Tuscia University - Faculty of Agriculture

The Silvicultural and Sustainable Management of Rattan Production Systems

BSc in Agroecology and Rural Development

Academic year 2004/2005

In Cooperation with

FAO - Food and Agriculture Organization of the United Nations

Università degli studi della Tuscia
Facoltà di Agraria
Via San Camillo de Lellis, Viterbo

Elaborato Finale

Corso di laurea triennale in
Agricoltura Ecologica e Sviluppo Rurale
Anno Accademico 2004/2005

Silvicoltura e Gestione Sostenibile della Produzione del Rattan

The Silvicultural and Sustainable Management
of Rattan Production Systems

Relatore: Prof. Giuseppe Scarascia-Mugnozza

Correlatore: Ms Christine Holding-Anyonge (FAO)

Studente: Edoardo Pantanella

RÉSUMÉ

La coltivazione del rattan, e dei prodotti non legnosi in genere, offre grandi potenzialità sia economiche, in qualità di materia prima e di prodotto finito, che ecologiche, intese come possibilità legate alla riduzione dell'impatto dello sfruttamento forestale attraverso forme di utilizzo alternativo alla produzione del legno.
Studi specifici relativi agli aspetti tassonomici e biologici del rattan, indirizzati al miglioramento della conoscenza sulle caratteristiche biologiche delle numerose specie e dei possibili sistemi di sviluppo e di gestione silvicolturale delle piantagioni, hanno una storia recente. Essi hanno preso il via solo a partire dagli anni '70, a seguito della scarsa disponibilità del materiale in natura.

Nel presente elaborato si sono indagati gli aspetti biologici e silviculturali del rattan. Su queste premesse si è poi proceduto ad una analisi di alcune tipologie di gestione silviculturale. Infine sono stati messi in evidenza elementi necessari per una gestione sostenibile sia dal punto di vista ecologico che socio-economico.
La raccolta dati si è basata su molteplici fonti bibliografiche e statistiche tra cui numerosi sono gli studi monografici e i contributi provenienti dai principali istituti di ricerca scientifica internazionali (Malaysian Forest Research Institute, Limbe Botanic Garden Cameroon, Royal Botanic Garden Kew) e da associazioni nazionali e/o regionali. La specificità di molti dati rende purtroppo ancora complesso e difficile il lavoro di sintesi; solo di recente istituzioni sovranazionali, come la FAO hanno dato inizio ad un lavoro volto ad incrementare le relazioni tra governi dei paesi e le organizzazioni internazionali coinvolte, allo scopo di acquisire un quadro più ampio di dati sulla gestione sostenibile della coltivazione. Tra le istituzioni più impegnate e più aggiornate in materia è da segnalare la INBAR (International Network of Bamboo and Rattan) che possiede una notevole banca dati sia sotto il profilo botanico-silviculturale che economico, relativamente alle aree asiatiche e africane.

Il rattan appartiene alla famiglia delle Palmae o Arecaceae, sub-famiglia Calamoidae. Il numero delle specie censito si aggira sulle 600 unità, suddivise per 13 generi: l'estesione della famiglia rende, com'è facilmente immaginabile il rattan particolarmene adattabile a differenti ecosistemi. Esso è prevalentemente presente in tutte le aree equatoriali dell'Asia e dell'Africa, spaziando tra una altitudine di 0 a 3000 m slm; vegeta ad una temperatura media annuale di circa 25 °C con minime nei mesi più freddi superiori allo 0 °C e precipitazioni medie annuali di circa 2000 mm.

Tra le specie più frequentemente coltivate si segnalano il *Calamus manan*, *C. caesius*, *C. trachycoleus*, *C. zollingeri*, *C. tetradactylus*, *Daemonorops margaritae*, la *Laccosperma secundiflorum* e la *Eremospatha macrocarpa*. Il criterio di selezione commerciale di tali specie risiede nella valutazione delle caratteristiche qualitative delle parti legnose della pianta: laddove più ricercati sono quei fusti che garantiscono una maggiore flessibilità alla lavorazione e resistenza meccanica. Dal punto di vista tassonomico il rattan si configura come monocotiledone, con caratteristiche di rampicante per la maggior parte delle sue specie. Il rattan può essere sia dioico che monoico con fiori ermafroditi o meno.

Esso è sia monocormico, sviluppandosi a fusto singolo, o policormico, con sviluppo a ceppaia; la lunghezza può variare dai 50 cm per le specie nane agli oltre 100 m. I fusti possono essere di piccolo diametro (< 2 cm) e, nel caso di specie a grande diametro (> 2 cm), arrivano a dimensioni dell'ordine di 10-20 cm. La parte più esterna del fusto del rattan, presenta delle lamine foliari che sono, nella maggior parte delle specie, ricoperte di spine che ne favoriscono la possibilità di sviluppo su alberi aventi funzione di sostegno.

Per quanto riguarda le caratteristiche fenologiche esso può fiorire una sola volta nel suo ciclo vitale, ovvero presentare molteplici fioriture. Nel primo caso all'esaurirsi della fioritura e dopo la fruttificazione segue la morte del fusto; le specie appartenenti alla seconda tipologia continuano invece a vegetare, senza compromissione delle funzioni vitali. I frutti del rattan sono ricoperti da scaglie, impiegano ca. 12-14 mesi per giungere a maturazione, presentandosi, mediamente, della grandezza di c. 2-2,5 cm e un peso di 1-1,5 gr. Una singola pianta produce tra i 2000 e i 5000 frutti per fioritura; nel caso delle specie rifiorenti l'intervallo tra una fioritura e l'altra è mediamente di 7-8 mesi.

Caratteristiche ecologiche necessarie alla coltivazione del rattan sono: suoli ricchi di sostanza organica, sciolti e profondi, con pH tendenzialmente acido (4,5-5,5) e un alto tasso di umidità. A questo riguardo è tuttavia da notare che la maggior parte delle specie mal sopporta ambienti con continuo ristagno d'acqua. I livelli di RLI (Relative Light Intensity) ottimali si attestano su 40-50%, al di sopra di questi la mortalità delle piante segna un forte incremento. In conseguenza di tali esigenze il rattan trova migliore habitat nelle buche di rigenerazione naturale delle foreste primarie e secondarie, nelle aree sottoposte a taglio silviculturale, o in quelle marginali; ovvero come pianta consociata in coltivazioni arboree o, ancora, nella fase incolta dei cicli della "shifting cultivation".

Per quanto riguarda gli aspetti riproduttivi del rattan esso può avvenire per seme o per riproduzione vegetativa per mezzo del trapianto dei rizomi o separazione di nuovi getti purché provvisti di radici. In alcuni casi si procede anche al trapianto di quelle parti del fusto che presentano radici avventizie. Tecniche più avanzate usano la micropropagazione anche ai fini della selezione genetica. La propagazione per seme necessita di specifiche attenzioni che ne preservino la capacità germinativa soggetta a un drastico calo in mancanza di adeguati parametri di umidità, e cure meccaniche per la rimozione di quegli strati esterni (sarcotesta) che ne inibiscono la vitalità.

Le giovani piante vengono poste a dimora dopo 12 mesi secondo una modalità in linea, con una singola pianta per buca, o a gruppo, con 2-4 piante per buca. La densità mediamente varia dalle 400 alle 600 piante/ha. I sesti di impianto differiscono a seconda della varietà impiegata e della tipologia di coltivazione.

Nelle foreste primarie e secondarie l'impianto prevede un forte diradamento della vegetazione esistente, volta alla eliminazione delle piante senza avvenire, di quelle di bassa qualità e di scarso valore economico. L'incremento dello spazio e della luminosità consente alle piante di superare lo stato giovanile e di svilupparsi su alberi con funzione di tutore.

Nell'ambito di questa tipologia produttiva, tra i vari sesti possibili, si evidenzia il "planting strip" caratterizzato da 2 file distanziate di rattan inserite entro strisce di 30-40 m di foresta di altezza progressiva. Altre varianti prevedono una disposizione 4,6 x 3 m in cui i rattan sono posti a 3 m sulla linea e distanziati da strisce di foresta di 1 m di larghezza, oppure 6,7 x 3,4 m in cui i rattan sono posti a 3,4 m sulla linea e distanziati da una striscia di 3 m di foresta.

Nelle aree sottoposte a taglio silviculturale l'impianto avviene in strisce liberate dal sottobosco ovvero dalla vegetazione di ricrescita, secondo una densità di 500-800 piante/ha per specie a fusto singolo con un sesto di 6-20 x 1-2 m o di 300-400 piante/ha per le specie policormiche con un sesto di 8-12 x 2-4 m.

Per quanto riguarda le aree marginali caratterizzate da specie pioniere di basso valore commerciale l'impianto prevede una densità di 800-1200 piante/ha ed un sesto di 6–12 x 1–2 m per le specie monocormiche, 400-800 piante/ha per quelle policormiche con un sesto di 4–12 x 2–4 m.

Una maggiore facilità di coltivazione viene dalle consociazioni con colture arboree. In questi casi il terreno si presta a una coltivazione di tipo industriale visto che le caratteristiche della piantagione determinano una stabilizzazione delle condizioni ambientali, una uniformità nelle rese e nei tassi di crescita delle piante, un'aumento della resa economica per unità di superficie (valore aggiunto del rattan alla coltura principale).

Tra lei più diffuse consociazioni si possono ricordare le coltivazioni con *Pinus caribaea*, *Acacia mangium, Hevea brasiliensis*. Il rattan viene in genere posto a dimora in un impianto arboreo già avviato; la fase taglio finale avviene in contemporanea per entrambe le colture al fine di evitare reciproci danni. Nel caso specifico della *Hevea brasiliensis* i più comuni sesti di impianto utilizzati sono:

1) *Hevea brasiliensis* 6.1 x 3.05 m; rattan 12.2 x 6.1 m
2) *Hevea brasiliensis* 6.1 x 3.05 m; rattan 6.1 x 6.1 x 6.9 m
3) *Hevea brasiliensis* 8.5 x 3.05 m; rattan 17 x 1.5 m

Ulteriori studi su consociazioni hanno visto l'impiego del rattan in piantagioni di palma da olio o di bamboo con risultati alterni: mentre infatti la produzione di palma da olio risulta parzialmente danneggiata dal grande vigore del rattan, nel caso del bamboo (*Gigantochloa levis*) l'intercropping garantisce un miglior uso del suolo già dai primi anni grazie alla precocità del bamboo nel produrre germogli per uso alimentare.
Per quanto riguarda la "Shifting Cultivation" la coltivazione del rattan si inserisce nel periodo in cui il terreno è lasciato incolto. Esso ne è un ideale colonizzatore in quanto il suo ciclo vitale corrisponde, a livello temporale, alle esigenze di rigenerazione del suolo. Sebbene tutte le aree tropicali siano soggette alla tipica gestione dello "slash and burn" il Borneo si propone per più varianti volte alla valorizzazione di differenti suoli con specifiche varietà di rampicanti. I rattan garden non presentano dei sesti di impianto rigidi, ciò è dovuto sia alla natura caotica del taglio che alla rinnovazione favorita da interventi di tipo antropico. Il taglio del rattan comincia dall'8-9 anno e si ripete in genere ogni due anni, la fine del turno per la maggior parte dei rattan garden è a 15 anni.

Le rese dipendono da numerosi fattori: tasso di crescita, sistema silviculturale, zona geografica, topografia, densità, tipo di suolo, luminosità, umidità del terreno. A ciò si aggiunga che ad incidere sono anche le classi diametrali nonchè le caratteristiche del fusto (mono o policormiche) in considerazione del fatto che le specie a ceppaia possono avere anche più di 50 getti. Una precisa determinazione delle rese risulta essere comunque di difficile individuazione, anche a causa della non abbondante letteratura a riguardo. Ciò che però si evidenzia è che sistemi ben gestiti possono rendere fino a tre volte di più rispetto a quelli scarsamente curati. Per le specie più commerciali si forniscono i seguenti dati:

- *Calamus manan.* Specie a grande diametro (2-8 cm) monocormico, presenta un tasso di crescita di circa 1 m per i primi tre anni e di 5-7 m quando raggiunge le chiome degli alberi, una stima conservativa può attestarsi su di un valore di 1-3 m/anno. Il taglio avviene in genere alla fine del turno di 12 o 15 anni, con una resa di 5500 m/ha e 11600 m/ha rispettivamente. Occorre inoltre puntualizzare che il turno più lungo risulta essere vantaggioso non solo per il maggior quantitativo di materiale prodotto ma anche per l'incremento delle classi diametrali fornite.
- *Calamus caesius.* Specie a piccolo diametro (0,7-1,2 cm) policormico, presenta un tasso di crescita a regime di 4-5 m/anno con punte di 7 m/anno. Il primo taglio viene in genere effettuato all'età di 8 anni su circa il 15% dell'intero numero di fusti per ceppaia (circa 45). La resa per ettaro va dai 0,5 t/anno dei primi raccolti ai circa 1.5 t/anno dal dodicesimo anno in poi pari rispettivamente a 17500 e 52500 m/ha/anno.
- *Calamus trachycoleus.* Specie a piccolo diametro (0,7-1,2 cm), policormico. Presenta rispetto a *C. caesius* una maggiore vigoria riproduttiva grazie anche alla presenza di stoloni. Il tasso di

crescita risulta essere superiore a 7 m/anno. Il primo taglio viene effettuato all'età di 7 anni su circa il 15-20% dell'intero numero dei fusti per ceppaia (circa 60). La resa per ettaro va dai circa 0,4 t/anno dell'ottavo anno a 1,9 t/anno dall'undicesimo anno in poi, pari rispettivamente a 16000 e 80000 m/ha/anno.

La filiera del rattan prevede una fase di raccolta, di trattamento e di lavorazione in prodotto finito. Le varie fasi sono configurate nel seguente modo:
La raccolta è articolata in modo molto semplice e può giovarsi di strumenti meccanici che non richiedono un grosso impiego finanziario. Essa viene effettuata da raccoglitori, che possono essere sia proprietari terrieri che operai. In seguito al taglio e prima del trasporto verso i magazzini di stoccaggio i fusti vengono ripuliti in loco dalla vegetazione tramite l'uso di semplici utensili taglienti. Il materiale grezzo viene successivamente ceduto ai distributori, o venduto direttamente nei mercati urbani. La manodopera in queste prime due fasi è prevalentemente maschile. Una maggior presenza femminile e di anziani si nota invece per tutti quei lavori che richiedono rispettivamente maggior manualità e contatto sociale (vendita nei mercati), maggiore esperienza e know-how (progettazione e design di articoli).
La fase di trattamento del prodotto grezzo in semilavorato consta di numerosi passaggi. In sintesi: l'eliminazione degli strati più esterni del fusto per favorirne la lavorabilità, l'essiccazione al sole fino ad un tasso di umidità del 15%, la fumigazione con anidride solforosa per preservare la sostanza legnosa dagli attacchi dei funghi e degli insetti, la bollitura in nafta o kerosene per la rimozione delle sostanze gommose e far acquisire una colorazione più scura, il trattamento in ipoclorito di sodio per eliminare le macchie e le imperfezioni. I fusti vengono sottoposti alla lavorazione per la definitiva trasformazione in prodotto finito passando, a seconda della loro destinazione finale, per le fasi di laminazione o di tiraggio e curvatura. Seguono poi le operazioni di assemblaggio e di rifinitura del prodotto prima del successivo trasporto o vendita.
Nella filiera i piccoli proprietari/raccoglitori sono generalmente dediti al lavoro agricolo ed integrano una grossa percentuale del proprio reddito con la raccolta del rattan (dal 40% all' 80%).
Gli altri ruoli della filiera, oltre ad essere più remunerativi prevedono una progressiva specializzazione:
I distributori/concessionari oltre a rapportarsi con le istituzioni per l'ottenimento delle licenze curano le fasi della raccolta indicando ai raccoglitori le specie e le quantità da tagliare, gestiscono lo stoccaggio ed il trasporto del materiale grezzo verso le aziende addette alla produzione di semilavorati o a quelle manifatturiere. Tra i concessionari e i raccoglitori esistono spesso dei "contratti di credito" i quali più che libere transazioni commerciali sono dei modi con cui vengono restituiti in materia prima gli acquisti di generi di prima necessità effetuati dagli operai o dai piccoli possidenti. Risulta scontato che questo tipo di accordi vada a tutto vantaggio del concessionario che propone il più delle volte dei prezzi di acquisto del rattan inferiori a quelli di mercato.

Le aziende di semilavorati provvedono al trattamento del materiale grezzo e sono collegate alle industrie manifatturiere tramite accordi di tipo commerciale o di partenariato. Le aziende manifatturiere rappresentano invece l'anello forte del sistema, per l'accesso diretto al mercato nazionale ed internazionale grazie alla standardizzazione della produzione, per la possibilità di usare il proprio ruolo dominante per imporre i prezzi alle altre categorie della filiera, per la facile reperibilità di risorse finanziarie che permettono il rapido adeguamento della struttura aziendale e dell'output alle mutate esigenze del consumatore finale. All'industria manifatturiera si affiancano i sub-appaltatori, piccoli artigiani che lavorano indipendentemente ma che, in condizioni di forte domanda vengono arruolati dalle aziende di maggiori dimensioni per sopperire alle temporanee esigenze di forza lavoro. Tale forma di collaborazione se da una parte permette la sopravvivenza delle piccole imprese di tipo familiare, dall'altra non permette alle grandi compagnie di raggiungere per tutti i prodotti elevati standard qualitativi. A chiudere il ciclo di produzione sono poi gli operai, inpiegati nel settore commerciale, dei semilavorati, manifatturiero. Risulta logico che più elevato è il livello nella filiera (e dunque la specializzazione) maggiori sono le possibilità di guadagno.

Il rattan è ampiamente diffuso nel mondo e genera un fatturato che si aggira sui 7 miliardi di dollari. A livello globale sono ben oltre 700 i milioni di persone coinvolte nella sua produzione e consumo finale. Sebbene il suo areale sia molto vasto l'estrazione e il commercio avvengono principalmente nell'area del sud e del sud-est Asia. Tra i maggiori esportatori si annoverano la Malaysia e l'Indonesia, che negli anni '70-'80 copriva da sola più dei due terzi del mercato mondiale. L'attuale produzione è prevalentemente orientata verso il settore mobiliero, degli articoli intrecciati e degli utensili. Sebbene una buona parte del fatturato verso i mercati internazionali provenga da industrie manifatturiere, una significativa percentuale della produzione, specie per il mercato interno, è prodotta a livello artigianale e locale.

Il rattan così come gli altri prodotti "non-timber" rappresenta una prudente strategia di conservazione del landscape forestale sempreché sia mantenuto un livello di gestione sostenibile. Gli studi e le tecniche selvicolturali indicano che questo rampicante, oltre a essere presente nelle foreste naturali o secondarie, trova, nei sistemi agrosilviculturali e nelle aree marginali, il pieno sviluppo delle sue potenzialità ecologiche ed economiche:

- Nel caso dei sistemi agroforestali il rattan si inserisce come coltura consociata permettendo un incremento delle rendite ovvero una strategia di differenziazione laddove le colture principali si dimostrino di scarso valore commerciale.
- Per quanto riguarda i rattan garden essi sono un chiaro esempio di come sia possibile coniugare la specializzazione nella produzione con la biodiversità: l'immissione del rattan nel periodo di riposo del terreno conseguente alla sua messa in coltura permette il recupero del suolo, simula l'ecosistema delle foreste naturali e mantiene elevato il livello di biodiversità.

- Per quanto riguarda le aree marginali il rattan rappresenta una valida soluzione laddove fenomeni naturali o condizioni sfavorevoli non permettono la valorizzazione del terreno per usi agrari.

Dal punto di vista ecololgico le sue esigenze in luminosità, se per le foreste primarie e secondarie risultano essere troppo invasive al di fuori delle naturali buche di rigenerazione, rappresentano invece una caratteristica ideale per tutte quelle aree disturbate ove si instaura una successione. La coltivazione del rattan si dimostra inoltre di maggiore sostenibilità rispetto alle produzioni legnose sia perchè mantiene inalterata la copertura del suolo, prevenendo così fenomeni erosivi, sia per la ridotta rimozione di elementi nutritivi rispetto alle essenze legnose dovuta alla maggiore quantità di biomassa e di sostanze minerali rilasciate sul terreno nelle fasi di raccolta.

Dal punto di vista economico il rattan presenta dei redditi interessanti se comparati con altri usi del suolo: esso fornisce un reddito lordo che si attesta tra i 100 e gli oltre i 250 $/ha/anno, a seconda delle differenti tipologie di produzione, ben superiori rispetto alle essenze legnose attestate a circa 10-18 $/ha/anno. Per quanto riguarda altri usi il rattan presenta risultati alterni: se da una parte le colture di riso (1,5 t/ha), gomma (0,25 t/ha) e gli allevamenti zootecnici di tipo estensivo forniscono dei redditi inferiori o pari al rattan (rispettivamente 295 $/ha/anno, 44 $ha/anno e 200 $/ha/3anni), dall'altro le colture di olio di palma e di altri frutti tropicali (rambutan) garantiscono redditi di gran lunga superiori (1500 $/ha/anno, 423 $/ha/anno rispettivamente). In linea orientativa un ettaro di rattan impiega, per coltura in piena produzione, tra le 66 e le 93 giornate-uomo a seconda della specie.

Il vantaggio del rattan risiede però nella sua importanza come strumento per diversificare il reddito, che va spesso ben oltre il puro calcolo finanziario: la flessibilità in termini di tempo e di disponibilità di manodopera rispetto alle colture annuali permette una migliore di allocazione delle risorse disponibili nonchè una garanzia di reddito, qualora le principali colture annuali, a causa di stagioni sfavorevoli, non garantiscano introiti sufficienti. Laddove poi la disponibilità di manodopera risulti limitata (es. aziende familiari) il rattan compensa i temporanei bisogni finanziari senza dirottare l'impiego di forza lavoro interna per lavori esterni, cosa che limiterebbe le possibilità di mantenere le colture per gli anni a venire.

In conclusione sebbene il valore del non-timber rispetto alle produzioni legnose possa variare a seconda dei contesti territoriali (tipologie di mercato, politiche forestali, accessibilità al mercato, tecnologie adottate), la chiave di una gestione ottimale risiede in una sinergia che permetta una integrazione e differenziazione sia economica che ecologica dei due sistemi. I numerosi benefici in termini di esternalità positive fornite dal rattan e dai prodotti non-timber in genere, possono garantire nel lungo termine una costante accessibilità alle risorse.

La sostenibilità della gestione dei sistemi deve in ogni modo essere vista in chiave olistica, ponendo l'attenzione, oltre che su aspetti tecnici ed economici, anche su quelli politici, sulle problematiche legate alla proprietà o uso della terra, sui ruoli e sul peso dei singoli nell'ambito della filiera produttiva, nonchè sull'equilibrio di genere.

Una comune strategia può risiedere nell'incremento del senso di sicurezza dei piccoli produttori, come strumento per prevenire l'eccessivo sfruttamento delle foreste per fini di sopravvivenza. In questo senso favorire un più agevole rapporto con le istituzioni (politica per le licenze, ridotta tassazione per i piccoli proprietari, credito fiscale, snellimento della burocrazia) e un più facile accesso al credito permetterebbe agli anelli più deboli della filiera produttiva (in genere i piccoli proprietari e la manodopera per la raccolta) di avere sia un maggior potere contrattuale con gli intermediari e con le istituzioni, che un maggior peso politico e legale. Una lungimirante politica della terra, che riconosca ai piccoli produttori il possesso o il diritto di usufrutto di aree forestali per lunghi periodi di tempo responsabilizzerebbe le parti per una sostenibile gestione di queste, evitando quegli irreparabili danni dovuti ad un indiscriminato sfruttamento.

Un notevole contributo all'innalzamento delle condizioni di vita può altresì venire da un migliore accesso ai mercati, sia in termini di standardizzazione della produzione secondo i requisiti della domanda che da una maggiore visibilità tramite l'istituzione di comunità o di associazioni di categoria.

È quasi superfluo affermare che il rafforzamento della produzione locale o il successo nello sviluppo di nuove strategie può essere raggiunto unicamente con un'attenta analisi del tessuto sociale delle comunità così come delle sue risorse/disponibilità interne. Parafrasando una affermazione di Dillon "Il rendimento di un sistema non deve essere valutato in termini di resa di ogni singola parte presa nella sua individualità, ma su come differenti parti di questo si rapportano reciprocamente e su come il sistema stesso si relaziona con l'ambiente e con gli altri sistemi che in esso si trovano".

Per concludere, il rattan è da considerarsi un importante elemento per lo sviluppo delle aree equatoriali e tropicali. Nonostante il suo valore i governi non hanno finora posto molta attenzione su piani di sviluppo e di gestione di questa coltura per ottimizzarne la produzione. Le cause di questa bassa considerazione risiedono presumibilmente nella sua scarsa visibilità rispetto ad altre materie prime e alla minore incidenza sui mercati internazionali, che non richiama l'attenzione dei governi sulle sue potenzialità di generare valuta.

Lo sviluppo sostenibile del rattan non solo presuppone l'uso di appropriate tecniche e del potenziamento della ricerca volta all'innalzamento degli standard di qualità, ma deve tener conto delle politiche nazionali nonchè del rafforzamento dei piccoli proprietati/operatori attraverso politiche di credito e microcredito, di stabilizzazione dei prezzi, di rafforzamento della capacità imprenditoriale della popolazione, di miglioramento delle tecnologie e delle infrastrutture. Essendo il rattan una materia prima proveniente dai paesi emergenti sarebbe auspicabile elaborare strategie che incrementino e diversifichino l'offerta locale verso i mercati internazionali. Creare quel valore aggiunto che permetta la trasformazione del rattan da materia prima a prodotto finale di elevata qualità sarà una sfida a cui i paesi in via di sviluppo devono tendere anche tramite il miglioramento dei rapporti politici e di interscambio commerciale mondiale basati su piani di reciprocità e di equità.

Tuscia University

Faculty of Agriculture

Via San Camillo de Lellis, Viterbo

Thesys

BSc in Agroecology and Rural Development

Academic year 2004/2005

The Silvicultural and Sustainable Management of Rattan Production Systems

Advisor Prof. Giuseppe Scarascia- Mugnozza

Co-Advisor: Ms Christine Holding-Anyonge (FAO)

Candidate: Edoardo Pantanella

TABLE OF CONTENTS

SUMMARY

Rattans and Non Timber Forest Products have rarely been considered major forest products by forestry research institutes that have paid not so much attention to these plants as a way to improve sustainable livelihoods and to reduce the impact of logging over-exploitation through the utilization of alternative sources of incomes.

The neglect of rattan changed in the seventies due to the shortages in the supply from the wild, which made several forest research institutes strengthen their studies in the taxonomy and biology of rattan in order to develop methods for the growing of rattan plantation. Several programmes have been developed and the importance of this product is nowadays recognized.

Although great advances have been made in the understanding of rattan both in the wild and as a plantation crop, there is still much that is unknown. Starting from the basic data, such as the botanical identity of many species as well as the ecological requirements and silvicultural potential, many of those problems that can threat the sustainable utilization of the canes still remain unresolved.

The present dissertation wants to describe the state of the art of silvicultural and sustainable management of rattans. Through the review of several studies on ecological, managerial, and economical issues the main aim consists in analysing rattan profitability and sustainability.

