

As rattan takes about ten years after planting to first harvest, it is often not sufficiently attractive for investors, particularly when other short-term options are available. A cost-benefit analysis by Belcher et al. (2004) comparing land-use systems in Kalimantan found oil palm to be the most profitable, followed by rattan gardens. Oil palm cultivation was clearly a much better organised industry that integrated the production and marketing systems, and rubber production was not profitable at the prevailing prices. Rattan was more attractive, with oil palm following closely, when returns to labour are considered. Rattan plantations for edible shoots in Laos are reportedly more profitable than rice cultivation. Pantanella (2005) gives the estimated yields and gross revenue of rattan plantations in Malaysia.

In many countries where rattan occurs predominantly in state-owned forests, it is unlikely that any significant competing land uses will discourage the development of rattan resources through assisted natural regeneration and minimal management inputs.

5. Climate change and ecological benefits

Rattan plantations that involve no great disturbances to the natural vegetation or removal of trees are relatively benign in their impact on the environment. Even the harvesting may be carried out with minimal disturbance to vegetation and soil or without resorting to slash-and-burn cultivation As a commercial activity, therefore, rattan plantations offer advantages that few other plantation activities can claim. The impact on climate change, therefore, should be highlighted, since most logging operations in tropical forests impact the climate by virtue of greenhouse gas emissions from slash-and-burn and the deterioration of tree cover.

Retaining mature trees in the forest is a prerequisite for the successful cultivation of most rattan species in natural forests or plantations. This activity, therefore, contributes to tree cover and protection of flora and fauna associated with forests in which rattan is a component. Increased tree cover has the additional benefit ofrehabilitation of degraded land, improving soil fertility and enriching biodiversity, including wildlife and soil microbiota.

6. Production of rattan planting materials

Seeds are the natural means of propagation for all rattans. Rattan can be propagated artificially through vegetative propagation as well as through micropropagation.

6.1 Propagation through seeds

The natural process of rattan reproduction is effected through seeds. Rattan fruits are produced in clusters often consisting of hundreds of fruits. The fruits range in size from 7 x 10 mm to about 15 x 20 mm and are globular to slightly ovoid in shape. Rattan fruits are characteristically covered by a scaly pericarp within which the fleshy sacrotesta is encased. The seeds are hard and have a ruminate endosperm with the embryo positioned below a hylum. Each fruit contains a single seed.

6.1.1 Collection of fruits

Rattan plantations are an easy source of fruits since access and collection are facilitated and cheaper than sourcing fruits from forests. In India and Nepal, the *Calamus* species bears fruit from April to August.

6.1.2 Extraction of seeds

Fruits are considered sufficiently mature for the extraction of seeds when the scaly cover breaks easily on pressing between the fingers and the seed can be squeezed out. The common practice is to remove the scaly pericarp as well as the fleshy sacrotesta before the seeds can be used for propagation, since they inhibit germination. The weight of rattan seeds is in the range of about 100 g/1000 seeds to over 3000 g/1000 seeds.

Seed extraction procedures vary in different countries, but all involve the removal of the scales and sacrotesta. Germination percentage was enhanced in *C. longisetus* by the pre-sowing treatment (Haider, 2014).The fruits are typically kept soaked in water for up to two days and the floating ones are discarded. Fruits are crushed by hand or underfoot after being mixed with sand or rubbed against a wire mesh to remove the fleshy sarcotesta, which inhibits germination.

6.1.3 Seed storage

After extraction, the seeds can be sown immediately to obtain the best germination rates, but often, in situations that require transport, they can be stored under moist conditions for up to six months. Moist sawdust can be used to store seeds to prevent them from drying out. Fruits can be stored in closed plastic bags for one month at room temperature and for three months at temperatures between 10°C and 14°C (Mori, 1980). Seeds stored in closed bags at room temperature maintain over 50% viability for six months (Darus Haji Ahmad and Aminah Hamza, 1985).

Excessive moisture content will induce seeds to germinate while drying to under 40% will reduce their viability. Treatment of seeds with fungicides—Benlate (0.1 -1.0%), Captan or Bavistin (3 g/kg)—prior to storage will prevent fungal growth (Renuka, 1991).

6.1.4 Pre-germination

Seeds are sown on raised nursery beds consisting of a 10 cm layer of sand or sandy loam, sometimes overlaid by a 3 cm-thick layer of sawdust or sawdust mixed with soil. Smaller seeds are dispersed throughout the bed while larger ones are sown at a spacing of 4 cm.