Rattan gross revenues show a great economical potential in comparison to timber. It can be harvested with continuity and with shorter rotation cycles and do not requires great financial investments either in maintenance, machinery and harvesting equipment and processing machineries.

On an ecological point of view, rattan management systems, if maintained within a sustainable level, avoid the damages to local fauna and flora, as it does not disturb local habitat like other forest utilizations have proved to do.

AKNOWLEDGEMENTS

I would like to express my sincere gratitude to Professor Giuseppe Scarascia for his kindness in introducing me in FAO Forestry Department, for all his lectures on the importance of silviculture in forest management, for his availability in assisting my studies.

I am grateful to Ms. Christine Holding Anyonge for her support in expanding the socio-economic issues of forest development and for assisting me in contacting FAO and international experts on NTFPs.

My special thanks are for Dr Alberto Del Lungo who supervised my research and gave me lots of advises on research methods.

I also wish to express my thankfulness to all INBAR staff for their quick helps in collecting information.

Last, but not least my deep gratefulness belongs to my beloved family to whom my degree is dedicated.

CHAPTER 1

INTRODUCTION

Nowadays biodiversity degradation is affecting the world with raising levels. Lack of ecological consideration and internalisation of ecological costs have resulted in habitat disturbance and extinction of many species of flora and fauna. Due to increasing awareness of these problems and concerns on climate modifications, efforts should be made to conserve existing biodiversity not only in restricted areas or reserves but also wherever human being modify local ecosystems.

Sustainable land use has to conjugate profitability and externalities. In this perspective forest products extraction should be considered on a more ecological level through the reduction of the logging impacts or the empowerment of alternative resources.

The interest in Non-Timber Forest Products (NTFPs) has grown in recent decades due to a number of propositions:

- NTFPs contribute to the livelihoods of forest dwellers and indigenous people providing them with food, fibres, tools and drugs.
- Harvest of secondary products does not harm the ecosystem, as great deals of species and niches are maintained allowing forest to be managed on a sustainable level
- NTFPs can provide employment and income accordingly to good practices and local knowledge. A sustainable extraction, thus, can play an important role in conservation and development.
- The increased value of the forests can help to maintain local resources by avoiding disrupting land conversion to other uses.
- The commercial use of NTFP can raise local population cultural identities through the valorisation of their intellectual properties and activities.

Forests harvested for non-timber products usually maintain their original appearance, although output levels should be deeply monitored due to plants' low densities and disturbing levels to local fauna’s habitat. Potential income from NTFPs such as rubber-rattan plantations or rattan gardens could be considerably higher than logging or agricultural uses of the forest, providing that sustainable management and market expansion for these ecological-friendly products are assessed.

The aim of this study is to analyse the ecology of rattans, the management practices of some of the most diffuse species, the profitability of some management systems. The analysis and evaluation of management systems will provide a basis for the identification of practical requirements to strengthen the role of rattan in development and biodiversity conservation.

The objectives of the present study are:

- ➢ Widen the knowledge on rattan both in biological requirements and silvicultural management.

- Evaluate rattan profitability by analysing yields and revenues of the most important species and comparing this land management with other kind of cultivations.
- Evaluate the sustainability of rattan production in the forests.

The methodology is based on literary reviews and compared case studies of several rattan management systems.

The study starts analysing the diffusion of rattan in the world, checking out the main biological and ecological characteristics, makes better understand the silvicultural needs of the different species and their potentials within agroforestry systems. At this regard cross-analysis on growth rates, forest coverage, moist levels and grades of disturbance have been collected and revised.

The present study shows in conclusion how sustainable management is possible whenever certain harvesting rules are attended. This product provides the same economic benefits of monocropping systems and logging, while it permits to increase population livelihood through added value transformation of commodities.

CHAPTER 2

2.1 TAXONOMY

Rattans are climbing Old World members of the palm family, Palmae or Arecaceae. There are about 600 species and 13 genera (Dransfield, 1992). All belong to a large subfamily known as Calamoideae that includes some non-climbing palms such as sago (*Eugeissona* spp.), salak (*Salacca* spp.), rafia in Africa and eastern tropical America (*Raphia* spp.) and the burity palm of the Americas and its relatives (*Mauritia*, *Mauritiella* and *Lepidocaryum*). All these palms have reflexed scales on the fruit. Many calamoids are spiny which is necessary for their climbing habits. Of the 13 rattan genera, three are found only in the equatorial rain forests of Africa, these are *Laccosperma*, *Eremospatha* and *Oncocalamus*. In recent times they have been increasingly harvested due to shortages induced by bans on the export of raw and semiprocessed canes in most of the Asian producing areas.

Although local people use local species belonging to several genera, the most important canes come from genus *Calamus.* Among the different groups there are several differences in the structure of the inflorescences and flowers themselves. In Africa subtribes *Laccosperma* and *Eremospatha* belong to the Ancistrophyllinae subtribe as they have hermaphrodite flowers. On the other hand *Oncocalamus*, despite its similarity to the other two genera, has unisexual flowers. As far as the Asiatic *Korthalsia* and *Metroxylon* are concerned, they have ermaphrodite flowers instead of dioecious ones as in *Calamus*, *Daemonorops*, *Ceratolobus, Pogonotium* and *Calospatha*. *Plectocomia*, *Plectocomiopsis* and *Myrialepis* share vegetative and inflorescence characters as they are dioecious with male flowers lacking in the female inflorescence.

Regarding the climbing habit it has evolved more than once from the shrub-like or acaulescent one. Despite recent interest in rattan resource much more work has to be done to know the rest of the flora. To date many research projects are carried out in order to classify and standardize the different species not only for academic purposes but also for botanists and scientist to develop better understanding of silvicultural crops and to ameliorate the quality of the commodities.

Palmae (Arecaceae)
- **Subfamily** Calamoideae
  - **Tribe** Calameae
    - **Subtribe** Ancistrophyllinae
      - *Laccosperma*
      - *Eremospatha*
    - **Subtribe** Metroxylinae
      - *Korthalsia*
    - **Subtribe** Calaminae
      - *Daemonorops*
      - *Calamus*
      - *Calospatha*
      - *Pogonotium*
      - *Ceratolobus*
      - *Retispatha*
    - **Subtribe** Plectocomiinae
      - *Plectocomia*
      - *Plectocomiopsis*
      - *Myrialepis*
    - **Subtribe** Oncocalaminae
      - *Oncocalamus*

Classification of rattan genera, from Uhl & Dransfield (1987)

2.2 STRUCTURE OF RATTANS

In the Family Calamoideae not all the species are climbers: some of those have very short and subterranean stems as is *Calamus minutus* or, as in *C. arborescens* it has limited ones (Dransfield, 1992). The remaining species are climbers; some climb high into the forest canopy (Fig.1) while others climb rather weakly or scramble in the forest undergrowth. Some rattan species are single stemmed, while others, which are the most important for silviculture, are clustered. However, some exceptions can occur by clustered species that grow in a single stem or viceversa. The suckers of clustered species are produced from the lowermost nodes of the original stem and can in turn produce further suckers themselves. As a rule new stems shoot in the axils of basal-most leaves, however, in few instances they are produced opposite or at a wide angle to the leaf. Suckers may be very short and so the clump will be dense or viceversa they develop into rhizomes or stolons producing a diffuse clump. Above the basal nodes the buds no longer produce further stems but flower-bearing branches. Some exceptions are common whenever some diseases or damages occur to the growing point or for certain species, resulting in canes' low quality.

Rattan stems are concealed by the leafs' spiny sheathings that, as the stem grows, shrivel and erode away exposing the rattan stem. As the rattan seedling grows there is a gradual increase in the diameter before the vertical growth. The stem presents a constant diameter except for the basal part near to the roots and in the uppermost part where it reaches the open forest canopy. The growing point of the stem is not found at the apparent tip of the rattan but occurs well below, enclosed by the leaves' sheaths. The tender young stem is the "umbud" of the palm heart of the rattan, which is very good to eat, although damages in this part cause the death of the stem itself.

Depending on the species, geographic location and altitude the diameter can range from a minimum of 3-4 mm to 20 cm and reach 30 m or more in length.

Leaves are produced spirally one at time at the growing tip of the stem, hidden within the leaf sheats of older leaves.

The leaf sheaths consist of a tubular sheathing base that arises from the node on the stem (Fig.2). At its upper end the sheath narrows into the petiole (variable in length and armed with spines) that continues into the rachis of the leaf (basically pinnate). Of the entire length only a quarter (or a third) is exposed beyond the sheath of the preceding leaf and is assumed to correspond with the length of the internode of the stem itself. The sheaths present different kind of spines, which are quite different among species.

As far as the climbing organ are concerned there are two whip-like organs associated with climbing in rattans, which are very similar but have different morphological origin: the cirrus and the flagellum. As a general rule they do not develop during the rosette stage of the palm and are mutually exclusive. The cirrus is an extension of the leaf rachis beyond the terminal leaflets while the flagellum is a sterile inflorescence born on the leaf sheath. Both have very rigid grapnel-like spines, although in the cirrus they grow directly on the extension of the leaf rachis while in the flagellum an axis is covered with very tightly sheathing bracts that bear spines. The different origin of the flagellum (considered a sterile inflorescence) is confirmed by the bracts' presence and is borne in the same position. Some exceptions can occur with some species that can climb without the aide of climbing organs. In such case the palm utilize the spine of the leaf rachis.

Another ecological feature of palms that is important in terms of management is their flowering: hapaxanthy (flowering once) and pleonanthy (multiple flowering) (Dransfield, 2001). In haxapanthy, after a period of vegetative growth, a simultaneous production of inflorescences from the topmost nodes lead to the exhaustion of the apex followed by the stem dead after fruiting (Fig.11). If the rattan is a single stem species the whole plant dies, on the contrary if the plant belongs to clustering species only the individual stem dies. In pleonanthic species, after a juvenile period of vegetative growth, maturity is reached and inflorescences are continually produced without compromising the vitality of the stem. These different flowering methods affect the silviculture in terms of cutting regimes and stem selection in order to maintain high levels of seed production. What is more haxapanthic species show a lower quality due to soft pith, which renders the cane unsuitable for bending and preservation. All the species of *Korthalsia*, *Laccosperma*, *Plectocomia*, *Plectocomiopsis* and *Myrialepis*, and a few species of *Daemonorops* are hapaxanthic. All other rattan species are pleonanthic.

As said before rattan species differ for their different inflorescences: while *Korthalsia*, *Laccosperma* and *Eremospatha* have hermaphroditic flowers, others are unisexual with separate flower in the same plant or dioecious (Fig. 8). In the latter case the pollination should occur with the presence of one individual for each sex, limiting the number of fruiting and seeding plants (Fig. 6, Fig. 7)

Rattan fruits are covered by neatly ordered scales (Fig. 9, Fig.10). At maturity the fruit wall does not split open neatly along predetermined lines, as do dehiscent fruit. Fruit maturity is indicated by slight change in colour, the scale separate easily, the inner seed-coat is dark in colour. In all rattans the innermost layer of the fruit wall consists of a thin membrane (no presence of woody layer or endocarp). Within the fruit wall (pericarp) lies the seed. In those rattans in which the pericarp is thin and not fleshy the outer seed-coat (sarcotesta) is thick and fleshy. On the contrary, where the pericarp is fleshy, the sarcotesta is thin and dry. Sarcotesta is generally attractive to animals that are the natural dispersers of the seeds. The rest of the seed (inner seed-coat and endosperm) contains the embryo that is susceptible of drying out.

2.3 STEM ANATOMY

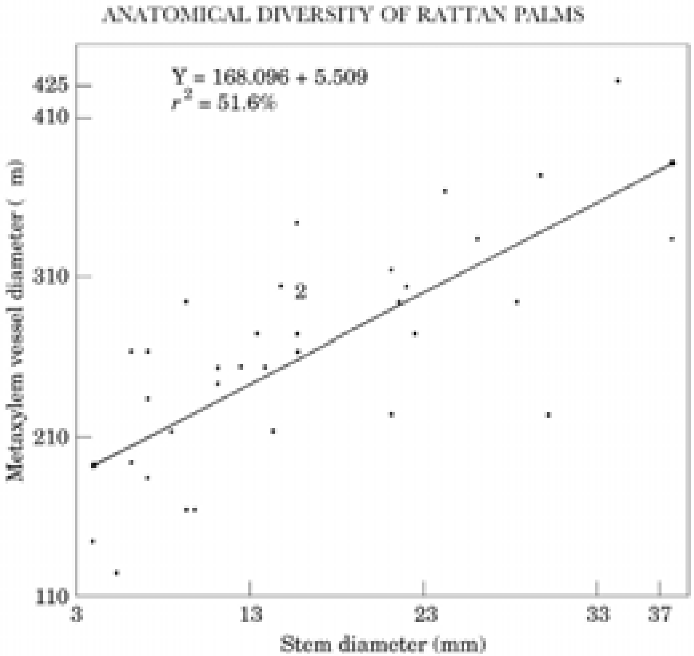
A cross-sectional view of a rattan stem reveals its principal architecture, consisting of two zones - the periphery with epidermis and cortex; and the central cylinder with vascular bundles with fibrous sheaths embedded in thin-walled parenchymatous ground tissue.

The three most important structural features that determine rattan properties are: fibre wall thickness, proportion of fibrous tissue and the diameter of metaxylem (Oteng-Amoako, A. A. &

Ebanyenle, E., 2000). It is because of definite patterns of variation in these structures that rattan species behave differently at different points along the stem and between species. The fibre wall substance (or thickness) contributes to the basic density while the metaxylem vessel diameter is inversely related to basic density because it increases the void volume of the stem tissue. With thinner wall, lower amount of fibre and wider metaxylem vessels, the apical younger internodes and the central core are weaker and have less utilization value than the basal and peripheral portions.

Dransfield (2002) in his studies emphasizes that the outer part of the stem, the epidermis, is often heavily encrusted with amorphous silica (0.9-2.7%), which could negatively affect specific products, such as ropes, binds and splits. The fibre sheath surrounding the phloem and metaxylem vessel(s) consists of thick-walled fibres with a polylamellate wall structure with a length that ranges 0.9 - 2.9 mm with an average of 1.3-1.8 mm. Density varies between 0.3 and 0.6 g/ cm^3. He also confirms that stems' fibre percentage and fibre cell wall thickness decrease from base to top internodes, whereas vessel diameter increases. This increase with age is caused by a fibre wall thickening within the individual lamellae by secondary processes, as well as by an additional deposition of further wall lamellae. Contrary to softwoods and hardwoods, the fibres in rattans are still alive.

Mathew A. and Bhat, K.M., (1997) in their studies on three major rattan growing regions in India, (species *Calamus*, *Korthalsia* and *Daemonorops*) have proven that equable temperature, high humidity (70–85%), heavy rainfall and less biotic interference, provide the best environment for cane growth. This is reflected in stem size, both in thickness and height. The canes of north-eastern states are relatively small in diameter probably due to higher latitude, unequal temperature and biotic interference. Among the species studied, plants from the islands possess the widest vessels (mean metaxylem vessel diameter = 294 µm) while rattans of north-eastern states show narrower vessels (mean metaxylem vessel diameter = 210 µm) (Bhat et al., 1993). Variations in vessel diameter can be correlated with the eco-physiological requirements of the species. Wide vessels are vulnerable but efficient conductors, and narrow vessels provide greater safety since they reduce gas embolisms. Most of the species studied grow at altitudes between 50 and 350 m, but they generally occur from sea level to altitudes above 1800 m (e.g. *P. himalayana* and *C. acanthospathus*), and latitudes between 6° and 28°N. Higher latitude is associated with narrower and shorter vessel elements. Altitudinal influence on vessel structure appears to be less important in rattan palms because species from similar altitudinal zones in the three regions show considerable variation in their vessel dimensions. Phloem shows some specialization in high altitudes. Altitude and latitude influence wood structure indirectly through temperature and availability of water. Structural adaptation for the climbing habit is evident from the patterns of variation in stem anatomy. As rattans are not self-supporting, the mechanical requirements are reduced; the stronger and more effective structural zone at the stem periphery enables the stem to resist external forces in climbing. The greater proportion of non-mechanical tissues such as ground and cortical parenchyma and conducting tissues not only make for a lighter liana life-form but also improve conduction and storage efficiency over great lengths.



Source: Mathew & Bhat (1997)

Lucas & Dahunsi (2004) in their studies on African rattans (*Calamus*, *Laccosperma*, *Eremospatha*) affirm that the diameter of the internodes and indeed the stem itself does not vary along their length and have a more or less circular section. Regarding the mechanical properties they decrease from the basal to the top portion of the stem, and depend on the age of the palm, with the highest values obtained in 12-years-old plants Dransfield (2002).

2.4 CHARACTERISTICS OF MAIN SPECIES

Marketability plays an important role in rattan selection. Not only already known species have an advantage to lesser spread ones but price also depends on different markets, chain's level and grade of processing as well as grade of profitability of planting venture. Clustering attitude allows repeated harvestings and fast growing rates in small diameter canes, while solitary canes show higher yields in comparison to clustering ones. Stems are selected not only for their diameters but also for the distribution of their bundles (that affects density), degree of lignification, internodes' distances, colour uniformity and grade of silicification. Species found in a wide range of habitats are planted extensively because of their better tolerance to different climatic conditions, topography, and different soil conditions. Light requirements define limits within species under forest canopy, as the high climbing palms require more radiative intensity (Supardi, 2001).

Following the most diffused species are shortly described in their ecological characteristics.

Calamus manan

C. manan is a robust single-stemmed cane. It produces the best strong durable cane, expecially for the furniture industry, with a diameter of ca 20–80 mm, even texture, with good surface appearance and internode length as long as 40 cm. The mature plant can be longer than 100 m with leaves over 7 m long (Fig.1, Fig. 3). *C. manan* is found naturally in Sumatra, Peninsular Malaysia, Southern Thailand and South Kalimantan (Indonesian Borneo). The species is found in the wild in perhumid tropical areas and in a range of 200-1000 m above sea level, usually on slopes on well-drained soils. However, in plantation, it has been proved to be less demanding and can be planted in the lowlands, although it does not perform well on waterlogged soils. The species is now in very short supply due to overexploitation and is being substituted by other large diameter species of lower quality (Rao, 1998).

Calamus caesius

C. caesius is a densely clump forming, small diameter rattan (Fig. 5). It produces high quality canes of 7–12 mm diameter and stems of over 100 m that are used for matting, chair cane, binding for furniture and furniture construction or baskets. Canes are resilient, durable and present a glossy siliceous surface, which is sometimes removed in order to make the cane more flexible. Growth rates are about 4–5 m/year, and in some case 7 m or more. Clump may have 20-50 or more stems, depending on local conditions after a full 6-year rapid establishment . *C. caesius* is closely related to *C. trachycoleus* with similar diameter and. The area where it grows is Southern Thailand, Peninsular Malaysia, Sumatra, Borneo and Palawan (Philippines), particularly in perhumid tropical climates, which is its growing line. Within forest *C. caesius* prefers lowlands, up to 900 m elevations and alluvial soil, despite it has been seen growing on other soils. Sporadic small-scale cultivation of this species in Borneo is historically reported. In one system, it is planted in the fallow period of the shifting cultivation cycle, lasting about 15 years, and harvested when the forest is felled again for rice-planting. Commercial rattan plantations have been established using this species since the Seventies. This species show a great potential for expansion of smallholder cultivation, especially in village orchards, marginal lands and buffer zones. The major untapped potential of this species is as a smallholder *C. caesius* is harvested in the wild often before flowering and fruiting, which presents a great danger for its conservation due to drastic reduction of sexual propagation (Rao, 1998).

Calamus trachycoleus

C. trachycoleus is a vigorous rapidly-growing, small diameter rattan (Fig. 4). Its produces resilient and durable high quality canes of 7–12 mm diameter, although *C. caesius*'s quality is considered slightly better. The cane's surface is glossy and siliceous and a removal treatment is often

performed in order to improve its flexibility. This species has an unusual clumping behaviour: it produces long stolons (usually 3 m) that metamorphose in stems or in other stolons at the same time. Growth rates of aerial stems can be very rapid (up to 7 m a year), which allow this species to be cultivated or to be used as a rapid colonizer, although it makes it difficult to control plantations.
The species is confined in central Kalimantan (Indonesia) where it has been cultivated for over 100 years on a large scale after being introduced by missionaries in 1850. Nowadays it is diffused into several parts of Indonesia and Malaysia. The palm prefers perhumid tropical areas at low elevations and can withstand with little damage severe and prolonged seasonal flooding (1–1.5 m for up to 2 months). For its characteristics the areas of cultivation are in seasonally flooded alluvial flats on soil overlying highly acidic clay: soils that are not very suitable for permanent agriculture.
Kalimantan's successful cultivation system has been used as a model for the setting up of smallholder and commercial plantations both in Indonesia and Malaysia. The cane is splitted for weaving into matting, chair cane and handicrafts as it has softer and more supple stems than *C. caesius*. (Rao, 1998).

Calamus zollingeri

C. zollingeri is a clustering multi-stemmed palm. The cane's dimension is 4 cm x 40m long with 35-40 cm long internodes. *C. zollingeri* has 6-7 m long leaf, cirrate leaflets of 40x3 cm, male and female similar inflorescences of 1.1 m and small fruits of 5 mm diameter. The canes are widely utilized in the furniture industry for their good internal structure and appearance. Small diameter canes are used for making rough furniture, coarse baskets and household utensils
It grows in Sulawesi and Moluccas of Indonesia, in monsoonal to perhumid climates, from the lowlands to ca 1800 m in the mountains. Soils range from mangrove soils, freshwater swamps (but not peat-swamp), coral limestone and occasionally ultramafic soils. Although it is grossly over-exploited at present and shows different degrees of threat, some aspects of the growth form suggest it may be more amenable to sustainable cultivation than *C. manan* especially in view of the multi-stemmed habit and wide climatic and ecological range (Rao, 1998).

Calamus tetradactylus

Calamus tetradactylus is a densely clustering small diameter rattan, with good quality canes of 5–8 mm diameter and up to 30 m length utilized for handicrafts, binding in furniture and cordage. C. *tetradactylus* grows in Hong Kong and Vietnam, in China on Hainan Island, in southern Guangdong, Guangxi, Fujian, Morinees, where it is also cultivated in small commercial scale (Huangcan, 2000a). It requires an average temperature of 20-30°C, more than 1300 mm annual rainfall and relative humidity over 78%. This species is the most northerly of all cultivated rattans, occurring in areas where rare frosts can occur. This species has been severely threatened in the wild by overexploitation and habitat destruction (Rao, 1998).

Daemonorops margaritae

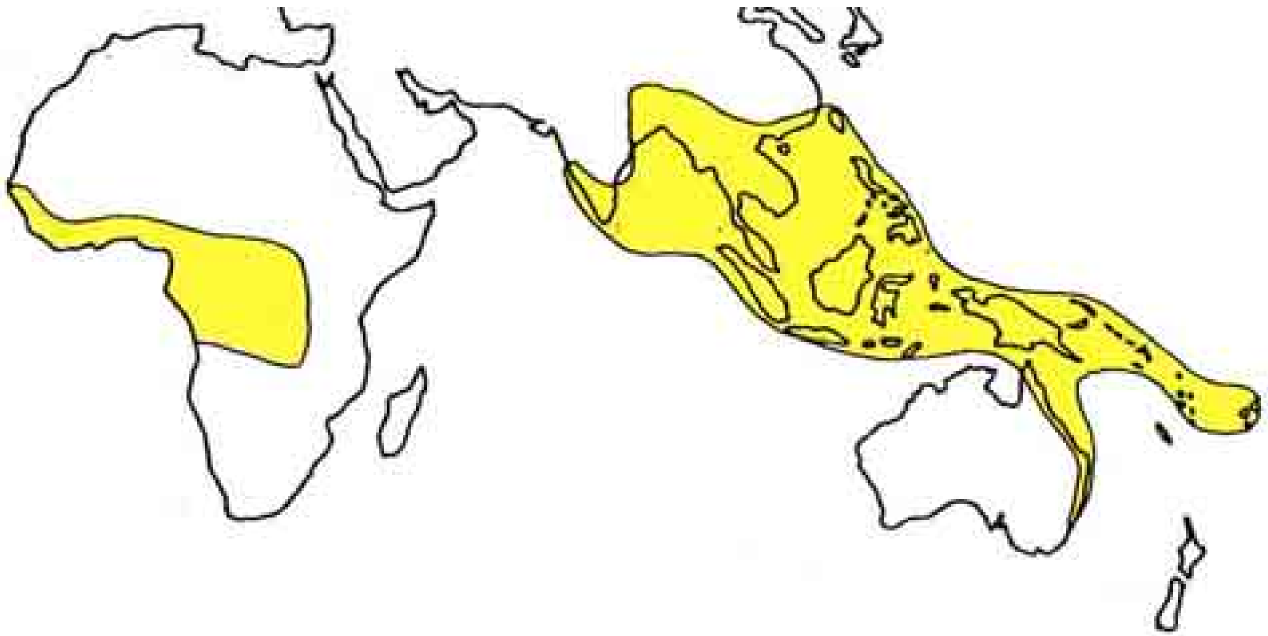
D. margaritae is a fast growing clustering palm with stems of 1.2 cm in diameter and more than 50 m in length. It is one of the main commercial rattan species in tropical or south subtropical zone, and originates from south China. Stems are used for furniture, handicrafts and religious ceremonies as well. On Hainan Island, except for the dry region in southwest part of China, *D. margaritae* is distributed from low coastal hills to high mountain forests up to an altitude 1100. This rattan prefers a mean annual temperature 20-24°C, mean temperature in the coldest month (Jan.) more than 12°C, low annual temperature -2.8-5.1°C, total illuminating hours 1900-2400 h, annual rain fall more than 1100 mm and humid fertile soil with good drainage (Huangcan, 2000b).

Laccosperma secundiflorum

L. secundiflorum is a clustering large cane with good quality canes of more than 2 cm diameter. It is the most important African cane species widely used on a subsistence level and forms the axis of the commercial industry through West and Central Africa. Canes are used as furniture framework (whole stems), or are splitted for basketry and bridge construction. Rachis are used as fishing rod, young leaves are eaten in stews as well as palm heart (Sunderland, 2004). *L. secundiflorum* is a common component of the forest flora and grows in a wide area from Liberia to Angola. It is a highly shade-tolerant palm and prefers to grow under the lowland forest canopy. It lives in areas where the average rainfall is 1800-2000 mm predominantly on acidic and poor in nutrients oxysols and ochrosols (Adu-Anning, 2004). Nowadays *L. secundiflorum* is threatened due to overharvesting and lack of land ownership. Its haxapantic characteristics, which exhibit an extremely long vegetative phase before a reproductive event, make this palm endangered by a drastic reduction of sexual reproduction.

Eremospatha macrocarpa

E. macrocarpa is a clustering small diameter rattan (below 2 cm). It is the second most important cane species in Africa, and, like *Oncocalamus mannii*, is not used in the adult state as it is considered too inflexible. Juvenile stems are splitted and used for baskets, weaving or furniture tying. It covers the same area of *L. secundiflorum* in the Guineo-Congolian forests of Central Africa (Sunderland, 2004). *E. macrocarpa* is a colonizer of heavy disturbed areas due to its high light-demanding nature and can withstand permanently flooded zones (Profizi, 2000).



World distribution of rattans. Source: Wan Razali (1992)

2.5 PHENOLOGY OF MAIN SPECIES

Phenological patterns of rattans are widely different. Some species produce inflorescences continuously through their adult life (although the number of total fruit could be very low), while in other species flowering is annual or seasonal. As a general rule the most important species produce abundant fruits, which could be one thousand per inflorescence. On the other side single-stemmed species such as *C. manan*, may produce fewer fruit per plant than clustering species, which means lesser seeds available for plantation and for renewals (Barizan, 1992).

In the case of *C. manan*, flowering is pleonanthic and the species is dioecious. There is no possibility to identify male and female without a proper recognition of the inflorescences: male flowers grow on third order's branches, while females grow on the second. In addition female inflorescences present on their rachillae sterile male flowers. *C. manan* comes into the first flowering at the age of 5.5 years although it does not bring any production of fruits. Large quantities of fruits and seeds can be harvested at the age of 10-12 years (Manokaran, 1984). Palms develop inflorescences in accord to a geographical seasonality ranging from January to May, as it is able to produce one to five inflorescences (March-April if once, starting from January if two or more). Fruits take about 14 months from fertilization to maturity. A single plant can produce 3000-5000 fruits/flowering. Fruits can remain on the stem till the next flowering season, which not necessarily occurs within a 12-month-period but every 7-8 months. Their dimensions usually are 25x20 mm and weight of 1.2-1.4 g.

Calamus caesius is a cluster dioecious and pleonanthic palm. Sex is undifferentiated till flowering that occurs for the first time at the age of 5.3 years. Inflorescences (usually 1 to 4) are produced in July-August and, in case of double flowering seasons, in October-November. However, being this palm a clustering species it could continually produce several inflorescences during the year. Fruits generally mature after 16 months from inflorescence’s emergence that takes 2-3 months to complete. Harvest usually reaches a number of 2000-3000 items whose measure at maturity is 15x10.8 mm and weight 0.85 g.

Calamus trachycoleus like *caesius* is a clustering and pleonanthic species that can produce inflorescences (1-4 ♂, 1-5 ♀) all year long. It has been reported that palms have had their first flowering at the age of 4 years. However, due its rapid growth (even 7 m) it has been assessed a maturity limit of 11.2 m in height in FRIM trial crop and a surprising age of two years in SAFODA plantation in Sabah, Malaysia probably caused by a long drought. Anyway it is clear that *C. trachycoleus* is able to produce fruits earlier than *C. caesius*. According to Manokaran (1984) this limit is at the age of 8-9 years. Fruits mature after 14 months from fertilization. Harvest usually reaches a variable number of fruit due to falling, which could be 50% of the total. However, a gross number could be estimated in 1900-2000 with a size of 10 x 7 mm and a weight of 0.3 g. In most of *C. trachycoleus* canes there is a reduction in internodes distance probably caused by the increased metabolites’ flow directed to the inflorescence.

Calamus tetradactylus is a clustering dioecious and pleonanthic rattan. Flowering is seasonal and starts in June-July, 2-3 months after inflorescence’s first appearance, from the age of 2.5 years. Fruits have a maturing ratio of 30% and mature in April to May and weight 1 g (Huangcan, 2000a).

Daemonorops margaritae flowers at the age of 4-5 years. Flowering progresses all year round, under suitable growth conditions, although the main period is from March to September. The buds take 40 or 50 days to reach anthesis. Fruits develop from October to December and take 210 to 240 days for the maturation. Clustering condition with continuous flowering and persistency on stems allows the plant to have fruits at different stages of maturity. Fruit dimension is 15 x 20 mm and 1.6 g (Huangcan, 2000b).

Eremospatha macrocarpa is a clustering and pleonanthic species. The first flowering occurs after two to three growth phases and this equally corresponds to a high level in the canopy of the marshland. Flowering occurs only at the plant's emergence above the top of support trees.

Flowering and fruiting of some important rattan species

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
C. caesius	**	***	***							***	****	****
C. hookerianus	***	***	***									
C. longisetus						***	****					
C. manan		***	***	****	**		****	****				
C. tetradactylus				****	*****	****						
C. trachycoleus			****	****	***							
C. radiatus					****							
C. pseudotenuis								****	****	***	***	
C. delicatulus			***	***	***							
C. rotang												
C. rivalis										****	****	
C. brandisi				***	****	****						
C. hookerianus								**	***	***	***	****
C. karnatakensis					***	****						
C. lacciferus					***	****						
C. stoloniferus					****	****						
C. vattayila				****	****							
D. margaritae	****	****	****	****	****	****	****	****	****	****	****	****

(yellow) flowering   *** fruiting

Source: Rao (1995) – modified

CHAPTER 3

3.1 ECOLOGY

3.1.1 Distribution

The large number of rattans cannot allow us to identify a well specific ecological characteristic, each species infact behave differently due to its taxonomic group and biological needs. As a consequence generalizations cannot be possible in evaluating commercial species' adaptability in a particular area by checking other palms' presence. However, gross ecological preferences for rattan species can be obtained trough observations, data collections and trial plots, although these essays take several years to be studied and data interpreted.

As far as the distribution is concerned Asian rattans reach their northernmost limit in southern China, Taiwan and the foothills of the Himalayas; the southernmost limit is in the New South Wales (Australia) At the extreme northern limit it is possible that they may occasionally be subjected to temperatures below 0° Celsius. In altitudinal range they occur from sea level up to 3000 m. Within the perhumid parts of South-east Asia, there are usually differences in the rattan flora between altitudinal zones. At an elevation of 1000 m there is generally a striking change in the flora; above this elevation several species or even genera abundant in the lowlands are replaced by other species and, generally, the rattan flora becomes less diversified.

Basu (1985) in his studies on Indian rattans confirms same ranges: in peninsular India conspicuous niches of rattans are in the forests of lower and upper hill valleys, mountain plains and deep ravines along water courses. Altitudinal range varies from 300-2000 m with a maximum concentration between 400-1000 m, while in the evergreen forests of Eastern and northeastern India the altitudinal range is almost the same. It has been noticed a floristic change in the vegetation between 1000 and 2000 m.

In West and Central Africa rattans are widespread and are a common component of the forest flora. Some species have particularly large ranges; for example, *Laccosperma secundiflorum* and *Eremospatha macrocarpa* occur from Liberia to Angola, while *C. deërratus* occurs from the Gambia across to Kenya and southwards to Zambia. In terms of diversity, the greatest concentration of rattan species and the highest levels of endemism are found in the Guineo-Congolian forests of Central Africa. Eighteen of the 20 known African rattan species occur in Cameroon and show Asia's same ranges of altitudes.

3.1.2 Soil

All major forest types have at least some species in a wide range of rock types except for the mangrove forest where only few *Calamus erinaceus* have been found. Some species of rattan are restricted on certain soil types: in Sabah (Malaysia) ultramafic rocks (rich in heavy metals) sustain a constant group of palms that never grow on other soils.

Dongmo (2002) in Cameroon has verified the presence of glades of *Laccosperma secundiflorum* on ochre red ferralitic soils and *Oncocalamus mannii* were found on brown sand-clay ferralitic soils.

Matius (2004) makes a distinction between Kalimantan's rattan gardens in Indonesia by dividing them into alluvial and terrestrial areas, each with its specific rattan species. Soil classifications in alluvial sites were included in Typic Hapludults (USDA 1991). Textures in alluvial areas consisted of clay and clay loam, with subangular blocky (SAB) structure being less cohesive in the upper part and angular blocky (AB) structure being strong cohesive in the lower part. The soils conditions were acid with an average pH 4.91. The Effective Cation Exchange Capacity (ECEC) was low and the Effective Based Saturation (EBS) was medium (PPT 1993). Soil classifications in terrestrial sites was Typic Tropludults (USDA 1991). The soil textures in these sites were silt, clay, loam, silty clay loam (SCL) and clay loam (CL). The geomorphology ranged from flat to hilly with areas that flooded every 5 to 10 years for a very short time. The average soil pH in flat sites of terrestrial plots was 5.02 and in hilly sites 4.67. The overall data about soil chemicals testify the strong importance of pH with a range between 4.04 and 5.14. Soil based cation contents (K^+, Na^+, Mg^{+2}, Ca^{+2}) range from very low to medium. The soil carbon content (C) ranges from medium in upper level of soils in alluvial areas to low in terrestrial clay loam soil and sandy soil, while it is low to very low in the lower levels. The total soil nitrogen content in the upper level ranges from medium in alluvial areas to low in terrestrial clay loam and sandy soil and from medium to very low in the lower levels.

In the Hainan Island (China) Bingshan & Huangcan (2000) in a north tropical oceanic monsoon climate have evaluated that the most suitable areas for rattan cultivation in Hainan Island are those with laterite, red lateritic, red and yellowish red type. Rattans also grew well in mountain yellow soil, limy soil and purple soil. In Hainan Island, thick, fertile, acid or slight acid soils were present. Balagopalan & Sankar (1992) in confronting 3 Indian different plots for genus Calamus (forest with cane, cane plantation, forest without cane) under the same climatic conditions (rainfall 1500-2500, temperature 18-38°C) and similar dominant tree species (typical to moist deciduous of the more humid sub types) described soil properties either for soil texture, carbon and pH.

Their results showed that the soil of the three plots were strongly acidic while in the area without cane it was medium acidic. It should be noted that the highest rate in organic carbon content are in the natural cane plots followed by the cultivated ones. The difference in organic carbon is directly related to the input at decomposition rates. In dry moist deciduous the decomposition rates are faster than in the moist faces. The least was in plot without cane. Similar trends can be applicable for water holding capacity. Rattans prefer thus strongly acid soils rich in organic carbon and with high water holding capacity, in other words canes require relatively poorly drained soils with rich humus layer (1.2 - 4.9%), medium loam, light clay and sandy loam and a low pH (4.5 to 6.0) in an 1300 mm rainfall environment.

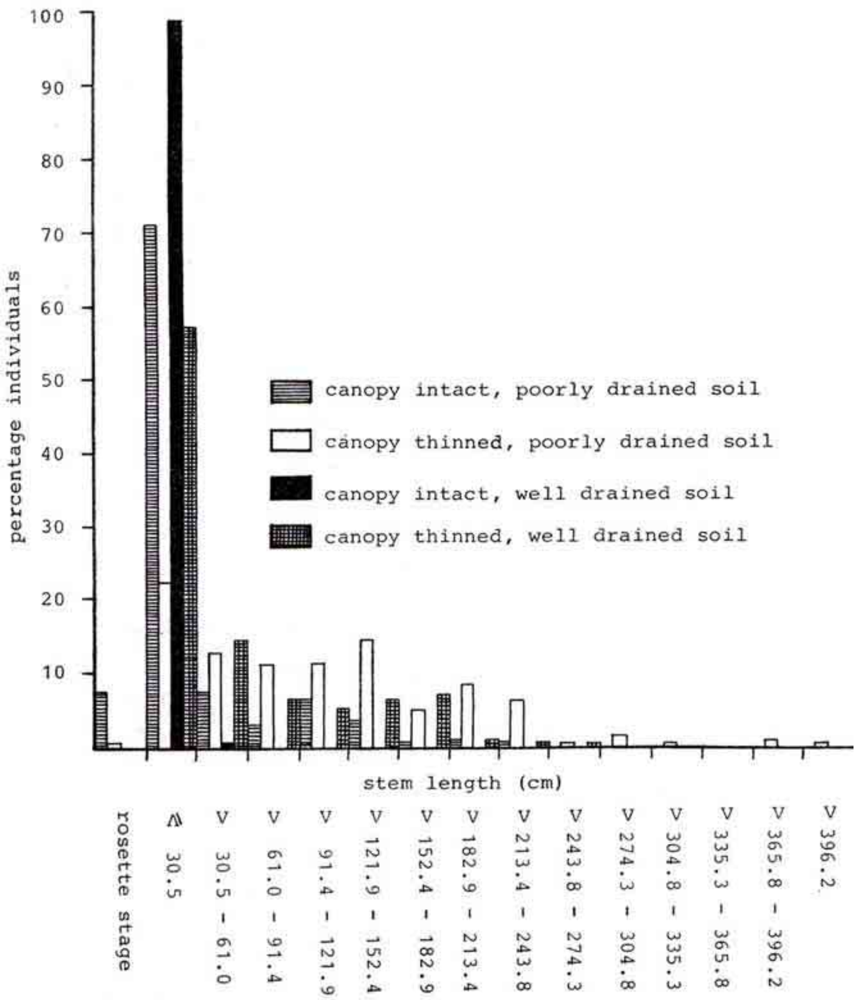
Properties	No cane			Cane planted			Natural cane		
	(Depth)			(Depth)			(Depth)		
	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60
Gravel %	4	11	5	7	8	12	4	11	8
Sand %	81	80	79	77	73	73	75	74	71
Silt %	10	11	13	16	20	19	19	17	20
Clay %	9	9	8	7	7	8	6	7	9
Soil pH	6.0	5.9	5.9	5.4	5.2	5.2	5.3	5.1	5.1
Organic Carbon %	2.2	2.0	1.8	2.5	2.1	1.2	2.7	2.2	2.0
Water holding capacity %	43	41	38	55	52	48	62	54	51
Light		bright			dim			dim	
N. overstorey trees (2500m^2)		100			150			162	

Table: soil characteristics in three land systems - Source: Balagopalan & Sankar (1992)

3.1.3 Soil Moisture Requirements

Rattans are adapted to different soil moisture regimes. In general rattans prefer soil not subjected to severe dry conditions and dislike waterlogging or prolonged flooding. Within the same area growth rates are higher in the low and middle hills; and lower on ridges, as the latter tend to be too dry in drought periods. Among different species *C. caesius* prefers poorly drained soils while *C. trachycoleus* likes moisture in more abundance as it lives near the riverbanks (Manokaran, 1984). As the forest canopy is lower in the up hills, in comparison with low hill areas, palms might find there better light conditions.

Aminuddin (1984), shows evidence of moist requirements for *C. caesius* as its survival rate, growth rate, clump formation and stem production were higher in less drained soil, scoring an average growth ranging from 0.06 at 2nd year to 8.3 m at 5.3 year, and the best survival rate of 72.5% for treated group-planted plot in poorly drained soil. As for *C. trachycoleus*, which lives in seasonally flooded river banks and margins of swamp forests, the survival rate at 1st and 4.5 year was 95% and 64% respectively, with a growth rate ranging from 59 cm in the first year to 283 cm in 2.25 year (average growth of 1.25).



Stem length distribution in two-year old *C. caesius* in different canopy and moist condition
Source: Manokaran (1983)

3.1.4 Climatic Requirements

As a general rule the mean annual temperature for rattan should be between 25 and 27 °C. There should be over 2,000 mm of well-distributed rainfall and a high relative humidity. Deep and/or alluvial soils are preferred but waterlogged or shallow soils should be avoided (Dransfield, 2002). The restriction of certain species of rattan to certain zone shows that each palm needs specific climatic requirements, which are different from a geographic area to another; some exceptions are however, verifiable for certain species of the northernmost part of China such as *C. tetradactilus* that can grow also in perhumid climate.

In a study done by Guangtian, & Huangcan (2000) in three different Chinese provinces, Hainan, Guandong, and Guangxi (in heavy laterite red soil with moderate organic materials, pH ranging from 4.5 to 6.0), behind rattan seeds' surviving rates and seedlings growth, data showed that high temperature was an important element for rattan development as the growth of the shoots was increasing over 25°C and decreasing under 10°C, showing, thus, a positive correlation of 0.75. Temperatures near 0°C are dangerous for canes as they cause irreversible damages to the leaves and the death of the seedling for -1.5°C. It should be empathized that most rattan grow better with average monthly rainfall above 150mm, 78% humidity and high temperature. On the contrary plants are damaged by drought conditions that last for several weeks. For certain species more resistant to critical conditions (*C. tetradactylus, C. dioicus, D. margaritae*) a positive correlation of 0.7 exists between rainfall and shoot growth.

Climatic conditions of trial sites

Site	**Forest type**	**lati.(N)**	**longi.(E)**	**elev.(m)**	**MAT (°C)**	**MT of Jan (°C)**	**LT (°C)**	**rainfall (mm)**	**dry season**
Hainan	tropical seasonal	18°42	108°49'	70	24.5	14.4	2.5	1617.7	Dec-April
Guangxi	South sub-tropical seasonal	22°30'	07°27'	200	21.7	13.5	-1.5	1223.3	Nov-Jan
Gungdong	South sub-tropical seasonal	23°08	113°19	36	21.8	13.3	0	1694.1	Nov-Jan

Notes: lati. - latitude, longi. - longitude, elev. - elevation, MAT - mean annual temperature, MT - mean temperature, LT - low temperature

Source: Guangtian, & Huangcan (2000)

Correlation of shoot growth with temperature and rainfall

Year	**1991**							**1992**						
Month	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**	**April**	**May**		
Temperature (°C)	27.8	28.3	28.5	26.8	25.1	20	14	1	13	16.9	23.4	26.2		
Rainfall (mm)	158	245	154	207	30.9	10	5.4	0	55	85.2	92.7	246	**Correlation**	
Species	**growth (cm)**												**temp/growth**	**rain/growth**
C. tetradactylus	9.4	15	25	7.3	6	3	0	0	0	3.5	1.5	3.5	0.64	0.54
C. simplicifolius	9.7	15.3	20.3	18.3	7	2.7	0.3	0	0.7	3	6.3	18.3	0.79	0.88
C. egregius	6.7	22	18.7	18.4	10	6	3.5	3	6	7	9.5	8.5	0.70	0.72
C. *balansaeanus*	4.3	5.7	6.4	3.3	7	4.6	0.7	0	0	1.3	3.1	4	0.82	0.43
C. distichus	13.6	18.7	14	14.4	5.6	6	1	0	0	7.7	11.7	10.4	0.85	0.84
C. *tetradactyloides*	3	7.7	15.6	9.9	3.4	1.7	0	0	0.5	4	10	8	0.69	0.67
D. margaritae	3.3	20.3	24.7	19.6	4.3	8.7	4.3	0	2.3	7.4	12	17.4	0.70	0.76
D. jenkinsiana	7.7	15.6	13	16.3	7.7	1	1.4	0	0.3	1.3	13.3	12	0.80	0.82
											average		0.75	0.71

Source: Guangtian & Huangcan (2000) - modified

In a study conducted by Bingshan & Huangcan (2000) in six different Chinese areas it results clear which climate requirements affect rattan growth: annual average temperature over 21°C, annual precipitation above 1500 mm well distributed with a peak during the growing period, a very short dry season and a January average temperature above 10°-12°C and a near-to-zero number of frost days.

Climatic conditions and suitability in different areas

Suitability	**Annual average temperature (C°)**	**Annual precipitation (mm)**	**Above 15°C accumulated temperature**	**Average temperature of January (°C)**	**Number of dry months**	**Number of frost days**	**Climate**
Most suitable cultivation area	23.2	1940	8372.3	16.2	0.9	0.4	North tropical oceanic monsoon climate
	21.4	1383.3	7238.1	15.4	2	0.1	North tropical monsoon climate
Suitable cultivation area	21.2	1576.5	6419.9	12.2	0.3	5.1	South subtropical oceanic monsoon climate
Second suitable cultivation area	24.5	1298.6	8947.4	19.7	4.3	0	Dry tropical climate
Latest cultivation area added	19	1550.3	5361.9	8.5	0	14.8	Subtropical climate
	18.9	1272	5375	10.9	3.2	8.8	Subtropical plateau

Source: Bingshan & Huangcan (2000) – modified

Climatic conditions in different areas of study

Area	Lati	Longi	Altitude	Dry seasons	Rainy seasons	Average annual rainfall (mm)	Mean temp. (°C)	Mean relative daily humidity	Soil	Climate
Dja biosphere reserve	2°50' and 3°30' N,	12°20' and 13°40 E	500 and 700m.	November - February; June - July	August - October, March - May.	1500	23.5°C and 24.5°C			Guineo-Congolian evergreen forest
West Kutai District of East Kalimantan, Borneo	0° 27'15" to 0° 31' South	115° 38' to 115° 41'30" East		July, August, September and October		2579 mm - 3000 to 3500 on higher altitude	22° to 30°C,	75.60%	Haplic Acrisols	mixed tropical lowland forest
Khao Chong Thailand	7° 22.5' North	99° 46.6'E		January February	May to Dec	2427	27.4			mixed evergreen forest

Water deficit affect plant development and morphology by changing the root/shoots ratio, as roots are less sensitive to water stress. In the case of *C. manan,* Aminuddin (1990) figured a ratio of 4.75:7, which differed from 1.5:2 of control condition.

Flooding represents the opposite problem for palms, many studies have showed that water can cause injuries to root systems.

3.1.5 Light Requirements

Another important factor that limits the growth of valued rattans is light. Its lack makes the plant/seedling remain in perpetual juvenility. Although many species can cope with a wide variety of light intensities, from dense over-shadowed forest to large gaps created by natural regeneration, most of the commercial species, such as *C. manan* need an adequate light regime. Palms that prefer dense shadow are generally the stemless species and a certain number of climbing ones. An intensity of 40-50% RLI (Relative Light Intensity) is the limit that consents seedling establishment.

As far as the African rattans are concerned the majority of the species naturally grow in closed tropical forest and are early gap colonizers. Because of this attitude they are extremely light demanding and respond well to a reduction in forest canopy. Increases in forest disturbance, such as logging activity, encourages the regeneration of rattans and they are often a common feature along logging roads and skid trails.

Nainggolan (1985) in his studies on the growth of *C. manan* under different canopy and moisture conditions showed that seedling mortality was highest under shade of full canopy and best growth both in wet and dry soil regimes was obtained under open conditions, although mortality was higher on wet soil. Seedlings under open condition were healthier than those under full shadow and half-canopy shade, which appeared also more slender due to lower light intensity.

C. manan growth and mortality rates under different conditions

	Moist condition	Mortality (%)	Min growth rate (cm)	Max growth rate (cm)	Leaves
Full shade	Dry	21.3	11.3	48	3-5
	Wet	38.5	24.3	52.8	4-5
Half-canopy shade	Dry	10	34.1	62.2	4-5
	Wet	13.3	61.7	80.9	5-7
Open conditions	Dry	17.3	65.0	94.0	4-6
	Wet	25.1	62.1	90.8	6

Source: Nainggolan (1985) - modified

Mean stem length of *Calamus manan* at different ages after planting, under various canopy conditions

age	mean stem length under different canopy openings				
	control	0.9 m canopy opening	1.8 m canopy opening	2.7 m canopy opening	3.6 m canopy opening
0	13.5	14.1	14.1	14.8	14.2
1	15.6	15.4	16.6	15.6	16.7
2	27.1	31.4	29.6	34.5	35.3
3	37.1	54.6	63.7	65.5	67.4
4	51.3	96.8	123.2	130.4	128.8

Source: Aminuddin (1984)

Aminuddin (1984) noted that *C. manan*, which is found mainly in hill forest rather lowland forests, requires light for optimal condition with a 10-15% shade condition in the 1st year. In Kepong, Malaysia survival rate was 65-78% after first year and 55-68% in the 5th year after planting, while the best growths (120 cm) were observed wherever more than 1.8 m opening was created.

3.1.6 Nutrient levels

Nutrient removal through rattan harvesting could affect ecosystem nutrient stores via direct loss (cane extraction) or soil loss due runoff. Tropical forest produces 300-500 t/ha of biomass and nutrient losses associated with timber extraction amounts to 2-5% of the total. Lianas represent more than 5% of total above ground biomass and have 5 to 20% of that biomass in foliage, compared to 1-2% of trees. When rattans are harvested the leaves and sheaths left on the forest floor keep the soil nutrients in high level. Indirect nutrient losses are not large as minor damage to forest canopy occurs and plant root are not affected. Reduced losses in nutrients following harvesting suggest that repeated uptakes are possible without affecting the ecosystem (Siebert 2001).

Mean (±SD) leaf and cane nutrients conservations in rattan (*C. zollingeri*) during dry and wet season

	Plant part and season (dry or wet)			
Nutrient	**(1) Leaf dry**	**(2) Cane dry**	**(3) Leaf wet**	**(4) Cane wet**
Cu (mg/kg)	7.64 (1.41)	13.16 (1.90)	6.66 (2.23)	8.56 (4.18)
Ni (mg/kg)	5.06 (2.10)	7.38(l.62)	3.48(l.25)	5.36(3-11)
Zn (mg/kg)	12.56 (1.26)	26.34 (5.60)	15.56 (5.88)	105.80 (54.81)
Al (mg/kg)	18.92 (8.60)	12.74 (4.96)	23.14 (7.28)	53.92 (63.57)
Fe (mg/kg)	87.44 (26.21)	141.70 (17.88)	57.84 (11.64)	109.38 (86.56)
B (mg/kg)	7.04(l.32)	2.96 (0.23)	5.820-54)	2.48 (0.43)
Pb (mg/kg)	3.72 (2.20)	7.70 (2.42)	0.28 (0.63)	0.48 (0.66)
Mn (mg/kg)	56.74 (74.41)	9.12 (5.09)	134.20 (20.64)	698.42 (529.82)
Ca (%)	0.44 (0.16)	0.12 (0.01)	0.50 (01.3)	0.14 (0.02)
Mg (%)	0.28 (0.06)	0.04 (0.00)	0.30(0-05)	0.05 (0.01)
K (%)	0.61 (0.12)	0.42 (0.05)	0.53 (0.08)	0.12 (0.03)
P (%)	0.11 (0.02)	0.06 (0.01)	0.12 (0.03)	0.14 (0.05)
N (M)	1.64 (0.13)	0.31 (0.02)	1.58 (0.12)	0.47 (0.13)

Source: Siebert (2001) – modified

3.1.7 Rattans and Animals

Animals play a fundamental role in the forests as they are the predominant means that plant use to disperse pollen and seeds. Due to high biodiversity in primary forest density for each species appear very low, making it difficult for flora to have sexual reproduction.

The seed of most rattans in Africa are dispersed predominantly by hornbills, birds and elephants. Among primates predominantly the drill (*Mandrillus leucophaeus*) and mandrill (*Mandrillus sphinx*), chimpanzees (*Pan troglodytes*) and gorillas (*Gorilla gorilla*) help spreading seeds or fruits. The seeds are often scattered far from the mother plant. Limited predation, and sometimes catching by rodents accounts for some additional, although limited, dispersal. Fleshy layer in the fruit wall or the sarcotesta appears to be attractive to the majority of the faunal population. Interestingly, significant germination also occurs near to the parent plants through natural fruit fall, particularly in areas where over-hunting has led to a significant decline in faunal dispersal agents. After germination, rattan seedlings can remain on the forest floor for some time waiting for the optimum light conditions needed to begin the long journey to the canopy (Sunderland, 1999).

On the contrary, rattan predation by herbivores is a major problem despite their protections against attacks by tightly tubular spiny sheaths. These predations result in the death of the growing point and hence of the whole stem. Common animals responsible for such damages are pigs, when rattans are reachable at ground level, rodents and elephants, which are the most destructive.

Interesting cooperation between plants and animals are described in ant/rattan relationship, which involve also scale-insects: the presence of the ants that find shelter on palms give the plant extra protection against animal attack and possible increase of nutrients brought by ants' foraging activities (Rickson & Rickson, 1986).