The seeds should be completely covered. Daily watering is necessary to keep the bed moist. Watering should take the form of a fine spray to avoid churning up the beds. Any exposed seeds should be covered up immediately. The beds are provided with shade to protect against sunlight and heavy rain. Weeding of the seedbed should be carried out as and when needed. No fertilisation is needed at this stage.

6.1.5 Transplanting to polybags

Seedlings are transplanted when the spears—the first seedling leaves—are fully expanded. Black plastic bags measuring 16 cm x 12 cm are typically used to raise the seedlings up to 10 months when they are ready for field planting. Bags measuring 15 cm x 23 cm have been suggested by Tan (1994), while others recommend 20 cm x 26 cm (WikiEducator, 2007).

A potting mixture consisting of forest topsoil and sand at a ratio of 3:1 was used by Renuka, (1991). A 1:1:1 mixture of soil: sand: farmyard manure is also recommended (WikiEducator). The germination bed is thoroughly watered to loosen the media and facilitate removal of the seedlings without damaging the roots.

Seedlings are transferred to polybags at the age of one to two months, depending on the species and the sizes attained. Healthy seedlings (4–6 cm high) are transplanted into the polybags when the first seedling leaves are fully expanded. Before transplanting, the seed bed should be watered to loosen the roots from the soil. The seedlings should be planted into the polybags by making a hole in the centre deep enough to accommodate the seedling root. The hole should be filled with soil, and care should be taken not to crumple the roots. After transplanting, the seedlings should be thoroughly watered immediately with a spray or a hose with a rose head. Weeding should be carried out as often as necessary. The crust of the soil should be broken up occasionally. It is also recommended that the roots of seedlings in the nursery be trimmed to prevent damage during transplantation.

6.1.6 Sex ratio in plantations

Rattans are dioecious and, to ensure regeneration in natural forests, it is essential that an ideal ratio of male: female plants is maintained. Since rattan collection is not influenced by the sex of the plant, it may be expected that a desirable ratio is ensured. In plantations, the objective being the production of cane, the sex ratio should not be of concern unless the plants are also envisaged as sources of seeds for future plantation programmes.

Morphology-based sexing of rattan at the juvenile stage is not possible, and the use of molecular methods is currently the focus of research. Clonal propagation, particularly through micropropagation of selected male and female plants, remains a theoretical possibility, but methods that permit propagation of plants at the reproductive age are either too slow, inefficient or not currently feasible.

6.2 Wildlings

Rattan usually produces fruits in enormous bunches and, although the fleshy fruits form the food of many animals, many of the seeds germinate to produce seedlings on the forest floor. These wildlings remain in the rosette stage until light is available, usually after the canopy opens due to treefall or other disturbances. Competition weeds out a large proportion of them and, therefore, collection of the wildlings to establish a nursery is an acceptable means of artificial regeneration. Collection is best done before the seedlings establish deep taproots and while they can be pulled out without much damage. Survival of *C. leptospadix* and *C. inermis* is low if tender shoots are damaged during transplantation of wildlings. Wildlings may be transferred to a nursery or directly planted in the same forest where supplementary planting is desirable to augment the stock. This method of wildling collection may not be practicable in most countries due to the high cost involved and the wildlings' low survival rate.

6.3 Micropropagated plants

Micropropagation is the accepted means of large-scale clonal propagation for many commercially important plants. The method utilises small plant parts and sterile tissue culture techniques to achieve higher multiplication rates. Micropropagation facilities require higher capital investments and skilled technicians.

Micropropagation protocols have been developed for seven species of *Calamus* of Western Ghats and the Andaman and Nicobar Islands, India, using immature or mature embryos or shoot tips of (one-to-two-year-old) seedlings for initiating the culture (Valsala and Muralidharan, 1998; 1999). The regeneration of plantlets in some species has been achieved through organogenesis in callus cultures as well as from *in vitro* leaf segments. Somatic embryogenesis and plantlet formation were also achieved from callus cultures (Valsala and Muralidharan, 1998). Similarly, tissue culture studies using explants from seedling embryos and collar zones were conducted on 16 Chinese species (Zeng, 2000). Goh et al. (1999; 2001) have regenerated two important Malaysian commercial species.