3.1.8 Symbiotic Fungal Effects

Relationships between rattan and fungi, as in the case of mycorrhizal symbiosis of two rattan species (*D. margaritae* and *C. simplicifolius*) with *Glomus*, *Acaulospora* and *Scleorocystis* (Mingqin & Fengzhen, 2000) show positive correlations and significant growth rates. Under natural forest condition VA mycorrhizal fungi colonize roots with an average rate of 20-35%. On the other hand artificial inoculation provides infection rates of 80% in plots inoculated with fungal iphae alone versus 43% in trials with iphae and fertilizer. Data show thus a strategy between rattans and fungi to survive in natural condition, which diminishes whenever soil's mineral concentrations make palms able to capture nutrients directly.

The interaction between rattan and fungi shows interesting increases of 117.2% and 87.9% in dry weight respectively for shoots and roots against control plots that have no inoculation. Symbiosis causes an increase in phosphorus and no growth in N, Ca, Mg and K tissues' concentrations as fungal presence increases phosphorus metabolism. The Mingqin & Fengzhen's study also showed that the general trend of VA infection is higher in the south subtropical forest than in tropical forest plantation.

Seedling growth of rattan treated with fungal inoculation and /or fertilizer

Treatment	Species	Leaf per (plant)	Root length (cm)	Shoot wt. (g)	Increase dry wt. (%)	Root wt. (g)	Increase dry wt. (%)
GS	*D. margaritae*	105	35.76	3.283	65.2	0.773	12.3
GS	*C. simplicifolius*	26	55.97	5.407	101.1	0.939	82.7
G	*D. margaritae*	195	28.75	2.235	12.5	0.647	-
G	*C. simplicifolius*	48	59.55	5.84	117.2	0.966	87.9
S	*D. margaritae*	23	28	2.567	29.2	0.579	-
S	*C. simplicifolius*	4	56.71	5.882	118.7	1.148	123.3
CK	*D. margaritae*	0	30.46	1.987	-	0.689	-
CK	*C. simplicifolius*	0	40.35	2.689	-	0.514	-

(G) 50 g of Glomus inoculum per pot, **(S)** 5 g of fertilizer mix per pot containing N:P:K =15:15:15, **(GS)** 50 g of soil inocula plus 5 g of fertilizer mix per pot, respectively. **(CK)** Controls had neither fungal inoculum nor fertilizer treatment

Source: Mingqin & Fengzhen (2000)

CHAPTER 4

4.1 SILVICULTURE

4.1.1 Background

Despite its diffusion rattan is almost harvested in the wild from disturbed forested areas (logged areas), fallow lands and community forests. Collection is done particularly in the dry season when canes can be carried away on the roads. However, many little craftsmen as well as forest dwellers harvest palms all year round. Due to the lack of cultivations in Africa there are neither rattan plantations nor any experience in cultivation. As a consequence the progressive increase in commerce have threatened the wild resources, which is nowadays overexploited due to removal of all of the individual stems and reduced by progressive conversion of forests into farmlands. In addition, higher pressure on clusters and immature stems harvesting limit sexual reproduction endangering the genetic variability of the species. Rattan harvesting is performed in archaic manner by the use of basic tools and a cutting ratio of 40% to 100%. Output is generally low, with a mere 28% for *Laccosperma* spp. and 44% of *E. macrocarpa,* because the upper parts of the stems are entangled in the forest canopy (Defo, 2004). The lack of a land tenure policy among African countries does not encourage population to manage in sustainable way forest resources leaving those areas to anarchy.

In Asia rattan collection is an important livelihood strategy to secure food and income. It is a way to differentiate risks through the parallel use of other sources of incomes: rice farming, slash and burn, cash crops. In Asia rattan is both harvested in the wild and cultivated in home gardens or are part of swidden agricultural systems. In the past a number of constraints prevented people from spoiling natural resources. Sacred believes, social hierarchy, an empiric ecological knowledge have been the best means to control village's resources. Mutual respect of a 10-20% harvest limit for clump was the main rule, which was eventually disattended by increased palms extraction caused by the growth in commercial relations. As a result continuous logging, forest conversions and fires have threatened certain species and ignored traditional forest management practices of indigenous minorities.

4.1.2 Propagation

Rattan in primary forest is present with a wide variety of species. However, biodiversity not always means profitability, as not all the species are utilizable for weaving. Species richness means infact that just a few individuals with economic value can be found per ha. In order to improve people's livelihoods it is thus necessary to choose those species which best fit the economic potential for future market expansion, whose adaptability has been proven and for which local people show strong interest due to long history of extraction of traditional use in the region. Key issues in decision-making process regard the yield and the plant ability to withstand continual stress caused by resource extraction, the life cycle and the biological characteristic of the species. Knowing the phenology or the fecundity of a variety is crucial in choosing the best method for the propagation: species that produce thousands of fruits do not have problems in sowing, while few seeds make the sexual propagation less feasible. High rate in seed utilization presents some important ecological aspects: the increase in biodiversity within the species, the growth in the total plants available with a certain number of seeds, the limitation of fruit overexploitation for wild animals' sake. Rattan seeds are, however, very delicate as they loose their germinative capability within few months unless steady temperature and moisture conditions are hold (as is the case of *D. margaritae*): at 15°C seeds can maintain intact their germinative capacity (above 71%) if their internal water content is between 29-31% or if the external conditions, maintained by storage material, do not fall below 65% of humidity (Guangtian, 2000)

Propagation has always been a common practice among indigenous people who used to collect fruits or seeds and operate direct seeding in forests. Sometimes seedlings or wildings were gathered for transplanting in other areas. All those techniques, though not expensive, did not give good percentage of success in nursing activities. Beside this first empiric method an Indonesian one consisted in two steps: 1) a daily watering for the removal of the sarcotesta in order to wash out all the inhibitory substances contained in the fruit's layers, 2) the sowing on a seedbed where seeds would germinate in few weeks and the following transplant in a wider spacing, till the height of 0.75-1 m (reached after a year). This technique had the advantage to concentrate the seed on a limited nursing area as in the seedbed but caused some problems for root damage and heavy loads of big seedlings to be carried in the forest while transplanting (Ching-Feaw, 1994).

Trials have shown that complete removal of sarcotesta improve the germination rate towards 90%, although less caring removal could decrease drastically the rates for embryo damage. The procedure consists firstly in crushing the pericarp and secondly in rubbing the sarcotesta using hands and repeated washings with water. A pretreatment with heat at 40°C for 24-48 hours seems to increase the germination rate as well. Modern sowing techniques consist in seeding onto beds and transplant seedlings into black polythene bags with a minimum flat size of 15x23 cm and 0,1 mm thick (Fig.13). The seedling could be transplanted (potting) when the first leaves are fully expanded, usually at the height of 3-5 cm after loosing the medium with water. In order to improve sprouting, appropriate soils should be chosen in seedbeds: loams, sandy loam, sandy clay loam seem to be the best ones. A good blending can be: forest topsoil and sand in a 3:1 ratio, and 3 cm of sawdust in the most superficial layer to maintain moist. Reliable protections against direct sun rays are compulsory as seeds need 50% reduction in light intensity and dislike dehydration caused by rain splashes' soil removal (Fig.14). Protections help seedlings to grow without the threads of litter falling from the above trees. Seedlings are so left in nursery till the height of 50 cm (Ching-Feaw, 1994).

Rattan can be also propagated in a vegetative way. In clustering species clusters can be separated from the clump and used as planting material, generally they have some roots and are put in the nursery for a certain period of stabilization. This method is normally used for those species that do not supply many seeds.

Transplantation of whole rhizome systems is another method that is used for those specialized stems growing just below the ground surface. A rhizome can support many suckers and can be dug with all the suckers and transplanted elsewhere. The success in this method is the rapid clump recovery, which develop much faster than seedlings.

Another vegetative propagation is done by stem cuttings, providing that an adventitious root system be initiated under proper conditions. In root cuttings a new shoot system needs to be initiated from an adventitious bud, the root piece often extending by production of adventitious roots.

Vegetative propagation by layering is a propagation method by which adventitious roots are stimulated to form on a stem while it is still attached to the parent plant. The rooted, or layered, stem is detached to become a new plant growing on its own roots (Yusoff, 1985).

4.1.3 Site preparation

Site preparation attains to all those tasks needed for the correct planting and maintenance of seedlings, which allow plants to grow fast. It generally consists in: site survey, field preparation, seedling transport and planting, post planting maintenance.

As far as the chose of correct planting site is concerned particular attention should be given to the characteristics of the area, soil and light availability, as rattans require certain levels of illumination and dislike swampy zones. Identifying the correct exposition, the presence of supporting trees, the altitude and topographic position can help in avoiding future problems and lower-than-expected yields. Forest canopy conditions, topography, time, also affect the direction of planting: although East-West alignment is recommended as it allows plants to receive maximum sunlight in 2-3 m planting path, North-South orientation allows plant to receive light all year round albeit of different duration. However, on steep slopes it is better planting following the contour rather than the slope.

Field preparation implies the creations of plots, pathways, plot borders (with the aim of protect the area against fires) (Ching-Feaw, 1994).

Underbrushing is the first physical task on forest vegetation. It consists in slashing all the field's undergrowth (bushes, seedlings, non commercial trees) or at least cleaning those areas that interfere in lining work. Clearings are particularly important for secondary forests, where vegetation impedes survey work as well as a perfect alignment of seedlings due a chaotic disposition of trees. Rotting trees should be felled as well to avoid casualties among rattan seedlings due branch falling. As a rule trees that occupy the planting path (generally 1.5-2.0 m) should be felled as they may interfere with the seedling and cause heavy shadow: the first branches to be cut are the lower ones and the trees with less value, though sometimes it is necessary to cut down some branches of valuable trees. If the forest canopy is well structured it is indispensable to proceed in felling or pruning the branches to lighten the understorey. In field preparation tasks it may be necessary to plant supporting trees (normally fast growing ones) in logged over areas or zones with bushy vegetation.

4.1.4 Planting

Once the plot is ready for transplanting seedlings are taken into the planting zone. Traditional carries concerned the use of baskets, which caused problems due plant dimension (about 1 m) and weight. Polythene bags in modern techniques make the task easier as the roots are safely transported. However, to prevent high casualties for high levels of sunlight and low quantities in water, a hardening off period is normally required by progressively leaving the seedlings with no coverage.

Planting holes are slightly larger in diameter than the polythene bags that are taken off carefully in order to avoid damages to the roots and disturbs to the soil ball. Depth of planting should be adjusted so that the upper part of the soil ball is more or less at ground surface and the suckering rate would be encouraged. In the case of large canes however, holes should have a width at least two times the bag's diameter. Positioning is another task that depends on several variables: planting the palm close to the path's border allow rattan to climb on the closest tree and improve its safety against big predators and a wider space is available in order to make maintenance work in the following years (Ching-Feaw, 1994).

The best period for planting is at the beginning of the rainy season, while filed preparation has to be done during the dry one. Correct timing should take care of species' different growth rates, germination time, and seeds' maturity. In the case of Indonesian rattans where fruits ripe from January to May and raining season occurs in October, an appropriate period of time ranging 12 months should be considered because three-month-old-seedlings are too little and weak to withstand stress. A nursing period of 8-12 months after potting, make palms able to cope with adverse conditions: longer periods are not recommended as it has been proved that plants after this time limit grow slower in comparison to younger ones (Fig.15). However, on a large scale it is cheaper to gather seeds in the first part of the spring and transplant seedlings at the age of 6-8 months in December, in the midst of the raining season. To summarize, any propagation management needs a compulsory period of time of at least 6 month between sowing and transplant, which should take place during the rainy season.

Planting density affect cane yields. Appropriate planting schemes should take into account the percentage of casualties caused by pests, diseases, predators, physical damages, drought, floods and sun that occurs during the years. Although traditional Indonesian gardens are not planned on a fixed scheme but are rather chaotic, modern techniques tend to regularize plant density according to previous plantation schemes (as in the case of intercropping) and estimated yields.

The reason lays in homogenizing preexistent forest structure and in facilitating workers' passage for maintenance and harvest. Some common schemes are: 9.1 x 2.1 m for a total number of 523 plants/ha in commercial plantations in Sabah, Malaysia; 2.7 x 6.1 m (607 plants/ha) in Malaysia private owned forests; double rows spaced at 2.4 within a 3 m clear path separated by 4.9 m forest strips (total 1379 plants/ha). Feaw, (1992) recommends 2 x 10 m spacing as the best planting scheme, although for *C. trachycoleus* sprawling habits it may be too narrow, as *C. caesius* and *C. trachycoleus* grow in clusters which require wider spacing of supporting trees: 8 x 8 m, or 160 trees/ha. Two planting holes are made close to each supporting tree and two or three seedlings are planted in each hole for approximately 700-650 plants/ha. The numbers of seedlings for *C. manan* are more numerous as this species grows individually. The supporting trees are spaced out 6 x 6 m, that is, 250 trees per ha are needed. Two planting holes are made close to each supporting tree and one or two seedlings are planted in each hole. Approximately 750-1000 seedlings will be required for a 1 ha plantation (Dwiprabowo, 1998).

4.1.5 Post planting maintenance

Post planting maintenance attains to those operations carried out to improve the percentage of success of young plants. It consists of different tasks: supply planting, planting path maintenance, canopy opening.

Supply planting aims to substitute those casualties due to stress or transplanting failure. Although it should not exceed 5%, wrong methods or diseases increase this ratio: bare root planting, damage of roots, flooding, unhealthy plants are common causes for the worker to replace the seedlings. The final stocking of the plantation must be at least 60% of the original number.

Planting path maintenance aims to clean planting lines from weeds that can strangle the young plants (other climbers), to allow workers to do all the tasks concerned to the management of the plot, to eliminate competition for water and nutrients in poor soils. A two to three times a year cleaning performed manually without the use of chemicals seems to be sufficient for most of the cultivations, but it depends on how vigorous the growth is (Feaw, 1992).

Canopy openings are the most important task that allows rattan to grow. It has already been written that rattans need a light intensity of 50% to start growing and leave their juvenile stage. This operation is firstly carried within 6 months after transplanting, when all the seedlings have taken roots, and in the following two years with a 6-month basis. Openings are carried out through branch pruning, tree felling or poisoning. Although the latter method is the slowest (it take one year for the tree to die), it does not present the risk of branch/trunk falling on young plants. Canopy manipulation is no longer required as soon as the palm reaches tree support. Sometimes workers help rattan in gaining support of trees. This activity is very important whenever palms are planted in low hill areas or valleys, as they are zones where sunlight does not reach the plants with sufficient intensity: the increased luminosity make rattans to grow faster and to avoid predators' attacks.

In the end further cuttings are done for pre-harvest maintenance that consists in: opening harvesting paths for access and to bring out the canes, removing dried rattan fronds to better the passage of workers, pruning the branch and felling some trees in order to facilitate the cane pulling from the canopy. Some other management tasks consist on mulching, particularly in those geographical areas with long dry season: it should be carried before drought to conserve soil moisture (Feaw, 1992). Nainggolan, (1984) confirms an interesting correlation between moist condition and light intensity in growth and mortality rate for *C. manan*. Mortality is at its lowest levels when the canopy is halved, furthermore 1 year old plants present a better growth rate for open condition (morning sun) with a maximum of 90 cm and 4-6 leaves rather than full shade. Mortality rate is somewhat higher in wet condition showing a sensibility to excessive wet regimes.

Growth rate mortality and leaf production of *C. manan* seedlings one year after transplantation

Shade condition	Dry soil condition				Wet soil condition			
	Growth rate cm/year		N. leaves	Mortality %	Growth rate cm/year		N. leaves	Mortality %
	min	max			min	max		
Full shade	11.3	48	3-5	21.3	24.3	52.8	4-5	38.5
Half canopy	34.1	62.2	4-5	10	61.7	80.9	5-7	13.3
Open	65	94	4-6	14.3	62.1	90.8	6	25.1

Source: Nainggolan (1984)

4.1.6 Planting systems

Climbing plants, as rattans are, need supporting trees to full expand their commercial potential and to benefit by forest canopy's shadow. Harvested mainly in the wild forest dwellers have started to cultivate rattans since last century in backyards or as a part of their slush and burn practices. (Feaw, 1992; Supardi, 1992). Since forests present low density in species, despite their richness in biodiversity, commercial production/large scale plantations have been recently introduced in different habitats in order to:

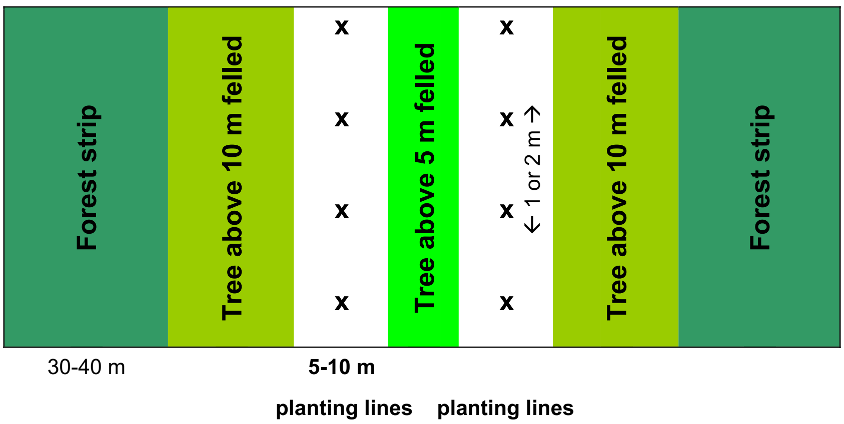
1) Select high value rattan both in quality, yield and growth.
2) Concentrate selected species under same environmental conditions, and uniform tree stands
3) Increase the output per unit of area allowing industrial extraction
4) Increase forest value by integrating rattan into pre-existent cultivations
5) Increase the production on an industrial level

Supporting trees and light requirements needs are higher in large diameter rattans and in plantation systems. High attention should be given to site characteristics and vegetation, as major clearings are needed for those areas with dense canopy and undergrowth. As a rule forest with dense undergrowth belongs to logged-over and secondary ones, which have just few tall trees and a big amount of light intensity. On the contrary dense canopy or multi-canopy forests belongs to virgin forest, primary or old secondary ones. Light and support affect rattans life continuously as their light needs bring them to grow on their crown above the forest canopy and the lack of branched trees make them susceptible to fall onto the ground at the increase of stem weight and height.

An important factor in choosing the ideal trees is the plants' strength, which has to be assessed accordingly with the nature of the rattan itself (clustering, single stemmed, large/small diameter, intensity of harvesting).

Silvicultural practices follow two main methods in planting rattan: in line and group. The first attains to plant only a single seedling per hole, the second for more than one. Planting, however, need a specific environment to be created both in light and supporting trees, which is sometimes difficult to ascertain without disturbing cuttings to the whole forest. A practical method used for small diameters canes is the "*Planting Strip*": plants are felled along strips and bordered by undisturbed forest strips The optimum draw consists of two planting lines per planting strip.

Planting Strip



Source: Supardi (1992) – modified

Some other schemes regard large diameter solitary palms (*C. manan*) planted in rows of 1.8 m where no reduction in yield is noticed despite the proximity. Some other attempts in group of three and five seedlings per planting point at different distances has shown that growth decrease sensibly whenever the number of seedlings per point exceed 3 seedlings/group. For clustering palms it is suggested that distance should be twice as those of solitary canes.

Natural forests

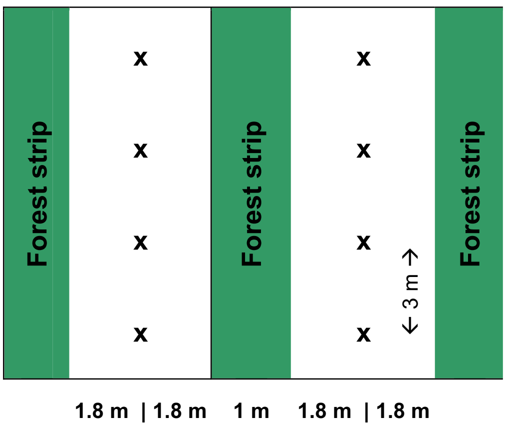
Forests are the natural habitat of rattan. They are suitable for cultivation providing that heavy shadow is reduced by logging or pruning activities. Rattan presence in the wild is confined into those areas where natural gaps occur due to tree felling for natural causes. As a matter of fact an increase of light intensity let wildings to grow leaving their juvenile stage. In addition to natural regeneration, logged over forests are ideal habitats for new plantations as many gaps are available, though attention should be given to the synchronization between logging activity and rattan cultivation in order to avoid mutual disturbance.

Enrichment planting, which has long been a response to the high intensity of logging in Asian forests and a means of re-stocking through the introduction of timber species in logged over areas, has stimulated rattan producers in order to reintegrate or introduce selected commercial rattan species (Sunderland, 2000).

Within forest definition several lands type concern to different levels of density and undergrowth (Supardi, 1992):

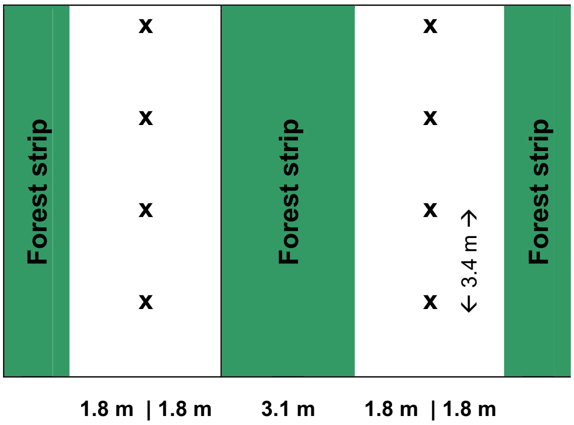
- Virgin Forest. Usually rich in timber but poor in light penetration. The forest undergrowth is rich but often covered by litter. The only openings in forest canopy occur whenever exceptional events such as lightnings and winds determine the felling of trees. Virgin forests are not the ideal habitat for rattan unless heavy clearings give way to natural regeneration.
- Old secondary forest. Old logged-over forests present a mature phase in forest canopy, low light conditions and a more developed undergrowth. If compared to virgin forests timber density and quality is sometimes lower due to previous logging. Rattan planting needs an intense clearing in order to create ideal conditions for the seedlings to grow. However, strip planting represents a valid alternative to major secondary forest damages through its partial clearing leading to an average density of 400 single stemmed plants/ha or 200 clustering plants/ha. Following this scheme the suggested plot would have a 5-10 m wide planting lines, a 30-40 m wide forest strip and a seedling distance of 1 or 2 m for solitary and clustering species respectively. Further planting lines suggested in INBAR TOTEM are: 6.7 x 3.1 m for clustering species, 4.6 x 3 m for single stemmed rattans.

Line planting layout for single stem rattan (*C. manan*) under secondary forest. Planting distance is 4.6 m x 3 m



Source: INBAR TOTEM

Line planting for cluster stem rattan under secondary forest (*C. caesius, C. trachycoleus*). Planting distance is 6.7 m x 3.4 m.

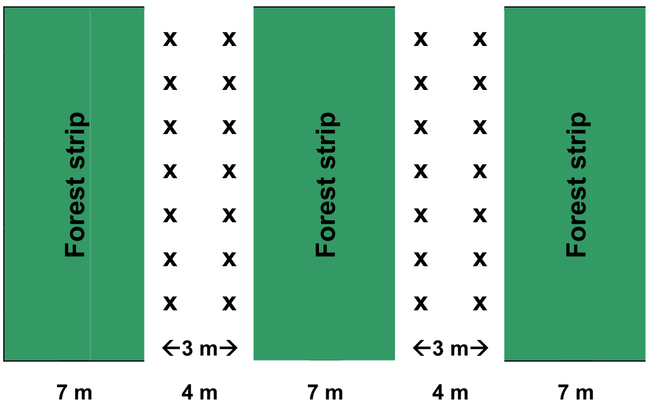


Source: INBAR TOTEM

- Newly logged forest. Forest canopy of logged forest is in the gap phase, whose extension depends on the intensity of logging (Fig.3). In such a type of forest clearing planting lines from dense undergrowth is the major task, as canopy does not represent a great problem. Line and group planting is recommended for solitary species. Line planting for clustering species is the only option available as group planting reduce plants vitality. Planting density is about 500-800 seedlings/ha for solitary rattans with a 6-20 x 1-2 m spacing, while it is a suggested density of 300-400 seedlings/ha for clustering species with a 8-12 x 2-4 m spacing.
- Regenerating forest and marginal areas forest. They consist on shorter pioneer trees with minimum or no value. Forest canopy is closed with few gaps and dense undergrowth. Canopy manipulation result easy to perform as there are two strata (ground vegetation and trees' crowns), though lot of maintenance is required both in the preparatory and in post-planting clearings. Line planting is suggested for both types of rattan while density changes from 800-1200 seedlings/ha and a spacing of 6-12 x 1-2 for solitary species and 400-800 seedlings/ha and 4-12 x 2-4 m for clustering ones.
- Easily accessible areas. They refer to those zones alongside roads or lakes utilized for maximizing forest land utilization, though compacted soil should be avoided. As these areas are open there is no need to operate many clearings and maintenances. Furthermore, costs are highly reduced due high accessibility, transportability and possible mechanization for the harvesting process. Planting lines alongside water reduce significantly water erosion.
- In enrichment planting, a good deal of canopy manipulation is necessary to ensure adequate light penetration for rattan development. Although light improvement is often attained through girdling and poisoning, for some regenerating areas with high value

timber these methods are not carried out for trees' sake, resulting in the detriment of rattan crops. Some trials however show an optimum growth of rattan under-crops in enriched forest on south-facing slopes, where light penetration is higher. The spacing of the rattan under crop also influences the light availability as traditional 6 x 3 m spacing are not feasible due too fast canopy regeneration for too narrow cleared planting rows. An ideal scheme has been the double-spacing, which implies a 4 m wide strip where two rows distant 3 m are set out. Within each row rattan is planted every 2 m. Each strip is 7 m apart from the next one.

Enrichment Planting



Source: Sunderland (2000)

The benefits of enrichment-forest systems, coupled with better management of the wild resource, include:

- Increased revenues from high value forest products, such as rattan
- Continued, and guaranteed, supply of raw material to rattan artisans whilst alleviating pressure on the wild resource
- Diversification of otherwise de-pauperized forest lands
- Increase in biodiversity
- Similar yields with plantation systems
- Maintenance of a forest canopy and multi-strata cultivation system (high species diversity and retention of ecological integrity).

Synoptic table of forest/land types

Forest type	Management	Clustering Species: Density seedlings/ha	Clustering Species: Seedling distance (m)	Solitary Species: Density seedlings/ha	Solitary Species: Seedling distance (m)
Virgin forest	Dramatic clearing	Not an ideal habitat due litter and dense shadow. Planting only in natural gaps			
Old secondary forest	canopy clearing, strip planting	200	5-10 (planting strip) 30-40 (forest strip) 2 (in the line)	400	5-10 (planting strip) 30-40 (forest strip) 1 (in the line)
Newly logged forest	less canopy clearing, planting lines clearing	300-400 (L)	8-12 x 2-4	500-800 (L+G)	6-20 x 1-2
Regenerating forest - Marginal areas forest	pre-post planting clearings, less canopy clearing	400-800	4-12 x 2-4	800-1200	6-12 x 1-2
Rubber plantation	Minimum clearings Rubber tapping	-	-	400 (or the same rubber density) (G)	6 x 3
Enrichment Planting	canopy clearing, strip planting	-	7x(3)x2	-	7x(3)x2
Easily accessible areas	Minimum clearings	Depends on the supporting trees and the conditions of the different areas			

L: Line planting; G: group planting

Source: Supardi (1992)

The production of forest rattan, however, arises some problems:

2) Palms' light demand may be incompatible with forest management in the reserves or parks, due to restrictions or prohibition on canopy manipulation.
3) Those areas dedicated to high quality timber production may limit rattan grow to good quality standards if high stands are given priority.
4) International development agencies forbid forest logging for the only purpose of rattan production

As a consequence of the above-mentioned points rattan plantations are thus preferably planned in logged over forests, in poor timber stands, and in alienated agricultural lands rather than secondary old or virgin forests (Feaw, 1992).

Plantation forests

In recent years forest plantation have been utilized for rattan. It is to emphasize that trees are not meant as trainers but for their timber production: planting trees just for rattan support is costly and unfeasible, unless the plantation is one that has been abandoned for failure. Planting rattan at a low density may agree with tree plantation management. Major species utilized are shown in the table (Feaw, 1992):

Calamus manan	*Acacia mangium, Pinus caribaea, P. insularis, Gmelina arborea, Agathis bornensis, Araucaria cunninghamii, Gigantochloa levis*
C. caesius	*Acacia mangium*
C. merrillii	*Endospermum peltatum, Eucalyptus deglupta*
C. palustris	*Tectona grandis*
C. tetradactylus	*A. auriculiformis, A. senegalensis, G. arborea, Manglieta hainensis, Michelia macclurei, T. grandis*
Daemonorops margaritae	*A. auriculiformis, A. senegalensis, G. arborea, Manglieta hainensis, Michelia macclurei, T. grandis*

The main advantage in planting rattans under forest plantation is the homogeneity of the stands and canopy, which allow rattan to grow well with a high surviving rate and ease workers' maintenance and harvesting work. Depending on the species trees modulate light intensity with their growth and density, support rattan stems both with a uniform branch structure and canopy height. Adequate planning should however focus on optimum tree age for rattan cultivation, and branch strength, as not all trees are capable to support heavy loads. Although uniform plantation eases collecting work, some problems occur for clustering species, as they tend to grow higher and tend to entangle into the canopy.

Pinus caribaea / Pinus merkusii

Calamus manan has been cultivated under a 17-year old trial plot in Malaysia. In the first three years rattans grew quite well as they reached a mean height of 5 m. By the year 9th however, the weight of 20 m long canes disturbed pines' growth and crown. In fact, due to rattan weight, lower branches and apical shoots were bent or broken by stems as a consequence of low trees' dimension and branches' weakness. Growing difficulties for rattans' climbing attitude are caused by pinus' tendency to lose their lowermost branches with ageing. *Pinus caribaea*, is a heliophile species that occupies the first stage of a forest succession (gap phase). It creates the ideal condition for palms' growth for the presence of large openings in the canopy. The low height of pines however, does not make this plant suitable for large-scale production of long stems (Feaw, 1992).

Pine intercropping has been attempted in Malaysia with *Pinus merkusii*. The planting scheme has involved a spacing of 8 x 8 m for the supporting trees (160 plants/ha) and 2 holes for each tree with 2-3 seedlings of clustering species each (600-650 rattan/ha) or, as in the case of single stemmed rattans, a 6 x 6 scheme for the supporting trees (250 trees/ha) and two planting holes with 1-2 seedlings each (750-1000 rattans/ha). The particularity was the synchronous end of the rotation for rattans and pines respectively at 15 and 25 years. Pines were thinned 3 times every 5 years and rattan was freed from weed for the first 2 years.

YEARS																								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
pine plantation				1 pine thinning					2 pine thinning rattan plantation (rainy season)	Plantation maintenance (weed control)	Plantation maintenance (weed control)			3 pine thinning										pine clear felling

Acacia mangium

The consociation between *A. mangium* and *Calamus manan* has given interesting results in growth rates: a total 20 m in five years and an average of 4 m/year in Acacia 3.3 x 3.3 m spacing. Attempts with lesser spacing (1 x 1; 3 x 3) have resulted in stunted rattan. Maintenance thinning (25%) has interested *A. mangium* in the fourth year to allow more light to penetrate in the understorey. *A. mangium* seems to provide still good support from 5^{th} year onwards. However some damages in branches occur leaving broken barks (INBAR TOTEM). Attempts with small diameter clustering species should take into consideration that the harvesting age of *A. mangium* is normally 15 years, quite inadequate for culms with a vegetative cycle of 25 years (*C. caesius, C. trachycoleus*) (Feaw, 1992).

Endospermum peltatum

E. peltatum has been cultivated in the Philippines with *C. merrillii.* Although tree height is bigger than rattans it appears to be unsuitable for the high position of its lowest branches and the canopy's heavy shadow, even with a spacing of 5 x 5 m (Feaw, 1992).

Lagestroemia speciosa

L. speciosa seems to be an interesting plant for small diameter rattans as growers are used to substitute rubber trees as a consequence of diseases or ageing. Although *L. speciosa* grows slowly and does not reach great height, it produces strong and low branches whose sparse leaves shed in winter allowing palms to receive a major quantity of light (Feaw, 1992).

Gigantochloa levis

Some rattan-bamboo intercropping have been done in recent years due to not fully satisfactory results with rubber and oil palm intercrops on the management level and with logged-over forest and forest plantations on the survival and growth rate level. The rattan saplings used were 4 years old (*C. manan*), while bamboo-planting material consisted in 3 months old branch cuttings of *Gigantochloa levis* a sympodial large size bamboo (18-23 m x 11-13 cm). Bamboos were planted in a 5 x 5 m scheme (400 plants/ha) in July and weeding management was carried out at four-month intervals. Thinning old bamboo culms and shoots were done two years after planting in order to control the production of culms to 4-5 stems per clump and to avoid *Gigantochloa levis*'s dominance. Rattan seedlings planted at 5 x 4 m (500 plants/ha), 21 months later bamboo (April), showed a relative high death rate due wrong planting management procedures. As far as bamboo is concerned, from the initial observations each clump produced 5 culms and grew 9.5 m allowing a first harvest of 1486.6 kg of shoots with an average of 11 shoots for clump. Bamboo-rattan intercrop guarantees production in the very early period of cultivation, but more researches have to be done to verify the timing of rattan harvesting and the capability of rattan in supporting climbing palms (Raja Barizan, 2002).

Rubber Plantations

Semi-abandoned plantations of *Hevea brasiliensis* have been used for intercropping with *C. trachycoleus* or *C. caesius* in central Kalimantan - Indonesia and Sabah - Malaysia, in order to boost or reconvert low yield rubber plantations with more profitable plants (Fig.16). Growth of rattan was generally better in lighter areas (borders or under thinned trees). In Sarawak 40 m length stems of *C. caesius* and clumps with 15-20 suckers have been found. No other extensive intercroppings have been noted for high yield rubber cultivations, the reason is probably linked with the interference of rattan in latex tapping operations. Rattan in this case results to be the main crop, rubber economic value is assessed only whether feasible, because of accessibility. Among the advantages of this kind of intercropping it should be noticed that no additional costs for intercropping are present, as rattan utilizes existing plantations with regular distance, hence homogeneous light conditions are guaranteed. Furthermore palms can take advantage of: 1) low branches for support; 2) *Hevea*'s fast growth qualities for easy establishment of shade and support in new plantations; 3) rubber's wintering attitude, which boost light availability.

On the other hand rubber in general prefers drier land, which makes it difficult the coexistence of the two species under the best growing conditions. In addition, rattan can disturb rubber production both in tapping, as it will be done less regularly and in wood quality due the presence of stems that bend the branches, or repeated thinning (Feaw, 1992).

Planting distance for rubber varies according to rubber spacing. In a plot in Dengkil spacing for *C. manan* was set to 6 x 3 m in alternate rows of rubber in order to let tappers not to be disturbed by rattan presence. Although this technique limit the overall number of planting point, it is possible to overcome this shortfall with group planting of 2-3 plants for a total number of 400 seedlings/ha (with a distance between seedlings of 1-3 m) and a supporting rubber plant for each palm. Rattans should not be planted at a density of more than 400 seedlings/ha or at least their number should not be greater than rubber's one. It becomes indeed difficult to manage latex extraction or doing maintenance work due to the invasive characteristics of rattan. The age of rubber however, play an important role in the rattan plantation, firstly because in more than 10-year old plantations canopy is already closed limiting thus light conditions, secondly because the progressive disappearing of lower branches limit rattan capacity to climb, thirdly because the rattans' growth rate is more constant when palms are planted under rubber of 4-7 year (Supardi, 1992).

Shifting cultivation

This method belongs to an old practice managed by indigenous populations. Rattan is integrated in a 7-15 cycle that starts with the forestland felling. Forest dwellers use these lands for crop cultivation for 1-2 years and left them fallow. The cycle terminates with the final harvesting of 15-year old stems. Sustainable management of this system suggests in a period of at least 15 years the ideal timeframe for preserving the habitat. However, recent years' land pressure has shortened the cycle endangering the forest's delicate equilibrium (Feaw, 1992).

Natural forests and intercropping systems show both some advantages and constraints. Arguably plantation systems favor rattan growth and management due to more regular planting scheme and an already suited area, which result in higher survival rate and increased economic benefits for the main hosting crop. However, the implanting cost is high (if meant only for rattan purpose), and a wide reduction of biodiversity level is attended. On the other hand natural forests/enrichment plantings are less capital intensive but do guarantee low mortality rates (40%) if not managed properly or in case that timber production is privileged.

Advantages and disadvantages of main planting systems

System	Advantages	Disadvantages
Plantations	• Economic benefits from parent crop (esp. if timber species) • High establishment and low levels of initial mortality (<10% mortality)	• Capital intensive; usually undertaken by commercial concerns only • Biologically and ecologically de-pauperate; few species and uniform canopy • Harvesting difficult due to high canopy and inter-twining of rattan stems • Canopy support for rattan stems often weak; much crown damage • Theft of mature stems before harvest
Enrichment planting	• Biologically/ecologically diverse systems with species diversity and multi-strata canopy • Multi-tiered canopy; better support for rattan stems • Capital extensive • Easily adopted by small-holders and small-scale farmers • Lower canopy = easier harvesting of mature rattan crop	• High initial mortality and low establishment due to high light interception from canopy and competition from undergrowth (up to 40% mortality) • Need canopy manipulation • Conflict with valuable timber species

Source: Sunderland (2000)

4.1.7 Intercropping Studies

This section analyzes two of the most diffused methods of rattan cultivation: rattan gardens and rubber intercrops. The first system use the fallow period within two crop cycles in shifting cultivation, a wide utilized practice used by indigenous people all over the world. Rubber plantation represents on the contrary a way to use abandoned or underutilized lands by enriching former monocultures with added value plants.

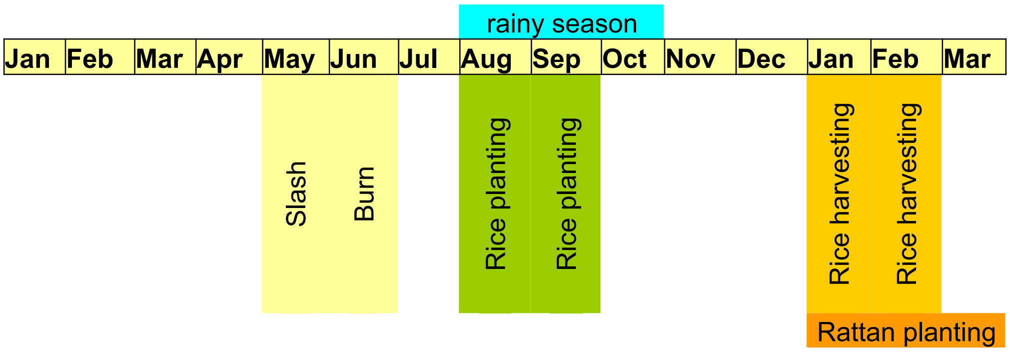
Rattan Gardens in Kalimantan, Indonesia

Rattan in Indonesia is produced not only from forest, but also from rattan gardens. History of rattan cultivation indicates that since last century rattan was utilized as a part of swidden cultivation. In Kalimantan's rattan garden two valuable commercial species are cultivated: *Calamus caesius* locally called “Rotan sega” and *Calamus trachycoleus* called “Rotan irit”. Both species belong to different habitats, in fact while the first grow on ultisoils and tolerate drier condition, the second lives on alluvial soils, as it lives on riverbanks, and can tolerate temporary flooding. The different species characterize also a diverse timeframe. For *C. caesius* two management systems are in fact possible: a temporary 10-15 years rattan garden normally utilized for file crops, and a permanent one with no time limit, which have on average 30 years old plants.

Most of Kalimantan people are indigenous tribes, belonging to the Dayak. The common livelihood management system is the shifting cultivation and every year a forest area of 1-2 ha per family is utilized for food production. The technique consists in slashing vegetation, burning it after a month of drying. So that seed germination is stimulated when rainy season comes (Matius, 2004). Rice is planted at the beginning of the rainy season (August/September) and harvested after five months (January/February). *C. caesius* in dry gardens can be planted either at the same time of rice planting or after rice harvest. Plantation usually occurs with two methods: direct sowing or planting of seedlings collected form other gardens. After a year of crop utilization land is left fallow letting rattan and early pioneer species to grow undisturbed. Major work during the first years consists in doing ground-clearings or girdling of big trees, which sear trees and maintain them on site for the rattan to climb. Criteria for cutting or girdling are thus performed following these priorities: only the dense and heavy shading tall trees are cut or girdled, trees with big dense crown or big leaf size that avoids the light to reach the garden floor, trees assumed as invaluable species for farmers, non fruit or honeybee trees.

Harvest starts from 7-10 years onward at a mean length of 20 m and is done mainly during the drier months from April to October. Two or three harvests are usually done, however, if the palms are left uncut till the end of the cycle at 15 years, a better harvest is possible as they can yield 3 times more than 7-year old plants.

Timeframe for rattan garden (1st year)



Data source: Arifin (2003)

Management system in permanent rattan gardens

Year	Activities	Information
S	Shifting cultivation	- Land clearing in dry season - Burning before beginning of rainy season - Planting of rice (August/September) - Harvesting of rice (February)
S + 1	Cultivation of rattan *C.caesius*	- Clearing of grass and shrubs - Cultivating of rattan (direct sowing or planting of wildlings) - Spacing of rattan 4 x 4 m, sometimes irregular
S + 1,5	Maintenance of rattan	- The ground-clearing of competitive plants
S + 8 or S + 9	- Harvesting of rattan 1st. *C. caesius*	- Rattan 10 - 20 m length - The harvesting is carried out in dry season
S + 10 or S + 11	- Harvesting of rattan 2nd. *C. caesius*	- Rattan sprouts 20 m length - Harvesting in dry season
S + 12 or S + 13	- Harvesting of rattan 3rd. *C. caesius*	- Rattan sprouts 20 m length - Harvesting in dry season
S + 14 or S + 15	- Harvesting of rattan 4th. *C. caesius*	- Rattan sprouts 20 m length - Harvesting in dry season

S = Time of Shifting Cultivation   Source: Arifin (2003)

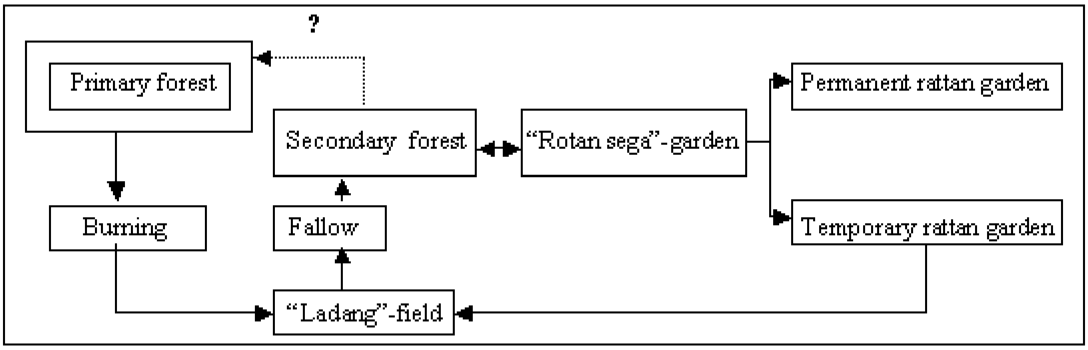
Management of the rattan gardens is quite similar. The main difference is the timeframe, as permanent plots can last for more than 15 years. Sometimes farmers cultivate rattans jointly with rubber trees. Clumps require regular thinning to encourage development of new sprouts and to increase the growth of residual stems.

Management system in temporary rattan gardens

Year	Activities	Information
S	Shifting cultivation	- Land clearing in dry season - Burning before beginning of rainy season - Planting of rice (August/September) - Harvesting of rice (February)
S + 1	Cultivation of rattan *C. caesius and Hevea brasiliensis*	- Clearing of grass and shrubs - Cultivating of rattan (direct sowing or planting of wildlings) - Spacing of rattan 4 x 4 m, sometimes irregular - Cultivating of rubber trees at the edge of garden
S + 1,5	Maintenance of rattan and *and Hevea brasiliensis*	- Ground-clearing of competitive plants
S + 8 or S + 9	- Harvesting of rattan 1st. *C. caesius* - Taping of rubber trees	- Rattan 10 - 20 m length - Rubber tree can tape everyday, especially in dry season
S + 10 or S + 11	- Harvesting of rattan 2nd. *C. caesius*	- Rattan sprouts 20 m length - Harvesting in dry season
S + 12 or S + 13	- Harvesting of rattan 3rd. *C. caesius*	- Rattan sprouts 20 m length - Harvesting in dry season
S + 14 or S + 15	- Harvesting of rattan 4th. *C. caesius*	- Rattan sprouts 20 m length - Harvesting in dry season
S + 16	Rice field ´Ladang´ again	- Land clearing in dry season - Burning before beginning of rainy season - Planting of rice (August/September)

S = Time of Shifting Cultivation Source: Arifin (2003)

Permanent/temporary rattan garden cycle



Source: Arifin (2003)

C. trachycoleus is cultivated in wet gardens (1-3 ha) alongside river banks. Plants find here a natural niche as no one utilizes these areas for food crops due frequent inundations (May/June). In the 'Rotan irit' garden *C. trachycoleus* develops diffuse open clusters. Juvenile individuals need an initial clearing of canopy and undergrowth. Afterwards no further management is needed. First harvest commences at 7-10 years at 10-20 m stem lenght.

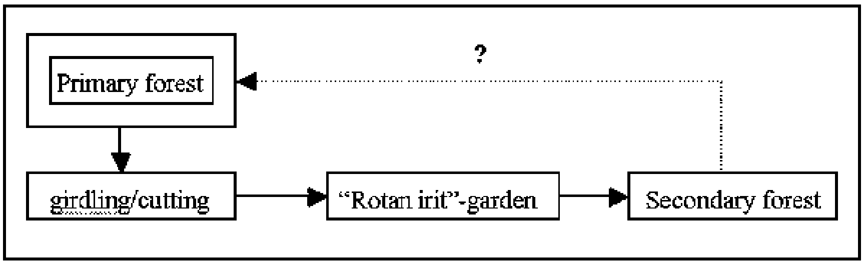
Management system in Rotan Irit gardens

Year	Activities	Information
S	- Land clearing - Cultivation of rattan *C. trachycoleus*	- Girdling of big trees - Cultivation of rattan (direct sowing or planting of wildlings) - Spacing of rattan 4 x 4 m, sometimes irregular
S + 0,5 or S + 1	- Maintenance of rattan	- Ground-clearing from grass and shrubs or the other competitive plant
S + 8 or S + 9	- Harvesting of rattan 1st. *C. trachycoleus*	- Rattan 10 - 20 m length - Harvesting in dry season
S + 10 or S + 11	- Harvesting of rattan 2nd. *C. trachycoleus*	Rattan sprouts ≥ 20 m length - Harvesting in dry season
S + 12 or S + 13	- Harvesting of rattan 3rd. *C. trachycoleus*	Rattan sprouts ≥ 20 m length - Harvesting in dry season
S + 14 or S + 15	- Harvesting of rattan 4th. *C. trachycoleus*	Rattan sprouts ≥ 20 m length - Harvesting in dry season

S = Time of Shifting Cultivation

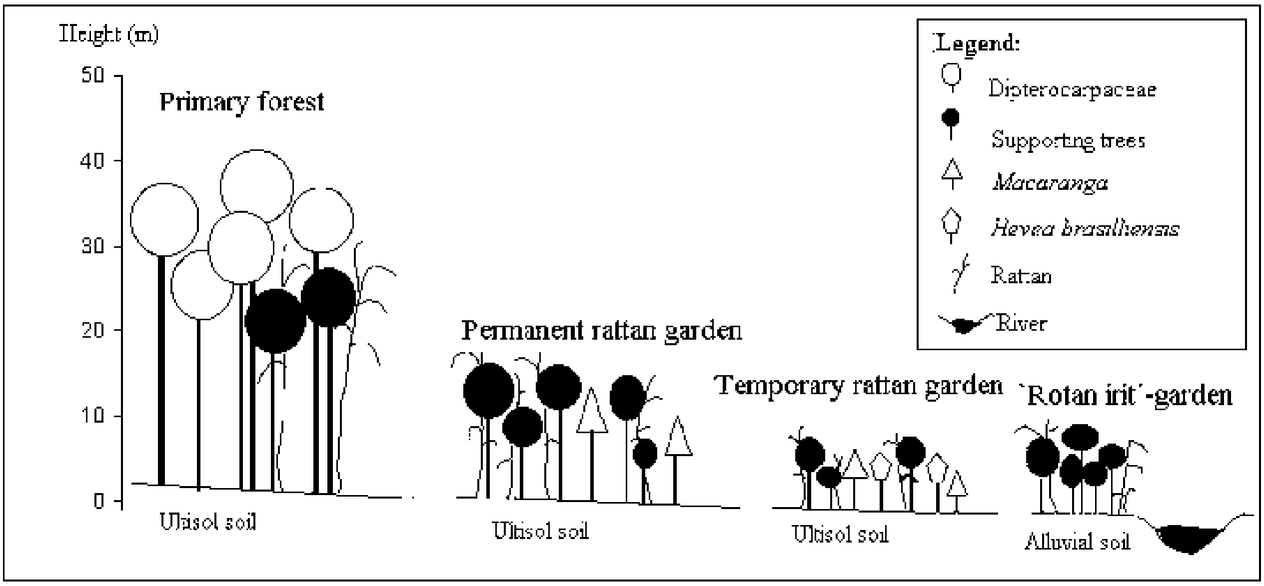
Source: Arifin (2003)

Rotan Irit rattan garden cycle



Source: Arifin (2003)

Structure sketch of rattan gardens in Central Kalimantan



Source: Arifin (2003)

Arifin (2003) in his studies empathizes on the number of rattan species present in these gardens by utilizing 25 plots of 400 m^2 and measuring rattan species > 5 m in length and tree species ≥ 10 cm dbh (diameter at breast height). Two indicators show also the diversity and homogeneity within the garden population: the Margalet's Diversity Index (D_{Mg} = (S-1)/ln N) and the Homogeneity Index by Berger-Parker (d = N/N_{max}) in which S = number of species, N = total number of individuals recorded and Nmax = the number of individuals in the most abundant species.

Diversity indices of rattans in different rattan gardens and primary forest (shoots length > 5 m) Central Kalimantan Indonesia - plot size 1 ha

Investigation area	Number of species	Number of shoots	Homogeneity index	Diversity index
Primary forest	11	392	3	1.7
Permanent rattan garden *C. caesius* (Rotan Sega)	10	352	1.4	1.5
Temporary rattan garden *C. caesius* (Rotan Sega)	10	339	1.5	1.5
Rotan Irit- garden	4	5925	1.1	0.3

Source: Arifin (2003)

Permanent and temporary gardens have the same diversity index though the permanent one has a better homogeneity index due to high domination of *C. caesius*.

The Primary forest is dominated by the genus Shorea. The topmost emergent layer in Borneo is composed of dipterocarpaceae and leguminaceae, while in rattan garden fast growing pioneer species prevail (Euphorbiaceae).

Diversity indices of tree species in primary forest and rattan gardens, Central Kalimantan Indonesia, plot size 1 ha

Investigation area	Number of species	Number of shoots	Homogeneity index	Diversity index
Primary forest	71	403	2,5	11,7
Permanent rattan garden *C. caesius* (Rotan Sega)	46	502	2,5	11,7
Temporary rattan garden *C. caesius* (Rotan Sega)	41	453	5,7	6,5
Rotan Irit- garden	19	139	2,6	3,7

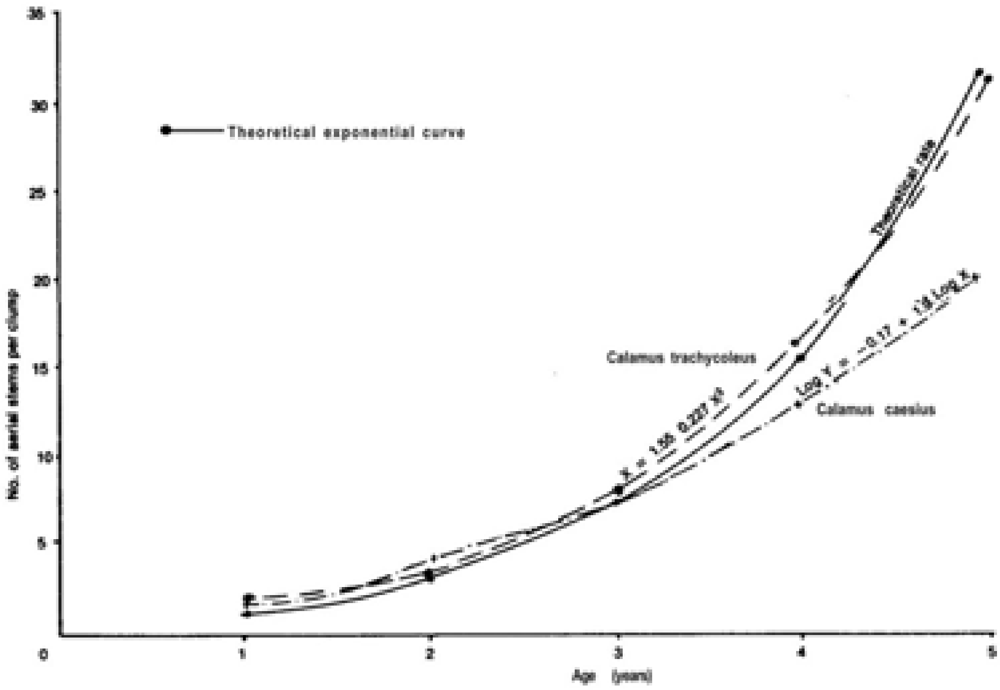
Source: Arifin (2003)

Behind the data it appears evident that primary forest, permanent and temporary rattan gardens have high species diversity showing a good equilibrium between field specialization in producing rattans and maintenance of original ecosystems. According to Wienstock (1983) the practice of fallow gardens do not leave an empty forest, but a mature rattan cultivation that helps preserving soil. Being a natural inhabitant of the forest, rattan does not upset or alter the ecological balance but rather helps in enriching it with organic matter.