As a means of producing planting material, micropropagation cannot currently be a viable alternative to seedling germination due to the cost of production. Only when superior genetic selections are required for mass multiplication can this technique offer any special advantage. Large-scale multiplication of selected genotypes is hardly a requirement today for any of the commercial species in rattan-growing countries.

6.4 Nurseries

6.4.1 Layout of nurseries

Nursery beds are set up on sites where flat land is available and with adequate water sources for irrigation. To avoid higher transportation costs, nurseries should ideally be located reasonably close to the intended planting sites.

6.4.2 Preparation of nursery bed

The bed may be made of wooden planks, bricks or split bamboo. The standard size of the bed is 12 m x 1.2 m. Protection from heavy rain and direct sunlight may be ensured using thatching or shade nets. Shade of 50% is usually implemented. The nursery bed is lined with a plastic sheet to prevent roots from penetrating into the soil from the polybags.

6.4.3 Nursery management

Daily watering is needed to keep the bed moist. Watering should take the form of a fine spray to avoid disturbing the sown seeds in the beds. Weeding should be done if necessary.

Seedlings thrive in about 50% shade and may be damaged by bright sunlight. Seedlings can be slow- or fast-growing, and the duration for which they should be maintained in the nursery can vary accordingly from about 10 months to as much as 20 months. Rattans grow best in temperatures higher than 25°C, and damage can result at temperatures below 10°C. Rainfall of above 150 mm and relative humidity of about 70% is conducive for rattan seedlings.

7. Planting operations

7.1 Planting season

Outplanting of seedlings is initiated during the first rainy season, but before the peak. In India and Bangladesh, it is initiated during the monsoon and completed before the commencement of intense rains in June–July. Rattan seedlings attain a height of 30–45 cm (from the base of the seedling to the tip of the tallest open leaf) and will have 4-6 leaves when in the polybags, as they complete one year's growth in the nursery.

7.2 Support trees

Rattans are climbers that use the spiny flagella or cirri to anchor themselves to the branches of trees in the natural habitat. The trees should be able to bear the weight of the fully grown rattan and resist damage when the canes are pulled down during harvest. The trees' canopy also influences light availability; therefore, the trees' architecture is a decisive factor in whether they will be used as support or host trees. Crowns that are too large and dense may hamper light availability. Support trees are known to influence the yield and quality of rattan (Weidelt, 1990).

Some support trees include *Gmelina arborea, Tectona grandis*, *Pithecellobium dulce, Largetroemia* sp., *Hopea* spp., *Dipterocarpus* spp., *Artocarpus* spp. and *Acacia* spp. Tree species that are deciduous and have thin crowns are desirable , but those with tall boles and without branches are not. Fast-growing short-rotation trees are not desirable.

When clearing sites for planting, trees are retained to provide shade for the seedlings and, later, to support the growing rattan.

7.3 Spacing

The spacing adopted for seedlings in plantations varies considerably across different nations. The seedlings are planted in partially filled pits of 30 to 75 cm^3 at either 2 m x 2 m (China), 3 m x 3 m (Bangladesh), 4 m x 4 m, 5 m x 5 m or 6 m x 6 m (India). Aminuddin (1985) reported 3 x 3 m to be the spacing that gave the highest growth rate in *C. manan.* Gengarajoo and Otigil (1998) found 1 m x 1 m better than 2 m x 2 m or 2 m x 1 m. Clump-forming species require 5 m and more space, while single-stemmed species require 2–5 m spacing (WikiEducator, 2007). In the planted or secondary forest, planting lines are prepared wherever feasible by clearing 1–1.5 m-wide grooves at 5-m intervals, and 9–12 month old seedlings are planted out in pits of 30 x 30 x 30 cm at 5-m intervals in planting lines before the onset of the monsoon. In other cases, pits are scattered but the spacing maintained as close as possible to the ideal, and the ground is cleared only around the pit. In homestead gardens or community forests, where trees are sparsely distributed, four seedlings can be planted 1.5 m away from the trees around the support trees. A distance of at least 1 m from the support trees must be maintained. Commonly, home gardens have trees on the borders of the plots. These can serve as support trees for rattan, which, together, act as a live fence. Under rubber plantations, spacing of 8 m x 2 m, 8 m x 3 m and 10 m x 2 m have been successful with *C. caesius* and *C. palustris* in Thailand.