As far as the growth is concerned *C. caesius* produces a rather dense clump of many aerial stems, often more than 15 in number, radiating from a condensed system of short underground rhizomes, while, *C. trachycoleus* produces diffuse open colonies, spreading by aboveground stolons or elongated rhizomes (Soon, 1985).

A comparison between Soon's (1985) observed rates of *C. trachycoleus* and *C. caesius* and those of Dransfield, demonstrates that both these rattans double the stem number every year, showing thus an exponential growth: *C. trachycoleus* can reach by the year 4.7 a potential of 44 stems per clump, while *C. caesius* shows, an average of 11 stems with a potential of 29 stems per clump by the age of 3.5 years. However, the same author mentions that longevity in yields presents some discrepancies between Dransfield’s (1977) exhausted rattans after the second harvest and Van Tuil’s (1929) chinese palms capable of continuous harvesting every 3 years (with appropriate growth conditions). *C. caesius* clumps in SAFODA rattan plantation at the age of 3.5 years produced 29 stems, the longest of which was 15.9 m and clumps occupying a space of at least 1.5 m in diameter. 100-150 aerial stems/plant are not uncommon in the wild.

Number of stems per cluster produced annually:
comparison between *C. caesius and C. trachycoleus*

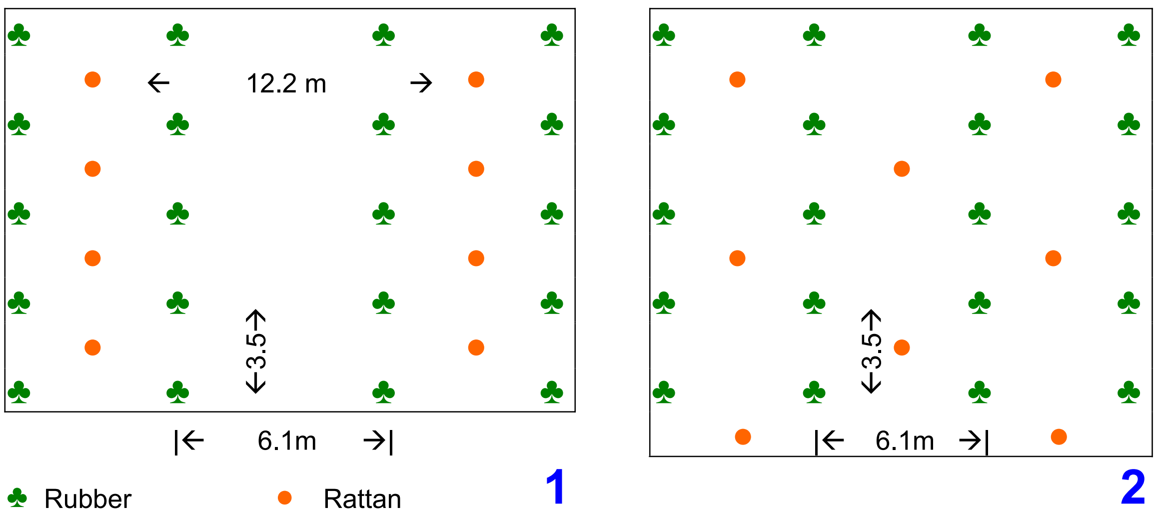


Source: Soon (1985)

Rubber plantations

Intercropping between rattan species and rubber (*Hevea brasiliensis*) has been done in recent years in either well-managed commercial rubber plantations or smallholdings and abandoned or semi-abandoned plantations (Ali, 2002). Different plantations regard those of SAFODA: *C. caesius* intercropped under 10-year old or older rubber plantations tapped irregularly, and in Sarawak: *C. caesius* interplanted with semi-abandoned irregularly tapped rubber trees (Fig.16). Common characteristic was that rattan plants were planted haphazardly and grew irregularly. Results have demonstrated that rubber trees can undoubtedly be used as support or shade trees for growing rattans successfully, providing that certain local conditions are respected (soil and moist requirements, correct timing), which make the abandoned rubber holdings for multiple-stemmed small-diameter canes more feasible (Feaw, 1992). However, although intercropping rattan with rubber trees appears easy to attain, rattan should be viewed as a supplementary crop only. In this case, rattan would be the main crop while rubber tapping the secondary one. The survival and stem growth of *C. manan* planted under rubber trees were reported to be better when this species was planted under forests. The establishment of rattan in rubber plantation is more cost-effective than planting in forest areas because the already managed state in rubber conditions makes them ready for immediate establishment of rattan seedlings. Rattan plants are usually planted in the middle of rubber tree rows with a distance that depends on rubber spacing. Another planting scheme consist on planting rattan in every other row of rubber trees. Among the possible options rattan can also be planted in group planting with 2-3 seedlings for planting point. Rattan usually requires about 50% of relative light intensity (RLI) that is considered to be a fairly open condition.

1) Planting scheme of Rubber 6.1 x 3.05 m; Rattan 12.2 x 6.1 m
2) Planting scheme of Rubber 6.1 x 3.05 m; Rattan 6.1 x 6.1 x 6.9 m

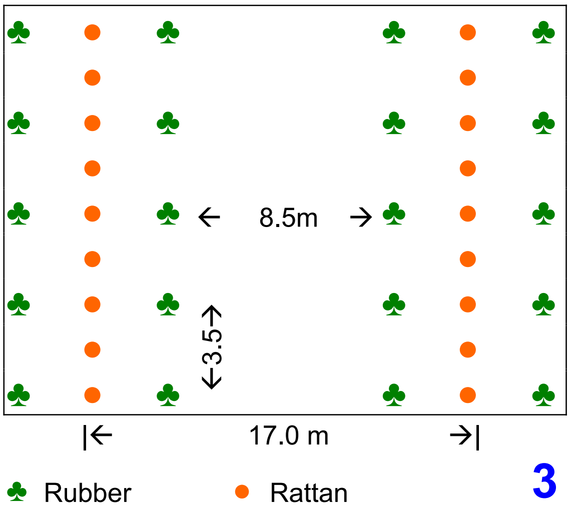


Source: INBAR TOTEM

INBAR suggests three planting schemes for rubber intercropping. In the first rattan is planted every alternate row of rubber trees showing a ratio of 1:2, this scheme is well adapted to active rubber plantations where adequate space should be provided to workers in latex collection. The second one is a triangular scheme with the same 1:2 ratio. The third is utilized for rubber inter-rows wider than 6 m. Rattans are planted at a closer distance in every alternate rubber line. Third model consents to plant more than a seedling in each hole

The techniques of planting *C. manan* under rubber trees have been well developed: four to seven-year old rubber trees were found to be best for intercropping with *C. manan.* Rattan planting performs better whenever an adequate timing is observed, as the harvesting has to occur at rubber trees' maturity, when they need replanting (from 25 years onwards). This synchronization would minimize the difficulties encountered during harvesting of rattan, and prevent damage to the rubber tree that could occur if the cane is harvested earlier. However, a longer planting time would mean that canes are allowed to reach maturity being thus more suitable for commercial processing.

3) Planting scheme of Rubber 8.5 x 3.05 m; Rattan 17 x 1.5 m



Source: INBAR TOTEM

Lessons learnt on planting *C. manan* under rubber trees (*Hevea brasiliensis*) in Peninsular Malaysia show how rattan's low density may agree with rubber management (Supardi, 2001): *C. manan* seedlings were infact planted in a single row between 4 rows of rubber trees of about 10 years old and were harvested after 15 years when the rubber trees were ready to be felled for replanting. An appraisal showed that this venture would be economically viable as it increased income with cane production. However, it is suggested not to exceed in rattan density as it cause management problems such as rubber growth rate and latex quantities reduction.

In setting rattan-rubber intercroppings, different clones of rubber could be chosen for specific characteristics: branching habits, maximum height attainable, strength of branches, adaptability to soil conditions and proneness to wind. With intercropping of rattan and rubber, some management problems can always occur: rattan can hinder tapping operations and the dense palms crown can prolong the drying of the bole of the rubber trees after a rain or can damage rubber trees branches as well.

Timeframes for *Calamus manan*/rubber intercropping

Year

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
P																								H
			P	P	P	P																		H

Year

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
P																								H
									P															H

Rattan   Rubber   P = planting   H = harvesting

Data source: Ali (2002); Supardi (2001)

Studies in growth, node development and estimated yield have been conducted on *C. manan* intercropped with 13-year old rubber (*Hevea brasiliensis*) in Malaysia. A East-West 6 x 3 m planting scheme both for rubber and rattan (420 rubber plants/ha), and *C. manan* planting lines sited in the inter rows of rubber trees, shows encouraging data in comparison with forest trials (Supardi, 1991). Results in fact indicate a 74.8% or survival in the eight year with a peak in mortality in the first three years. The following years showed instead a sensible death rate for the upper slope areas due to lateritic soil and drastic changes in microclimate. As far as the stem is concerned it is to say that the mean stem lenght increases slowly in the first 5.5 years, followed by a boost in the following 1.7 years. Lower slope shows better increases due to better microclimatic conditions (about 4 times more).

***C. manan* mean stem length (in meters) and std deviation in a rubber plantation**

Age (years)	Lower slopes	Middle slope	Upper slope	Whole plots
1.0	0.15 ± 0.04	0.16 ± 0.04	0.13 ± 0.03	0.14 ± 0.04
2.0	0.27 ± 0.13	0.21 ± 0.08	0.14 ± 0.03	0.21 ± 0.10
3.0	0.83 ± 0.38	0.48 ± 0.20	0.19 ± 0.06	0.45 ± 0.30
4.8	1.80 ± 1.29	1.29 ± 0.82	0.41 ± 0.22	1.17 ± 0.78
5.5	2.78 ± 2.04	1.92 ± 1.24	0.50 ± 0.33	1.53 ± 1.20
7.2	11.07 ± 3.89	5.74 ± 3.14	1.01 ± 1.01	6.83 ± 5.04
8.2	14.21 ± 4.21	9.65 ± 4.52	2.10 ± 1.35	9.98 ± 5.99

Source: Nur Supardi (1991)

Percentage distribution of stem length classes for *C. manan* in a rubber plantation

Stem Length Classes (m)	Years			
	4.8	**5.05**	**7.2**	**8.2**
<1.50	71.8	60.5	23.5	11.4
1.51-3.00	20.0	23.5	7.5	7.6
3.01-6.00	8.2	13.6	15.0	12.3
6.01-9.00	-	2.4	15.0	11.4
9.01-12.00		-	17.9	13.3
12.01-15.00	-	-	15.0	17.1
15.01-18.00	-	-	4.7	17.1
18.01-21.00	-	-	0.9	6.6
>21.01	-	-	-	0.9

Source: Nur Supardi (1991)

By cross-checking data among different planting conditions 3 years after planting (Nur Supardi, 1986) it is evident that rattan-rubber consociations perform quite well in comparison with forest reserves. Better performances are attained only in those areas where several maintenance works is carried out, while rubber plantation shows similar growth rates but with minimum costs. To sum up rattan plantation under rubber is more economical as compared to planting under forest conditions due to maintenance costs reduction (weeding, field survey/preparation).

Comparative mean stem length of *C. manan* seedlings grown under different planting conditions at 3 years after planting

Place		Mean stem length (cm)	Range (cm)	Survival (%)	Source
Rubber plantation Dengkil, Selangor		45.17	10 to 250	80.6	
Block D3, Sg. Buloh, Forest Reserve	Treatment I (Control)	37.2	10 to 80	84.5	Aminuddin; Nur Supardi (1986)
	Treatment 2 (3' opening)	54.6	13 to 150	87.8	
	Treatment 3 (6' opening)	62.3	10 to 135	74.0	
	Treatment 4 (9' opening)	65.6	15 to 175	79.7	
	Treatment 5 (12' opening)	66.7	10 to 150	83.7	
Field 41, Bkt. Lagung Forest Reserve		36.3	5 to 254	67.1	Anon. (1981)
Field 28, Bkt. Lagung Forest Reserve		31.7	8 to 107	55.0	Anon. (1981)

Source: Nur Supardi (1986)

4.1.8 Harvesting

Harvesting of rattan is very strenuous as work involves coming into contact with rattan spines, pulling the stems down from the forest canopy, hauling down death tree branch and being in contact with animals or insects' nests (Supardi, 1992). While operating in forests it is important to consider:

- Distance from major means of transportation system and for reaching the mill in time as long as time-unprocessed stems can be attacked by fungi and insects.
- Forest structure, as it determines the difficulty of harvesting, due to an increase of labour time to perform as it takes more time to do all the operations required.
- Selection of mature stems, as they determines the quality of the product since too young stems have different densities and fiber composition that affect the final product. As a rule, criteria that distinguish mature stems are: the presence of a nude stem, a brownish leaf-sheath, the lowermost leaves yellow or dry, stem length above 15-20 m, stem in bright yellow color instead of whitish or pale yellow.
- Age of harvesting depends on the species, locality, and growing dynamics of rattan plantation. However, rattan can be harvested from the age of six ears, while in small diameter rattans it can range from 6 to 10 years after planting. Harvesting can be done several times, though for *C. trachycoleus* it has been reported a decline in yield.
- Wastage in harvested rattan could be high due to: stem entangled into the canopy, collection of not mature stems, lack of appropriate processing in short period of time. Average percentage in wastage can reach 12.6 - 28.5% of the total quantity.

Harvesting equipment consists in very basic tools: a jungle or machete for cutting stems and fronds slashing undergrowth for movement in the forest; an axe to cut big branches, a pole with a cutter (shear) at the end to cut fronds or stem at a certain height; chopper to split the leaf sheath of large diameter rattans. It is important not to forget the security equipment as well to protect workers against the danger of the spiny stems.

Techniques

There are two different harvesting techniques that utilize different levels of technology. They share however the same time for harvesting, as it happens in the dry season in order to ensure that rattan dries easily. In South China rattan is collected in autumn, while in India during the dry season from October to March. In Indonesia the collection seldom occurs in rainy season (Supardi, 1992).

Manual method

It is undoubtedly the most diffuse method as it done by smallholders. The tasks require large stamina as it is an energy consuming job both for harvesting itself and for the need to reach the

harvesting zone on foot carrying heavy loads of stems on the way back. The cutting happens at the base of the plant, generally at 1,5 – 2 m in order to avoid any harm to the clump. The point of cut is where the stem is regular, without aerial roots or defects. For large diameter canes the stem is cut with a chopper above the part with prominent nodes. The following task consists on pulling down the stem, which requires large amount of manpower as stems are often entangled in the forest canopy. Different leaves dimension, as those in small diameter cane can ease the job because the cane encounter less resistance in being extracted from the tree branches. Direction of pulling is important as small diameter and light tolerance species climb at the edge of the tree crown determining an effort in sideways direction. If the rattan get stuck it become necessary to use a pole with shears to free the stem from its leaves. A common method available only for small size rattans and small trees is to employ 1-2 workers who climb the trees and free the stems from upward, though many workers tend more easily to leave the uppermost part of the palms into the tree crowns by simply cutting the stem at a specific height.
Using traditional methods like those of Orang Asli, an indigenous Malaysian population who is good at climbing trees, a rattan harvesting trial has demonstrated in 2-7 plants the average quantity of palms fully processed (harvest, clean, cut) per person/day.
Although at least one-third of rattan crowns are left hanging in the forest canopy reaching up to 50 percent of total cane length (Ali, 2002). The forest structure not only does affect the quantity of harvestable rattan by affecting its growth and its extraction from the canopy, but also determines the duration of every single harvesting operation. The table below shows how a regular planting scheme can speed up cane extraction, which can affect the final price/gain of the commodity.

Time study on various operations in harvesting one *C. manan*

	Average time in minutes	
Operation	**Old Secondary Forest**	**Rubber Plantation**
Cutting the Base	0.5	0.3
Climb/Cutting fronds	30.0	15.0
Pulling	20.0	7.0
Stripping the leaf sheaths	15.0	10.0
Cutting into lengths	5.0	2.5
Bundling	3.0	1.2
TOTAL TIME TAKEN	**73.5**	**36.0**

Source: Supardi (1992) - modified

Mechanical method

It consists on dragging the rattan by a four-wheel drive vehicle or a trifore and winch (Fig.17). In the first case the stem is tied at the rear of the vehicle and dragged. It takes about 4 minutes for two workers and a driver to drag down a *C. manan,* though it can be carried only in areas accessible to roads, with planting systems that allow the car to transit and with an angle not wider than 45° in order to avoid the stem to stuck firmly into the canopy. However, cars cause some drawbacks such as plant damaging and soil constipation.

When harvested some other task concern the preparation of the cane such as the sheath removal that imply the bending of the stem in two tree branches or the pulling into a narrow passage so that the external layers are stripped off. The green part of the stem should be removed by slashing the petiole as close to the stem as possible and by chopping the leaf sheath and pull it out of the stem. The stem is then cut into required length by discarding the upper green portion and eliminating the defective parts. Bundle measures vary in general from 2 to 6 meters for large diameter and 5 to 9 for small diameter (Fig. 24). Particularly important is the drying process, as canes need to reduce moist to an average of 20%. Stems are firstly left vertically to drain out the sap and afterwards are dried at the sunlight (Fig. 20). A test held by Supardi (1992) attested a quantity of water ranging from 0.14 to 0.42 litres that flushes away from 3 m of *C. manan* stem.

4.1.9 Effects of Harvesting on Rattan Population

Ecological sustainability implies taking into consideration possible direct and indirect biological effects. Harvesting in fact not only does affect species level, as the abundance of the population structure changes when a harvest occurs, but also gene flow, genetic vigor, ecosystem nutrients, forest structure, forest succession and food resources, which are modified in their equilibria.

Empiric and traditional harvesting methods have implied a limit of harvestable product of 20% of the whole number. However, the increase in commercial exploitation has raised these levels beyond plants' growth rate.

An interesting study of Siebert (2004) shows how rattan population is affected by a harvest in a primary forest in Indonesia (3000-4000 mm/year of rain, species studied *C. zollingeri,* harvest occurred after 1996 assessment). Despite the constant plant number and stem number there is a drastic change in mean cane length and harvestable canes (>10 m length). Class density also varies with a sensible reduction of longer canes and a raise in smallest length class in year 2000. To a physiological point of view, harvesting stimulates the regeneration of clumps by sprouting but it does not seem to affect 5-9 m stems growth rate, which remains at 1.4 m/year. From a primary forest population of 67-90 rattans/ha the mean number of stems (>1 m) is on average 12-15 per clumps, of these the harvestable ones (>5-10 m) are 0.8-0.6 per clump, leading to a sustained-yield harvest of 100-60 m/ha/year. Sustained-yield harvest should not be confused with ecological sustainability, as this implies not only the intra-specific variation of a population but also interaction between species. Present management of rattans (cuttings for >10m length) involves drawbacks in plant reproduction through sexual means, as it is ascertained that stem maturity occurs from lengths of 10 m and inflorescences appear whenever the stems reach the forest canopy at 30 m.

Changes in rattan clumps and stems in a 4-year period following harvesting

	1996 (pre)	2000 (post)
No. of plants	62	62
Total no. of stems >1m	752	752
Mean no. stem/plant	12.1	12.1
Mean cane length ≥ 5 m	16.7	6.8
Median cane length ≥ 5 m	20	5
No. harvestable canes ≥ 10 m	41	5
Total length harvestable cane ≥ 10 m	844	75

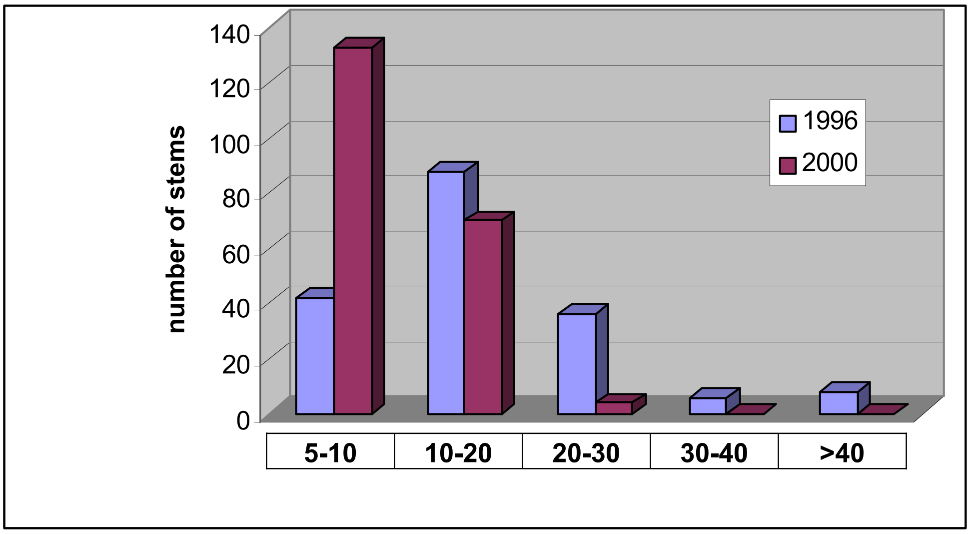
Source: Siebert (2004)

Mean number of rattan clumps, stems and harvestable canes per hectare in a 4-year period

	1996 (pre)	2000 (post)
No. of plants	74	67
No. of stems ≥ 1 m	918	995
No. harvestable canes ≥ 10 m	39	11
Canes cut	223	163

Source: Siebert (2004)

Effect on Cane Length after Harvest (1996 pre harvest; 2000 post harvest)



Source: Siebert (2004)

4.2 IMPROVEMENT AND GENETIC ENHANCEMENT OF RATTAN

Rattans are mainly harvested from the wild or from stands in degraded forest areas. The increasing growth in harvesting, which is exploiting natural resources and forest biodiversity, makes it necessary to develop rattan cultivations for commercial purposes as the best way to overcome impoverishment. To meet the increasing demand for quality canes commercial species of rattan must come from improved strains, through identification and trials of indigenous and exotic species, selection and establishment of quality seed orchards and crossing. According to Lawrence (1985) the lack of systematic improvement in the past years makes the genetic enhancement of rattan really appealing for its yield potential.

It is evident that every rattan improvement plan should take into account that selection has to consider site adaptability and plant's end use. Not all the species are in fact able to live in different climatic zones or to cope with different soil condition: rattans from perhumid areas are not expected to survive well in monsoonal zones due to long dry seasons. On the contrary monsoonal rattans could have some advantages due a continue contribution of water, and a wide adaptability both in the northern and southern hemisphere for areas with similar climatic characteristics (Shim, 1995). Criteria for the selection of rattan consist in:

- Sucker production. For clustering species it increases with clump dimension: species with characteristics similar to *C. trachycoleus* should be preferred due long stolons and rhizomes that allow new stems to grow with no competition. In case of single stemmed species the presence of multiple sucker should not be selected as main stems lose dominancy, which results in lower quality and stunted canes.
- Growth rate. It is affected by microclimatic and nutrient factors. However, in similar conditions growth rate is the result both of internode’s production rate and internodes length.
- Internodal lenght. It varies among species (*C. subinermis*, 31 cm; *C. manan*, 22 cm and *C. trachycoleus* 22 cm) and is an important criterion for selection both for cane growth and for its final use in the furniture chain.
- Nodal diameter differences. The smaller difference the better quality, as changes within internodes determine inhomogeneous proportion of the final product.
- Cane diameter. Not often this criterion is taken into account as it depends on climatic conditions and species.
- Color and blemish of skin. They depend on the species and from the type of treatment.
- Inflorescence. The presence of the inflorescence determines a reduction in the internode length in the immediate distance and a flat shape of the cane. As a rule canes that produce inflorescences later in life or those that do not flower every year are preferred.

In rattan breeding two strategies are proposed:

A short-term strategy where immediate planting occurs with improved stock coming from selected indigenous commercial plants or plantations, while awaiting better seeds from high quality seeds’ orchards. The result will be, however, a heterogeneous population.

Long-term strategies imply the use of best seed from species and provenance trials through recurrent selection of individuals.

It is to say that some problems in maintaining seed viability for a long time make it difficult to have even-aged plants and similar fruiting periods. In addition the maturity stage reached at 7-10 years does not allow immediate production of seeds and plant quality forecasts in little time. The other alternative to seeding, which is the vegetative propagation, is on the other hand expensive and uneasy to perform on a large scale, due to insufficient production.
Recent research highlights (Rao, 2001) prioritize the correct species identification firstly because it is a way to transfer information and predict rattan properties, secondly because assessment and inventory allow a better identification of the most suitable areas for conservation and development, thirdly because it ease the recognition of the genetic diversity across species and sites.
However some external factors affect the research as rates of extraction and natural regeneration, which depend on environmental conditions as well, have a sensible impact on establishing proper *in situ* measures and sustainable utilization of the resource for indefinite economic benefits.

Rattans. Priority species and species of national and regional importance

	Value			**Domestication**	**Climate & Ecology**		**Genetic resources**			
Taxa	cane size	Commercialization potential	Rural Industries		Ciimate	Habitat	Genetic Erosion	In Vitro reseach needs	Exchange needs	Survey
Calamus manan	L	++	+	Domesticated	humid tropic	dryland	H	L	H	M
C. caesius	S	++	++	Domesticated	humid tropic	dryland/wet	H	L	H	H
C. trachycoleus	S	++	++	Domesticated	humid tropic	seasonally flooded	L	L	M	L
Calamus sect. *Podocephalus*	M-L	++	+	Semi Domesticated	humid tropic subtropic	saline mangrove to montane	H	L	H	H
C. subinermis (and relatives)	M-L	++	+	Semi Domesticated	humid tropic subtropic	dry (coastal hills)	H	L	H	M
C. palustris (and relatives)	M-L	+	++	Semi Domesticated	humid tropic (monsoonal)	varied	H	L	H	H
C. tetradactylus	S		++	Domesticated	Cool	dryland	L	L	L	L
C. deeratus	S-M	(+)	++	wild	humid tropic subtropic	wet	H	L	H	H
C. hollrungii (and relatives)	M-L	+	+	wild	humid tropic	dryland	H	L	H	H

Cane size: L-large, M – medium, S – small **Commercialization potential:** ++high; + medium; (+) not fully known **Rural Industries**: ++high; + medium . **Genetic Resources**: H – High; M – Medium; L – Low

Source: Rao (1998) - modified

4.3 RESEARCHES ON RATTAN

Rattan and bamboo, the major NTFPs, have a centuries-long documented history in human use. Taxonomic and silvicultural studies have been pursued since the 70s, although large gaps in knowledge still persist especially in inventory efforts, which are fundamental to determine the presence of different species and the level of threat caused by overexploitation. Resource and biodiversity assessment thus result essential factors in identifying species, areas, volumes, population structure and growth rates as they are the best methods to monitor levels of depletion and to identify different genetic diversity patterns within species in different areas.

The need of a global information database based on the idea of "*what grows where"* should take into consideration the ethnobotany or the selection made by local peoples and the indigenous knowledge. The correct identification and assessment of species among different countries will definitively determine the best species and their provenance for targeted research.

On the level of production particular emphasis should be given to agronomic studies to better determine the best conditions of moist, elevation, exposition and soil requirements. Plantations, however, have to achieve a technology standardization based on agronomic studies for fast growing tree species and for typical raising areas such as degraded lands, logged over forest, marginal farmlands in agroforestry initiatives or integration within agricultural/horticultural crops.

Following Sonwa (2000) suggestions, some issues should be taken into consideration particularly in those areas of secondary forest or underutilized lands where it is important to determine not only the genetic diversity and dynamics of rattan populations, but also the rate of re-growth after harvesting, the impact of rattan silviculture on forest dynamics and the level of biodiversity.

As for fallow and/or abandoned lands, which have ecological similarities to the natural habitat of several rattan species, it is important to determine the precise period for introducing rattan within a fallow cycle and the socio-economic and ecological impact of new plantations. Since land pressure is becoming higher it is not well known how the reduction of fallow period from an optimum of 15 years to 5, or the introduction of other intercrops within the plantation, such as leguminous plants, can modify the fertility and the recovery of the soil.

Due to the presence of monocrops and fluctuating world prices on commodities it could be worth planting rattan as a strategy of differentiation of family incomes. However, further studies should be carried out on the negative allopathic influence of rattan against main crops either in management methods and yield reduction. Present studies tend in fact to focus on rattan yields but do not consider what is the extension in yield reduction of the main crops (Rodrigo, 2004; Nur Supardi, 1991) due to canopy damage/competition, nutrient reduction, and mutual shade. Density and spatial arrangement studies apart, research should concentrate some efforts on the level of carbon retention and nutrients consumption in order to evaluate the disturbance or amelioration brought by the rattan, as well as improve the best techniques to manage and harvest the plants (Sonwa, 2000).

Another sector, which should capture researchers' attention, is the post-harvest treatment, that aims to reduce cane waste during the collection and the following processing: limit biotic attacks and improve canes' quality. Product development represents thus a strategy to diversify the offer and to develop new market niches: new processing technologies would lead to great diversity in

products of better quality either in finishing and in wear resistance, development of new rattan products and diversification of their end use target, according to species properties.
Boost in production should, however, take into consideration the primary beneficiaries of the rattan PCS by developing techniques targeted on a smallholder basis. It is important in fact to privilege no-wealthy rural and urban dwellers, as non-labor-intensive plantation programs could lead to major forest destruction for subsistence purposes by local people. Socioeconomic studies should also consider the role of women in forest projects, as craftworks represent an important share in household incomes contributing for at least 1/3 of the whole amount.

4.4 YIELD ASSESSMENT

Rattan yield is determined by numerous factors: growth rate, geographical zone, topography, planting density, soil, light intensity, moist, drought length, and predators. It is quite a complicated task for rattan to define precise estimations as not many scientific and standardized studies have been done on the matter. In addition the clustering characteristics of certain species makes sometime difficult to determine the real extension/boundary of a plant from the following one. Van Tuil in his studies did a first yield estimation in 1929. He compared the yields of two different management systems: a poorly managed and well managed field in Indonesia (clustering small-diameter canes: *C. caesius* or/and *C. trachycoleus*, not specified by the author):

Comparison between two different management systems for clustering small-diameter rattan in Indonesia

	Poorly managed holding	Well managed holding
Number of plants/ha	200	400
Growth rate/year	2 m	3
Number of stem/cluster	20	40-60
Number of stems cut/harvest	10	15
Number of cut/stem harvested	3	5
Length/cut	5	5
First harvest	6-8 years from sowing	10-12 years from sowing
Harvest frequency	every 3 years	every 3 years
Yield/ha/3 years	1.5-2-0-metric tonne	7.5 metric tonne

Source: Wan Razali (1992) (from: Van Tuil, 1929)

According with this study a well-managed system can yield net profits four times higher than of the poorly managed one.
Several studies on small diameter clustering rattan in the South-East Asia are summarized in the following table:

First Harvest Period, Yield, Growth Rate and Following Harvest Yields in Different Locations

Species	First harvest (year)	Yield (t/ha)	growth rate (m/year)	Following harvest (year) (t = tonn)	Location	Author
C. trachycoleus	7-10	6	-	every 1 - 2	Kalimantan	Dransfield (1979)
C. trachycoleus	7	8 (wet); 2.5 (dry)	-	-	-	Johari (1980)
C. caesius	3	0.5	-	6 (2 t); 9 (4 t); 12 (10 t)	Central Kalimantan	Manokaran (1981;1982)
C. trachycoleus	increase from 0.1 - 0.3 t to 1.0 - 1-2 t		3	-	Sabah	Shim & Tan (1984)
Caesius?trachycoleus?	6 - 8	5 - 7.5	-	every 2	Indonesia	Tardjo (1986)
C. caesius	10	2.3 - 3-1	4	every 2	East Kalimantan	Priasukama (1986)
C. trachycoleus	10	2.2 - 3.9	5	every 2	East Kalimantan	Priasukama (1989)
C. trachycoleus	-	1.47 - 12	4	-	Central Kalimantan	Godoy & Tan (1989)
C. tetradactylus	6	1.2	-	every 3 - 19th (4.5 t)	China	Xu (1990)

Data Source: Wan Razali (1992)

It is noticeable how yields differ sensibly. Apart the above mentioned physical conditions it is to say that some of the estimations have been extrapolated from interviews and sometimes they lack in specifying the age of the smallholding, the frequency of harvesting and planting density.

Calamus caesius

Figures about *C. caesius* (Rotan sega) are however available in Feaw's model (1992), whose conservative assumptions are:

1. Spacing of 2 x 8 with an initial total number of 625 plants/ha.
2. A total 20% casualty with a final density of 500 plants/ha from the eight year onward.
3. Each stem is assumed to be harvestable at the age of 8 years. The first stem produced in year 1 is usually pruned off by the end of year 1 in order to stimulate more suckering.
4. Cane growth rate is assumed to be 2.5 m/year giving a total stem length of 20 m after 8 years. From the total length 2.5 m (12.5%) of the uppermost part is discarded, leaving a net length of 17.5 m.
5. The stem number per plant / cluster increases from 1 to 45 by year 9 and stabilizes at that number.
6. Yearly harvestable stems increase from 2 in year 9 to 6 from 12 year onward.
7. Total cane length (m) is assumed: (500 plants) x (17.5 m) x (num of harvestable stems)
8. Assuming 1 metric ton of dry canes at farm level before further treatments is 36,000 m, the total length obtainable from point 7. should be divided by 36,000 in order to have the total number of metric tons.

The model's yield ranges from a first harvest of less than 0.5 t/ha/year to a steady 1.458 t/ha/year from 12 year onward. It is evident that this estimate is more conservative than the studies of Manokaran (1981; 1982).

Yield estimate of *C. caesius* in a 30-year rotation

(**Full spreadsheet in ANNEX II)**

	1st harvest (year 9)	4th harvest onward (year 12->)
Total cane length - m/ha	17500	52500
Total weight of dry canes - kg/ha/year	486.000	1458

Data source: Feaw (1992)

Calamus trachycoleus

As far as *C. trachycoleus* (Rotan irit) is concerned Feaw's model (1992) use quite the same conservative assumptions used for *C. caesius* (a low growth rate is used despite some reports ascertain that a stem length increase rate of 7 m/year is possible). The model does few changes in consideration of the more aggressive and sprawling suckering habit of the plant:

1. Spacing of 2 x 10 m with an initial stand of 500 plants/ha.
2. A total 20% casualty with a final density of 400 plants/ha from the eight year onward.
3. Each stem is assumed to be harvestable at the age of 7 years. The first stem produced in year 1 is usually pruned off by the end of year 1 in order to stimulate more suckering.
4. Because of its aggressive habit and his production of stolons the stem number per plant or cluster is 60.
5. Yearly harvestable stems per cluster are estimated to be 10.
6. Cane growth rate is assumed to be 3.5 m/year giving a total stem length of 24.5 m after 7 years. From the total length 4.5 m (about 18.5%) of the uppermost part is discarded, leaving a net length of 20 m.
7. Total cane length (m) is assumed: (400 plants) x (20 m) x (num of harvestable stems).
8. Assuming 1 metric ton of dry canes at farm level before further treatments to be 42,000 m, the total length obtainable from point 7. should be divided by 42,000 in order to have the total number of metric tons.

The model's yield ranges from a first harvest of less than 0.4 t/ha/year to 1.905 t/ha/year from 12^{th} year onward.

Yield estimate of *C. trachycoleus* in a 30-year rotation

(**Full spreadsheet in ANNEX II)**

	1st harvest (year 8)	4th harvest onward (year 11 →)
Total cane length - m/ha/year	16000	80000
Total weight of dry canes - kg/ha/year	381	1905

Data source: Feaw (1992)

Matius (2004) in his studies on rattan gardens compares the two varieties of rattan mainly used in alluvial and terrestrial soil with the data of Shirai (1997). In the figures he considers dry rattan weight as 50% of the weight of wet stems. Potential yield/ha are per 3-year harvesting period.

Harvesting potential of rattan gardens in Besiq (Matius 1981) and Damai subdistrict (Shirai 1997)

Result from	Species	Potential yield ranges per ha for dry rattan (kg)	Average (kg)	Potential yield value ranges per ha for wet rattan (kg)	Average (kg)
MATIUS (1981)	*C. caesius*	975-2450*	1869*	1950-4900	3738
	C. trachyloeus	975-2875*	2032*	1950-5750	4064
SHIRAI (1997)	*C. caesius*	N/A	N/A	1203-3169	2184
	C. trachyloeus	N/A	N/A	1411-3629	2398

* Calculation based on 50% of the weight from the water content of wet rattan

Source: Matius (2004)

Obviously Matius values confirm Feaw (1992) models both for *C. caesius* and *C. trachycoleus* in the upper part of the range, as is verifiable by dividing Matius ranges by three:

Yield comparation between Matius and Feaw (kg/ha/year)

MATIUS (1981)	*C. caesius*	650-1633
	C. trachyloeus	650-1916
FEAW (1992)	*C. caesius*	1458
	C. trachyloeus	1905

Calamus manan

Regarding the large diameter solitary rattan, such as *C. manan*, which is one of the most cultivated solitary-stem species in Asia, several projects are carried out in order to estimate yields, though many of these trials have not been terminated yet.

Nur Supardi & Aminuddin (1992), while attempting to project a detailed yield and financial analysis have verified that one of the factors of great concern is the great variability in growth of *C. manan*. This rattan has in fact a growth rate of about 80 cm for the first 3 years, 1 m from the 4th year onward and can reach 5-7 m/year when palm reaches the canopy. Growth of 1 – 3 m/year has been observed in adequate light conditions and in rubber plantations. At Dengkil, Selangor an average length of 9.98 m was recorded in a 8.2-year plantation.

Among the different planting schemes rattan density varies from 500 to 800 plants/ha for distances of 6-20 x 1-2 m. It is to say, however, that *C. manan* expected yield varies in function of the age of the plant.

Growth rates of *C. manan* and percentage of occurrence during the period of 6-11 years after planting.

Growth classes (m/year)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Occurrence (%)	8	10	15	30	20	10	5	2

Source: Nur Supardi's & Aminuddin (1992)

Nur Supardi's & Aminuddin (1991) study on *C. manan* intercropped with rubber (*Hevea brasiliensis*) on a 6 x 3 m planting scheme shows interesting yields. The mean length at age of 7.2 and 8.2 years was 6.83 m and 9.98 m. considering stem's usable part as 1.5 times the dried parts the estimated yield varies between 1590.4 to 2,315.7 m/ha. Of the total stem length the lowermost part of the stem, 1 m, is usually discarded as well as the uppermost 7 m (due to high presence in moist and too low density). Assuming that commercial sticks are 3 m long and considering the discards that occur, a stem of 11 m represents the lowest limit for harvesting.

Estimated yield of *C. manan* under a smallholding rubber plantation

Age (year)	Plants per ha	Mean stem length (m)	dried part (m/plant)	Usable parts (m/plant) (dried part x 1.5)	Estimated yield (m/ha) (usable part x n. plants)
7.2	423	6.83	2.51	3.76	1590.48
8.2	415	9.98	3.72	5.58	2315.7

Source: Nur Supardi's & Aminuddin (1991)

For large diameter canes the suggested timing for harvesting is 12 – 15 years. On the other hand in their yield prevision Nur Supardi & Aminuddin (1992) assume a density of 666 plants/ha, two different spacing (15 x 1 m and 10 x 1.5 m) and an average survival rate of 78% (as it varies from 60 to 95%). Harvesting happens at the end of the rotation (in clustering species it is done in a continuous way) respectively at the end of the 12th and 15th years. In the model stems are cut in commercial 3 m sticks of different diameter, whose dimension depends on the growth rate. A comparison between the two harvesting regimes shows an increase of more 100% in length in only 3 years.

Yield of two different harvesting regimes. Clearing at the end of rotation

(Full spreadsheet in ANNEX II)

	12 years	15 years	increase %
Total no. of sticks/ha	1612	3602	123.4%
Total amount of odd length (m/ha)	192	790	311.5%
Total marketable length (m/ha)	5028	11596	130.6%

Source: Nur Supardi & Aminuddin (1992) – modified

Class distribution of different stick diameters of harvested canes. Clearing at the end of rotation

(Full spreadsheet in ANNEX II)

diameter (mm)	12 years	15 years	increase %
No. of stick - 18-24	192	478	149.0%
No. of stick - 25-29	384	904	135.4%
No. of stick - 30-34	192	426	121.9%
No. of stick - 35-39	752	1428	89.9%
No. of stick - 40 & above	92	366	297.8%

Source: Nur Supardi & Aminuddin (1992) – modified

CHAPTER 5

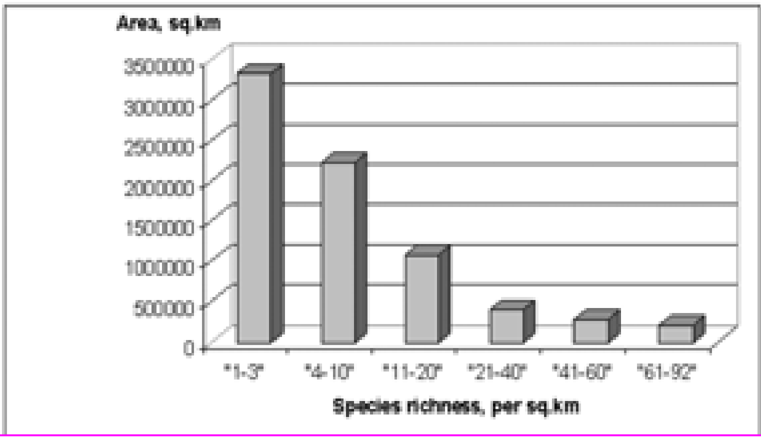
5.1 DISTRIBUTION OF RATTANS IN ASIA-PACIFIC AND AFRICA

Despite their economic and social significance, statistics on rattan resources, are very limited. Classified as a "Non-Timber Forest Product", rattan is not routinely included in resource inventories. With habitats ranging from sea level to over 3,000 m elevation, from equatorial rainforests to monsoon savannahs and the foothills of the Himalayas, there is a huge range of ecological adaptation among rattans (Fig.30). However, rattans are predominantly plants of primary rain and monsoon forest or secondary ones and are mainly spread in tropical and subtropical areas in the Asia-Pacific and Africa regions. No rattans are found growing naturally in other tropical and sub-tropical areas, or in the temperate regions. Bystriakova, N., & Dransfield, J. (2002) by cross checking multiple records for each species have ascertained that Indonesia has the largest complement of species with 246 different palmae, followed by Malaysia (205 species).

Genus	**Number of species**	**Distribution**	**Ecology**
Calamus	370	All areas	No species in semiarid habitats. From sea level to 3000 m
Calospatha	1	Malaysia	
Ceratolobus	6	Malay peninsular, Java, Sumatra, Borneo	
Daemonorops	115	From India and south China through the Malay Archipelago to New Guinea	Primary tropical rain forest on great variety of soils
Eremospatha	12	West Africa, Congo Basin, eastward to Tanzania	Rain forest, swampy soil
Korthalsia	26	Sunda Shelf, Indochina, Burma, Andaman Islands, Sulawesi, North Guinea	Lowland and hill tropical rain forest, absent in montane forest
Laccosperma	7	West Africa, Congo basin	Rain forest, swampy soil
Myrialepis	1	Indochina, Burma, Thailand, Peninsular Malaysia, Sumatra	From sea level to 1000 m, prefer disturbed sites in primary forest.
Oncocalamus	5	Equatorial west Africa and the Congo Basin	Lowland tropical rain forest
Plectocomia	16	From Himalayas, south China and Hainan, through Burma and Indochina to the Sunda Shelf and the Philippines	From sea level to 2000 m in the mountains.
Plectocomiopsis	5	South Thailand, Peninsular Malaysia, Sumatra, Borneo	Wide range of forest types, up to 1200 m altitude
Pogonotium	3	Malay Peninsula, Sarawak	700-1000 m altitude, transition between lowland and montane forest
Retispatha	1	Borneo	Hill dipterocarp forest, absent from montane and heath forest

Source: Bystriakova & Dransfield (2002) - INBAR

In addition, combined GIS analysis for each genera in Asia-Pacific and Africa shows a potential rattan growing area of more than 7,5 millions of km^2. More than 57% (4,365,000 km^2) of the total forest area containing rattans shows evidence of the presence of 1 to 5 species per km^2 while potential species richness of more than 46 species per km^2 was recorded for about 436,000 km^2 (less than 6% of the total). The maximum potential species richness, 92 species/ km^2, was recorded for an area of 8,400 km^2 in Sarawak, Malaysia. In Africa, the highest potential species richness (up to 15 species per km^2) was recorded in a rather small area in Cameroon.



Distribution density of rattan species richness classes
Source: Bystriakova & Dransfield (2002) - INBAR

Rattans in Africa are widespread throughout West and Central Africa and are a common component of the forest flora. *Laccosperma secundiflorum* and *Eremospatha macrocarpa*, which are the most commercial and common secies, have large ranges and occur in Western Central Africa with 3,195,390 km^2 and 4,259,660 km^2 respectively, whilst *Calamus deërratus* is particularly widely distributed in 8,049,170 km^2. In particular, *L. secundiflorum* grows in West Africa (Senegal, Ivory Coast, Ghana, Benin, W. Nigeria) and in West/central Africa (E. Nigeria, Cameroon, Congo, Gabon, E. Guinea); *E. macrocarpa* on the other hand share the same region of *L. secundiflorum* and is also present in D.R. Congo and Central African Republic; *Calamus deërratus* share the same *Laccosperma*'s West African countries and the Southern/Eastern Africa region (Zambia, Uganda, Kenya, Tanzania). In terms of diversity, the greatest concentration of rattan species, along with the highest levels of endemism, are found in the Guineo-Congolian forests of Central Africa. Eighteen of the 20 known African rattan species occur in Cameroon. The diversity of rattans in the Upper Guinea forests, by comparison, is somewhat poor with only seven species, none of which are endemic to that region (Sunderland, 2002).

According to Dransfield (2002), among the Asian countries genus *Calamus* is by far the predominant genera as it counts an average of 370-400 species distributed in India, Sri Lanka, China, south and east to Fiji, Vanatu and Eastern Australia; the second genus is *Daemonorops* with 115 species distributed in India, China to western-most New Guinea; *Kortalsia* shares 26 species in Indo-China and from Burma to New Guinea; while *Plectocomia* has 16 species in Himalayas and from south China to western Malaysia.

Approximately 90% of commercially valued rattan comes from wild palms. It occupies a position rather similar to ebony, greenheart or rosewood. It is a relatively rare plant, preferentially sought and extracted. As with other similar plants, the degree of extraction exceeds the local regenerative capacity and resources as well as biodiversity are lost.

5.2 TRADE

Among Non-Timber Forest Products rattan, whose name derives from the Malay “rotan”, a common name for climbing palms, is by far the most important plant in international trading. Not only is it widely diffused, as it grows in the tropical and equatorial parts of Asia and Africa, but it has tighten its destiny with peoples’ livelihoods and subsistence since immemorial time. The ancient Egypt, the Asian indigenous forests, Europe, in all these areas is given evidence of the large use of rattan and its interaction between daily use and cultural/religious aspects of peoples’ lives.

Gross figures show that domestic trade and subsistence use of rattan create benefits estimated at US$3 billion per annum and another US$4 billion are generated through global exports of the most known species. Worldwide, over 700 million people trade in or use rattan for a variety of purposes, however there are no quantitative estimates of the true economic/social value of rattan (Sastry, 2002).

UN COMTRADE analysis of world's raw rattan trade shows that the major exporting countries are Indonesia with 52% of the world share, followed by Singapore 28% and China 17%.

Indonesia used to dominate the world trade in raw rattan accounting for about 80 to 90 percent of the trade till a ban was imposed on export of raw rattan in 1979, followed by another ban on export of semi-processed rattan in 1988 whose aim was to encourage domestic manufacturing industry. Similar regulations have been followed by other Asian countries.

China, Singapore and USA have been the major importers in 2004, with 34%, 27% and 13% of the world share.

5.3 RATTAN PRODUCTS

Rattans are widely utilized. Forest dwellers or people living near the forest use almost all the species encountered, on the contrary, the rest of world population is in touch with just those few species utilized in the furniture industry. With their strength and flexibility rattans are an ideal material for binding, for weaving matting and fine basket-ware after splitting. Parts of the plant can be used for thatching in order to make temporary shelters with leaves, prevent bats from rosting with its spiny petioles or thieves from climbing fruit trees (Dransfield, 1992). The barbed climbing whips have been used to construct fish traps while the leaves are used as cigarette papers. In certain part of South-East Asia, rattan shoots are used by indigenous communities to prepare tasty baked foods and soups or sold in the markets as well as the fruits or certain species that have a good taste. A red resin locally called “dragon’s blood” (Fig.12), which is an exuded between fruits’ scales, is used as a medicine and as a colour. Some other curious utilizations regard the scraping of coconuts by using spiny sheats as in Nicobar Islands, their use as walking sticks, as a mat beater and even as a punishment tool for kids. Some indigenous people make extensive use of long canes in bridge construction. Rattan is also linked to religious rituals as Tharu people do in Nepal by using palm sticks in temple believing in their capability of warding off evil spirits. Buddha-bead or headwear, bracelet and waistband as most minority communities of Yunnan do (Kanglin, 2001). The art of weaving rattan is particularly well developed among peoples living near the forest in Southeast Asia, where an astonishing variety of carrying baskets can be found. As well as hats, sleeping mats, personal mats (“tikar burit”, which is worn around the waist and provides instant seating in the forest), tobacco pouches and other woven items. Some rattan artworks are indeed visible in museums in the form of carving and painted works (Fig.29). In craft and furniture making it is very common to mix different species in the same product in order to improve its mechanical resistance and for esthetic purposes.

5.4 THE NATURE OF THE TRADE

5.4.1 Stakeholders

Although some differences occur among countries and continents, as processes are carried out differently among stakeholders, it is possible to identify specific roles within the Production to Consumption System (Astana, 1998).

Gatherers. The function of the gatherers is to harvest and collect rattan from the forest to the trade outlet. In general the majority of those involved has little work opportunities and harvest mainly in forestland, while a small percentage is occupied in plantations or rattan gardens. Collection in the forest usually varies from a one-day trip to 7-10 days, depending on the people's involvement in rattan activities: daily basis is done mainly by farmers who are more agricultural oriented (rattan in this case is more a integration to the family income), while a week basis is for harvervesters who depend mainly on rattan income and concentrate their activities into the forest. Rattan gatherers in general obtain low incomes in comparison with other stakeholders. The collection usually is performed upon request from a village cooperative and/or intermediary (trader/concessionaire), who in general hold a license for extracting rattan. In more informal agreements the gatherer is more in touch with village artisans or semi-processors.

Traders. A trader carries out several functions: collects information on rattan species and quantities in the forest, applies for a license from local authorities, places orders with gatherers indicating the species, quantity and price, grades and weights the product collected and sells it to semi-processors. Among all the traders' activities, the most difficult one is the license application, as it is requested to specify either the harvest quantity and the period. The licensing involves the payment of a fee in advance, which is sometimes unaffordable for small scale/family enterprises. Trading tasks can also be carried out by local village cooperatives.

Semi-processors. Semi-processors operate between the trader/harvester and the manufacturer. Their tasks regard the selection and price making of the material, the payment of agreed prices and royalties, the treatment and storing of rattans, the further process of the products according with market demand, the selling and transportation of the product to the buyers. Semi-processors can be divided in two groups: those who do not have link with manufacturers and have to seek for a buyer, or those who work under firms who have manufacturer units. It is clear that the latter scheme is more performing as a semi-processor does not have problems in finding a buyer and can sell the excess of production in the market with no constraints.

Manufacturers. From semi-processors rattans are sold to manufacturers. It is important at this level to ascertain the quality of the product to be processed, as this task determines the final quality and price. In general rural firms/artisans are of a lower quality level while village/larger firms produce a more standardized output according to market demands. Depending on their link with third-party semi-processors (or their internal semi-processing unit) manufacturers can have a predominant position into the market with higher bargaining power, although dimension not always imply efficiency. Dwiprabowo (1998) confirms the predominant role of bigger manufacturer as a key factor for success not only for their role in the markets or for their easy accessibility to raw material, but also for their capital/financial facilities, which makes enterprises more active to cope with market requirements.

Sub-contractors. Sub-contractors have the role to up the production process of a bigger firm that is temporarily unable to fulfill all its contracts in the requested time. A sub-contractor is engaged through a formal contract to the firm. For its dimension a sub-contractor does not have a position to export its products alone. Many craft persons that run home-based industries work also with subcontracts. Some disadvantages however occur for both sides as the employing firm cannot withstand standardized qualitative specifications and the employed industry does not extend its incomes to any appreciable extent. Despite these drawbacks this form of cooperation allows little artisans to maintain alive their activities and traditions and at the same time boost local economy through small entrepreneurships.

Labourers. There are three types of labourers: 1) those who work for traders, 2) those who work for semi-processor firms, 3) those that work for manufacturing firms. Arguably the higher level in the production chain the better the wages.

5.4.2 The Processing Chain

The present part aims in describing the whole chain of rattan production. It starts with harvesting; whose methods vary slightly from place to place. In general the stem is cut at 0.3-2 m and then pulled. It could be a dangerous task not only for the spines but also for the debris that can fall from the above canopy. If the stem is entangled the harvesters climb the tree to free it, otherwise the uppermost part of it is left into the canopy. Depending on the zone the commonest tools used are: a hook-like knife put at the end of a bamboo, a sickle and a small bend, a fish-hook type grapple spliced to the end of a rope that is pulled down (Gnanaharan, 1993; Dransfield, 2002).