Seedling planting is done in such a way that the root collar is at the same level as the ground surface. During planting, care should be taken that the soil is well consolidated, leaving no gaps between the soil around the root system and that in the pit.

7.4 Tending of plants

Once the rattan seedlings are planted and established, they require little attention other than occasional loosening of the soil around them by hoeing and weeding every three months to prevent smothering. Mulching with humus helps in the development of new shoots. During the early stages, light is not very important for the establishment of the seedlings. Later, when growth begins, weeds around the plants should be cleared to about 35 cm to 1 m to improve light availability. The canopy should be periodically opened to regulate the light availability with the aim of improving growth. Protection from fire by the removal of dry grasses and other residue and conducting a fire watch during the dry season are recommended. Replanting should be performed in the first year if survival falls below 60% and sufficient seedlings can be kept ready in the nursery for this purpose.

8. Harvesting

Small-diameter rattans, such as *C. rotang*, will be ready for harvest after about six to seven years, while large-diameter rattans, such as *C. thwaitesii* and *C. hookerianus*, take about 10–12 years for harvesting.

Traditionally, harvesting was carried out by local indigenous communities who were familiar with the forests and had the necessary skills. Besides the shortage of skilled labour and the inefficiency of the process, such harvesting in modern times is bound to be economically unviable. Gnanaharan and Mosteiro (1997) describe the local tools and technologies available in different countries for rattan harvesting. The use of mechanical devices has been tested by FRIM in Malaysia, but was not found to be very promising due to the time taken and the damage resulting to the rattan harvested as well as the support trees (Chong et al., 1998).

No pretreatment is carried out when rattan stems are harvested; they are dried under sunlight and stored in sheltered and lifted wood frames. Transportation certification should be obtained if they are transported from one province to another in China.

Harvesting of edible rattan shoots in Laos is done as early as eight months after establishment (Ketphanh et al., 2004). The longest shoot is extracted during the first harvest, followed by another two weeks later. Production of shoots from each clump can be done once a month. With proper irrigation, fertilisation and cultural management, shoot harvesting can be done all year around. Otherwise, the production may be limited to during the rainy season.

9. Policies, land tenure and gender issues

9.1 Natural resource policies

Government policies have considerable influence on how rattan resources are managed and utilised (Freese, 1997; Ripetto, 1998). The factors that hinder small farmers as well as large investors from taking up rattan plantations include the long gestation period until harvest, the uncertainty of tenurial rights and difficult market conditions (Sastry, 2002). Policies are often more conducive to other land-use options that offer better returns for investors.

Ambiguous or unfavourable property rights discourage conservation of biological diversity or efforts to cultivate and manage non-timber forest products, including rattan, on the part of communities (Brandon, 1996; Fortmann and Bruce, 1988; Peluso, 1992).

9.2 Cutting rights; sustainability

Sustainable management of rattan resources through cutting licences was not found to be very successful since the ten-year tenure was not a sufficiently attractive incentive for users to exercise restraint in collection. Longer tenures of 25 years extendable by an additional 25 years granted to community-based organisations did, however, encourage responsible management and reduce overexploitation of resources. Likewise, the mere collection of a rattan deposit from licensees intended for developing plantations in harvested areas did not ensure plantation activities, despite the accumulation of a significant amount as deposit. Therefore, implementation of a stricter management regime using the revenue earned from deposits to supplement resources through plantations in exploited forests is recommended.

Indigenous communities have often been granted the rights to collect rattan and other non-wood forest products from forests, and this is implemented through permits issued to collector groups, cooperatives or contractors. Local communities will benefit, since levies are not usually charged, and when cooperatives are involved, the benefits are directly accrued to the collectors themselves.

9.3 Gender roles and responsibilities

Due to the arduous nature of the task of collecting rattan from the deep forests, men are primarily involved in its collection in most rattan-growing countries. Likewise, men have greater involvement in establishing rattan plantations, but women could play a significant role in nurseries, in activities such as the preparation of seeds and raising and tending the plants in addition to their role in the manufacture of rattan products, particularly baskets and mats. In Laos, rattan shoot collection was mainly performed by women while men extracted the cane. Policy interventions aimed at increasing rural participation in the value chain should include removing gender stigmatisation, providing rural artisans with technical and marketing support and establishing cottage industries as part of the effort to integrate rural communities' businesses into local tourism.

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