Primary Processing

- Deglazing. It is the phase in which the outer epidermis of the leaf sheaths and the silicified layer is removed (Fig.18, Fig.19). Methods vary: hit the sheathed and silicified cane with a plaited wood, twist the rattan by hand and rub it with fine sand, steel wool, coconuts husk, or by rubbing through wrapping the cane around tree trunk. Following the deglazing phase canes are washed in water (Fig.21), air-dried and graded for diameter, internodes distance and defects (Fig.22).
- Drying. It is essential for the reduction of moist and to prevent attacks from insects and fungi. The time varies from 1-2 to 3 weeks. Firstly the canes are left vertically to reduce the sap content and then left horizontal in sunny places (Fig.20). Some drying methods have been carried out with dryers, leading to a total moist reduction in 8 days using wood-waste feeded furnaces, and 3 days for charcoal ones.
- Fumigation. It is mainly done for large canes using SO_2 in a small chamber for a period of time of 24 hours or more. The aim is to bring the best light brown color are kill larvae and prevent fungal attacks.
- Bleaching. Sodium hypoclorite or peroxide are used in a 1% solution for 1 hour or more depending on the cane dimension.
- Oil curing. It is done to remove the waxy layer and gummy substances, to achieve an ivory color and for a preservative perspective. Boiling brings also to a further moist reduction (done after air-dry phase), which allows the cane to be stored safely. In general the liquid solution used is a mixture of coconut oil and naphtha or coconut oil, kerosene and aluminum sulphate. The boiling time varies depending to stem diameter: 5-10 to 30-40 minutes. Where these materials are not available indigenous methods are used instead: 1) boiling the canes in a mud solution for 24 hours and clean them; 2) rubber the cane with sand and treat it with linseed oil, heating for about a minute, and rub it with a cloth soaked in kerosene.

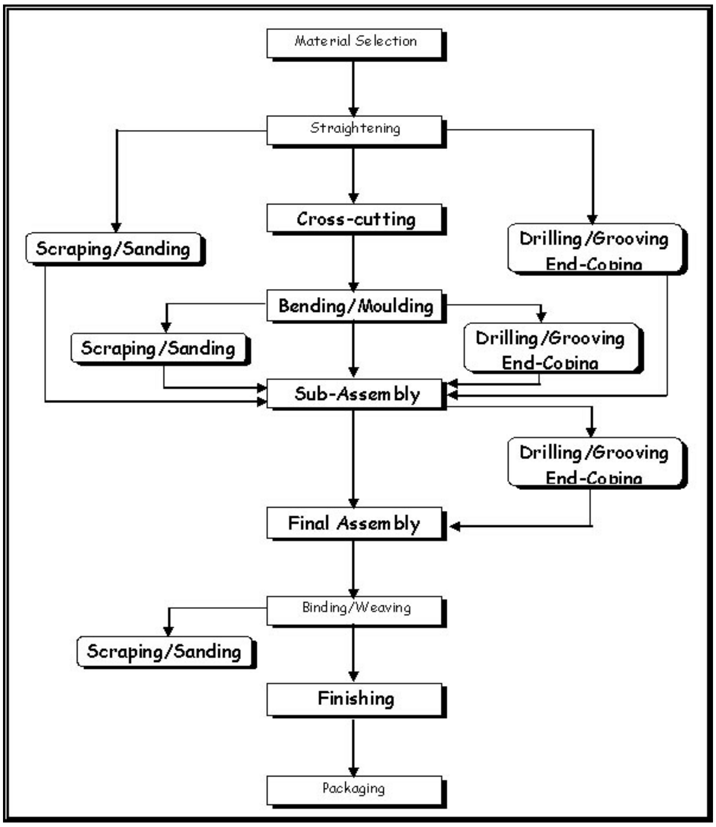
Secondary Processing

- Straightening. Dried poles are scraped and straightened using wooden jigs for small industry and straightening machine for bigger units. Canes are also graded (Fig.22) and crosscut using saws. Diameter affects the final destination: while large diameter poles are primarily used for furniture, small diameter ones are used for decorative purpose, weaving or, if very thin, peeled

- Steaming. Asian method for bending cane is based on steaming (in Africa blowtorches are used instead). The steam temperature is 100°C for 20-30 minutes (Fig. 25).
- Bending. Moulding benches, usually made of steel are used. Canes after heating with steam or blowtorch are immediately put into moulds and left for about one day (Fig. 26).
- Splitting. Whenever rattan is used for weaving or binding the outer hard layer has to be removed (Fig. 23). The core is then resplit into smaller sections. Thin canes are splitted into two halves with a knife, while larger ones are splitted into 4 strips plus the core. Skin and core are used for basketry, mat making, weaving.
- Dyeing. It is mostly done by indigenous people (i.e. coil) for specific local uses related to cultural and religious aspects of social life.
- Sanding and buffing. Is a step to make the poles as smooth as possible. Usually three profile sanders are used in a progressive fine finiture. Bent canes are sanded on buffing machines using pneumatic cylinders and brush heads.
- Dowelling. Dowel belongs to furniture sector as canes are drilled in accordance to their dimension.
- Coping or scribing. Is the commonest method to joint canes. It is performed with a chisel in order to scribe round surfaces to create a perfect fit.
- Drilling and grooving. They are performed during the final assembly when different spare parts are incorporated in the final structure. Grooving is done with a drilling machine.
- Jointing and binding. In the final assembly sub-assemblies are joined by using nails or screws. After jointing the binding process is carried out to strength the furniture (Fig. 27, Fig. 28).

Finishing

Final phase consists in dyeing or giving a final treatment to the product. Indigenous methods use natural materials such as tree barks or natural oils. Commercial methods consist in spraying in appropriate processing units (tunnel). Basically dyeing consists in two steps with a base coat and a final application.



Rattan processing chain Source: Ali (2002)

5.4.3 Production to Consumption Systems (PCS)

Production-to-consumption system is defined as the entire chain of activities that are carried from raw material extraction to the end users utilization. The system, which covers several stages of intermediate sales and processing not only does it include the technologies used to process the material, but also the different social, political and economic environment in which these processes operate.

In general within the PCS two major systems can be identified: harvest and transformation. While the first attains more to forest dwellers and countrymen the second is more centered in an urban level. The system, due its rural characteristic, is not well organized on a market level, as most of the trades at basic level imply a direct transaction between the harvesters and the artisan or well defined social networks. The system is structured in four activities: harvesting, transportation, processing and consumption.

Harvesting and transformation is in general undertaken almost exclusively by young men, as the collection work is very hard and quite dangerous. Women are more involved on a small-scale production of tools and basketry (Sunderland, 2004). Rattan collection is often a secondary job, which is undertaken either at the end of the day, when primary activities are almost carried out, or as an integrative income whenever some extra cash is needed. Occasional harvesters are principally farmers, miners, traders, tailors or mechanics. Due external conditions the supply in rattan varies accordingly to agricultural calendar, season, school calendar or great feasts, resulting in a wide price oscillation (Defo, 2004).

Africa

The rattan PCS is essentially a low input labour intensive system characterized by: the extraction of raw rattan from the state forest, community forests and natural reserves; the processing of the rattan at urban and rural levels into different products and their sale in domestic urban and rural markets. Processing of rattan both at rural and urban levels is largely on a small-scale basis and is done manually (Oteng-Amokao, 2001).

Although the great importance of cane and cane products in Equatorial Africa, no visible effort has been made to organize and develop a local trade in rattans nor to establish rattan nurseries and plantations or even evolve policies to rule conservation and management.

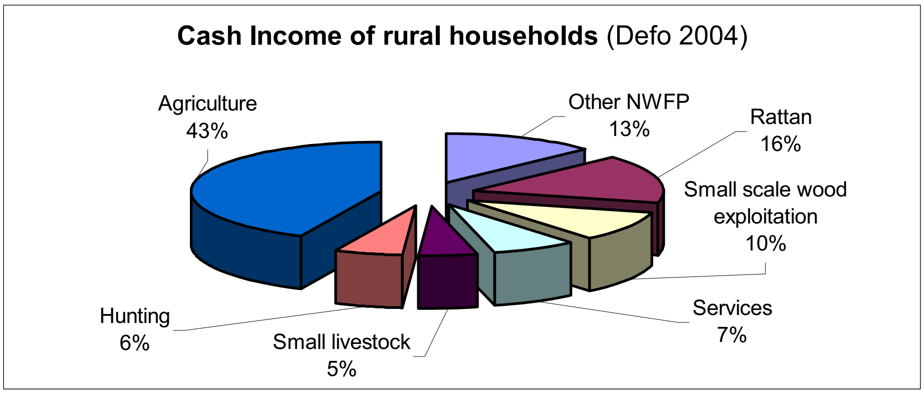
In general there are two areas of use: the small subsistence collector-processor who produce low quality products and reside mainly in villages, the urban-based processor who produce more sophisticated products. Both stakeholders are not able to expand significantly their activities because of socio economic factors such as weak financial position, the lack of required knowledge, expertise and organization, as well as low level of education (mostly primary and secondary). What is more being the rattan production system done more on a subsistence level there are no significant efforts to project plantations.

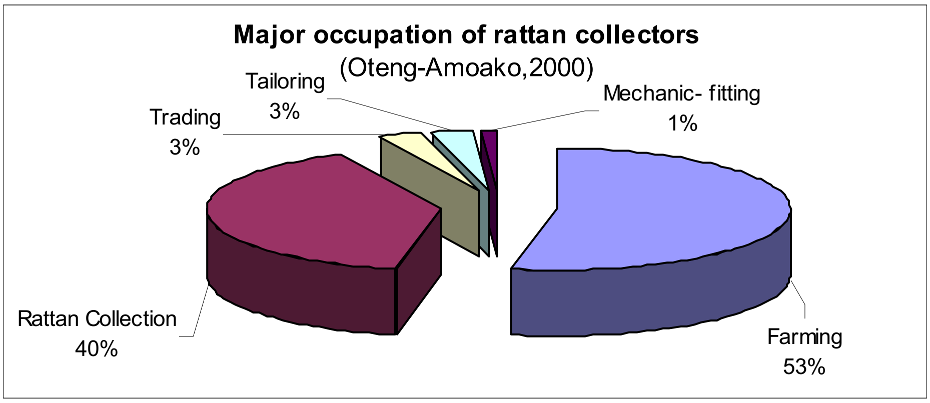
The high degree of labour is the reason for high young male employment rate in most of the intensive tasks. Harvesters in fact range from 20 to 40 years and are in majority males due to the needs in strength and stamina for harvesting, carrying canes and for the collecting trips, which take on average 5-7 days whenever it does not occur in the village proximities. Elder are usually devoted to higher skill levels such as designing activities and furniture making (assembly and finishing), while youngsters are involved in low-wage intensive apprenticeship, generally centered on the preparation of the material (cut, split, bending). Women and sometimes children are more involved in the production of light and small weaved cane products.

Age, gender and education of people involved in rattan PCS for some African countries

	Age	Sex %		Education %			
		Male	Female	No	Primary	Secondary	Tertiary or above
Uganda	29-38	93-100	0-7	-	31-27	54-69	2-15
Nigeria	-	88	12	42	24	29	4
Ghana	30-39	90	10	-	22	67	10
Cameroon	16-40	85	15	1.2	60	38.8	-

Source: Defo (2004), Olubanjo (2002), Oteng-Amoako (2001), Esegu (2000)





As far as the stakeholders are concerned Defo (2004) indicates in 16% and 42% the rattan cash income respectively for rural and producer households, while Oteng-Amokao (2000) figures 40%. What is clear is the strategy to differentiate the incomes and to consider rattans as a parallel income.
In Africa harvesters generally sell the stems directly in urban markets or to local village traders. Some levels of primary and secondary transformation occur in rural villages, though the products are of low qualitative level and final products are sold directly on roadside for local/rural customers. On a harvest level it is to say that no cultivation exists and, due over-exploitation, paysans are forced to widen their searches very far from their villages (more than 5 km) causing the price to grow for cost opportunity reasons. In Africa the tight and loyal relationship between the harvester and the artisan represents a solid social link, which is difficult to break. Artisans, who are city dwellers, produce a wide range of articles that are sold in local markets or exported, providing that the quality would be satisfactory. Handicrafts do not need large warehouses as production is more based on a continue supply of raw material from the forest (Sunderland, 2004). In general three are the main species utilized: *Laccosperma secundiflorum, Eremospatha macrocarpa, Calamus deeratus*, whose utilization is mainly for house/building, weaving and frames. The large diameter canes are preferred for its ease in being processed and its high remuneration.
In most village communities there is the paucity of formal harvesting regulations: indiscriminate and unsustainable harvesting regimes are usually the norm. Rattans are usually harvested in community and government forests. Forest reserves in general need periodical licenses to be harvested but allow local communities to collect certain products or receive royalties.

Permission for forest reserves is normally asked to the Forestry Department upon presentation of an application and a following verification of the availability by forest officers. While a license is issued a royalty has to be paid for a specific period of harvesting time. In the same time unofficial levies are very common and are paid to officials in form of small cash fees or drink. Regarding community forest off-reserves or fallow farmlands regulation is usually restricted to the payment of commissions by non-natives to village chiefs (US$ 1.4-2.5) while natives do not have to pay anything (Oteng-Amoako, 2000).

In Africa rattan is thus an open access resource: neither customary law nor land resource management rule the forest. Whoever, external to the community, can access the forest, providing that a small fee is given. Such a type of situation is the worst menace to forest sustainability as nobody cares to public territories. To sum up where State holds the property of land, only local dwellers are allowed to continue their traditional usage rights, while whoever would harvest NTFP should apply for a permit and pay the appropriate tax, plus other formal and informal levies (Defo, 2004).

Collectors and natives are skilled to prospecting for mature canes, though there are still some gaps in knowledge on safe collection modes, on preservation and processing techniques. Furthermore most of the communities are not aware of the chances of raising rattan, a possibility which is mined as well by stakeholders' positive attitude in inexhaustible stocks, and by present land tenure systems or land scarcity (Olubanjo, 2002). The limit between collection and following processing is quite indefinite, as infinite variations in output exist among collectors. However, a grading is always performed to improve the quality of canes since their collection on field, basically done on a shape and hardness basis (Oteng-Amoako, 2000).

As for processing rural stakeholders are more involved in production of carriers and storage baskets, fish traps, mats, binding ropes and furniture for rural markets as well as building and mending material for houses and roofs. Urban processors produce mainly furniture, baskets for urban markets. In general rattan processing is a major occupation for the majority of the processors who are often traders and self-financed as well. The best way to learn and gain skills is through apprenticeship or formal education.

In Africa the degree of rattan transformation is quite rudimentary as it utilizes basic tools. On a harvest level it means that:

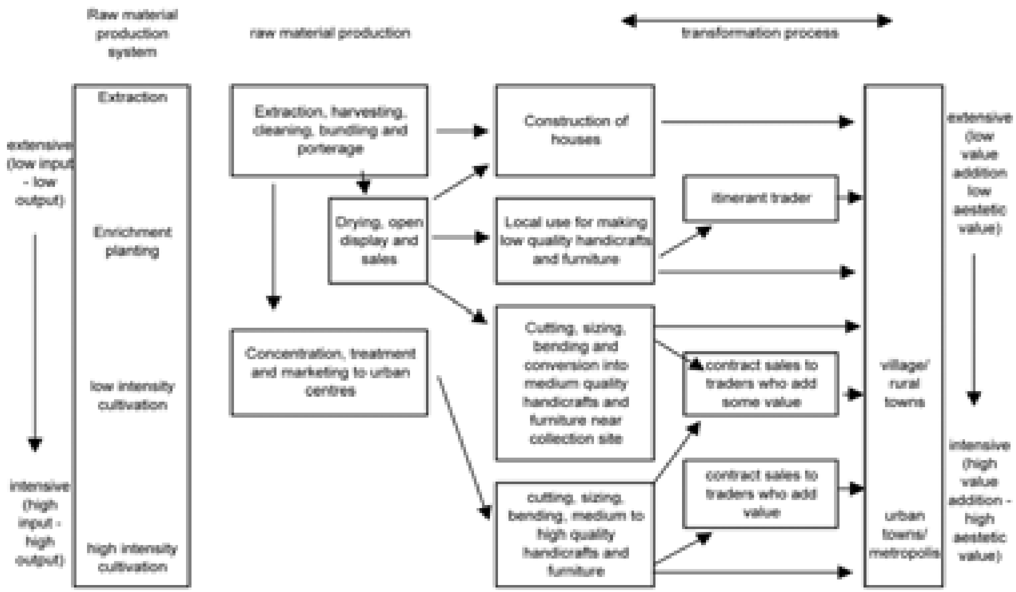
- The extraction output is very low, it averages 28 - 44% of the total utilizable cane length, as entangled stems are left into the canopy
- In order to compensate the low yield, over-harvesting is a common practice that causes either reduction in sexual propagation of plants and genetic variability,
- By using basic knives to remove the spiny sheaths some damages on canes' surface occur, spoiling the whole cane.

- As for secondary transformation cane bending is made with blowtorches instead of steam. Direct flames are thus the cause of many black scorches, lowering the quality of the final product.

Interestingly the rattan production is highly profitable, as it does not require high capital investments and working capital: the cost of equipments in fact do not exceed 70 - 90 US$.

On average the income varies from 20 to 200 US$/month and can approximately cover 40% of the global household gains.

Rattan Production to Consumption System in Southern Nigeria



Source: Olubanjo (2002)

Among the constraints of rattan collection a big percentage regards problems with licenses. Lack of money and high costs discourages in fact the majority of collectors from acquiring permits, leaving them to officers' harassment. Accident and injuries represent a major negative factor for harvesters who should cope with labour intensive tasks as well, due to difficulties in reaching rattan areas and lack or roads. As for the processing sector the absence of rattan plantations and the overexploitation of resources make supply irregular, especially during rainy season when collectors divert their labour into farming and other economic ventures. Other problems regard labour intensive processing methods and improper shelter for raw material and inadequate know-how, which cause quality deterioration. The lack of a proper standardization does not guarantee proper improvement in quality and price control limiting earnings possibilities from good semi processed or final products. Financial constrains determine in addition retards in processing material due to lack of inputs and workforce resulting in unstable output quantities. Trading is thus enormously affected by the seasonality of the supplies and the lack of adequate shelters and/or poor quality of production.

Chain improvement require thus adjustments in quality as well as well organized marketing systems with standardized products and prices. A better-organized production system could help in making licensing more affordable and flexible for singles, which would encourage collectors to honour their tax obligations and avoid illegal bribes by officers.

Constraints and Recommendations for the development of African rattan sector

Constraints	Recommendations
Scarcity of raw material (rattan)	Form artisan unions (price fixing)
Competition between artisans (lack of custom)	Greater access to raw material
Lack of technology for processing & transformation (labour intensive)	Provision of machinery for processing and transformation
Lack of capital	Access to credit
Open workshops and storage (adversely affected by weather)	Exhibition / promotion of rattan products
High costs of inputs (nails, plywood etc)	Central enclosed workshops
High taxation (formal and informal) - Harassment	Training in improved artisan techniques for better quality products
Rattan considered "poor man's furniture"	Increased markets
Transport of finished products to market	State support in sector
Poor quality of cane	Develop export markets
Dangers of cutting cane in forest	Lower prices for inputs (subsidies)
Lack of artisanal union/rattan association	Cultivation of rattan
Low formal education and technical assistance	Delocalisation of govern
Lack of standardisation and grading	Employment increasing in the informal sector-transfer from formal sector if in crisis
Poor state of National Economy	End of harassment by police and forestry officials

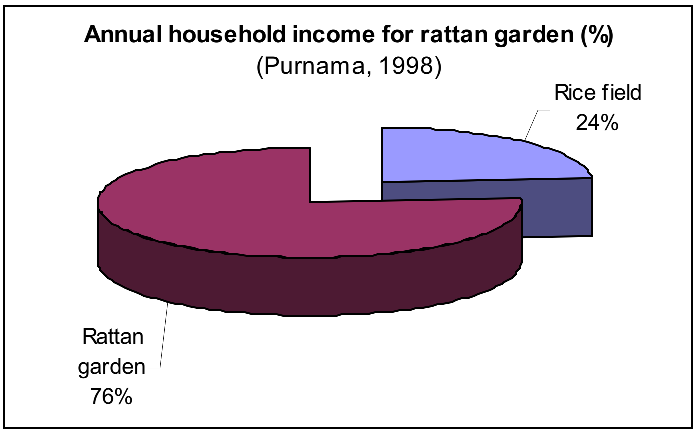
Source: Sunderland & Defo (2000) – modified

Asia

Asian NTFPs are generally affected by intense logging. Indigenous population, usually hunters and gatherers, have progressively settled down adopting the shifting cultivation and, more recently, joined government programs to convert land into crops. NTFPs are, however, one of the biggest opportunities to raise family incomes, as they share, in some South-East Asia countries (i.e. Philippines), the 60% of the total. In most parts of South-East Asia rattan represents a good way to diversify production (it is commonly believed to be a sort of bank saving), and a recognized way to identify land property, firstly because natural capital is left growing till a major cash shortage force forest dwellers to harvest, and secondly because the presence of an anthropic flora is recognized as a land ownership (Pambudhi, 2004).

In Indonesian Kalimantan rattan collection is undertaken mostly by local people who have limited work opportunities. In general raw material comes from two sources: plantations and natural forests. While continuous exploitation without regeneration has resulted in a decrease of rattan in natural forests, which has forced collectors to go deeper into forests for harvestable canes and has lead to a decrease in productivity, on the other side rattan plantations are more sustainable and guarantee a steadier income. Development of rattan gardens and rice fields are conducted simultaneously. There are neither external labour costs, since family members are employed for the purpose, nor rattan seed costs as they are obtained from other gardens. In

East Kalimantan the average farm extension is 5.6 ha with 4.1 ha of rattan and 1.5 of rice, which guarantee almost 500 kg/ha/year of rice and 730-1300 kg/ha/year of rattan. In general harvesting is followed by a basic processing (W&S - washing and sulfuring) carried out by traders and a second phase that involves the processing of treated rattan into final products, which is done mostly by industry (Purnama, 1998).

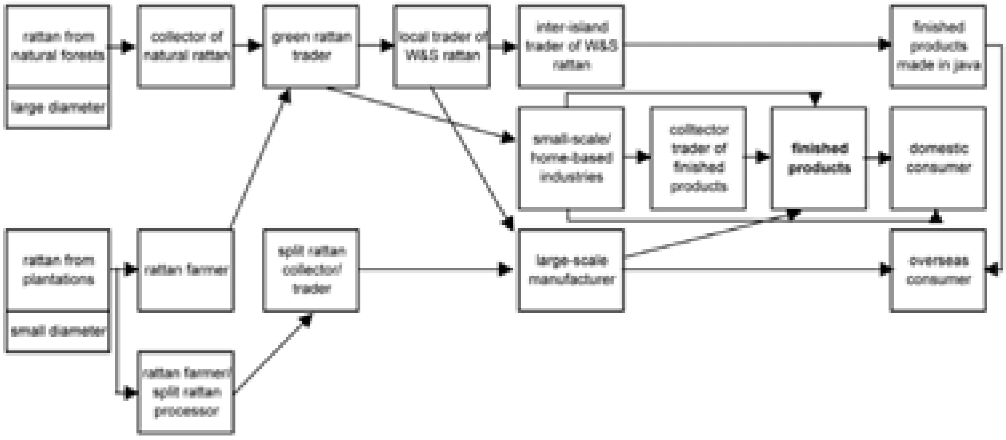


The property status of rattan within a village forest territory shifts from “open access” to common use by a harvest group depending on the village. Specific management rules determine the grade of harvesting for clump in order to maintain plants’ productivity (usually 10-20% of the total stems). Plantations belong to the planter who originally claimed the land by clearing the forest for cultivation or by inheriting the land. As for natural forest there is uncertainty about legal property status, as the government claim for ownership. However, despite indigenous people legal right to collect minor forest products within timber concessions, villagers have at times been denied to entry in those areas under the menace of having their harvested rattan confiscated (Peluso 1991).

Most of the Indonesian industries are home-based and involve the use of basic tools and a lot of manual labour. Gender participation in Kalimantan is affected by the ethnic characteristics of the population: Chinese-origin and Muslim women are not allowed to carry out labour intensive tasks but trading jobs instead, while Dayak women are used to share with males the different harvesting and processing tasks.

In general a form of credit determines a precise trade agreement among villagers and local merchants or boat holders. People are in fact allowed to purchase goods and food with no money providing that they pay back the total due in rattan bundles at the fixed traders’ price. As a consequence only a part of the total harvested belongs to the collector or farmer, which is all that remain from the payback. Such an arrangement constrains more than half of rattan stakeholders. In the production chain the weakest ring belongs thus to harvester, who are not tenant and range their incomes due to work market conditions: where non competition occurs an agreement between farmer and harvester guarantee two third of the whole quantity to the latter (*bagi tiga*), while in areas with high unemployment only 50% of the total harvested quantity could be claimed (*bagi dua*) (Weinstock, 1983).

Linkages in the rattan Production to consumption system in East and South Kalimantan



Source: Purnama (1998)

In general three types of products are supplied: handicraft, carpets and furniture. It is to say that rattan sector does not allow large margins of incomes, as farmers/gatherers are mostly price takers: low political corporate power and low education level determines reduced decision making possibilities and weaken their contractual power. Rattan production is also affected by a high seasonality, as farmers tend to harvest canes during slack periods in agricultural season (Peluso, 1991). Furthermore a reduction in the cultivation extension has been noted due to a conversion to oil palm plantations, which guarantee higher incomes per hectares and reduced period of time for the first harvest (4 years instead of 8). Improvement in the Rattan PCS should lead stakeholders to increase their decision making possibilities through a better access to market information, an increase in technologies, design and standardization finalized to final product optimization. What is more a reduction in chain length through the creation of cooperatives for harvesting and processing green material in the nearby forest could help small holders to empower their position against dominant stakeholders (Purnama, 1998). Some problems are in the agenda of local authorities: the impact of migrants who disregard sustainable management rules, the lack of credit to set up local entrepreneurships instead of local “credit contracts”, and a better allocation of rights to forest rattan collection from local authorities. Property right should be properly allocated allowing indigenous people priority to forest territories and claims to non-wood forest products collection in already leased timber areas. Enforcement of the latter right implies strengthen local populations' political power and enforce their own rights when faced with uncooperative timber company. Logging companies’ responsibilities should extend to the planting of rattan, or at least the sponsoring of rattan planting on their concession lands. A more attentive forest policy should also: 1) avoid outright destruction of rattan in the course of logging activities (torn down rattan as a consequence of extra-logging is the major cause of income and reseeding capacity decline for which loggers are not held responsible), 2) the misuse of concession rights by timber companies that cut more than the entire allowable amount of wood in the very first years of a multi-lustrum lease, leaving the province without pretence of reforestation.

Rattan gardens in Borneo are, however, facing major threats by government policies whose aim in empowering the cash crop sector has weakened their presence in favour of oil palm and rubber. These different plantations are in fact seen more profitable both in cash and in time. Rattan has been mined by the consequences of forest fires in the 90's as well (whose responsibilities should also be debited to forest clearings for cash crops), which has definitely disrupted the sense of security of local population (Pambudhi, 2004).

Age, gender and education of people involved in rattan harvesting

	Age	Sex %		Education %			
		Male	Female	No	Primary	Secondary	Tertiary or above
East South Kalimantan	28	mainly	-	5-6 years of schooling			
Philippines	38	51	22	5 years of schooling			

Source: Pabuayon (1998), Purnama (1998)

In the Philippines old growth forests are usually leased in concession to private individuals. The rattan concessionaire hires men and women to gather the products from the forest giving in advance credit or goods for their livelihood. Gatherers commonly sign this particular form of "credit" contract, as they have neither money to spend for the journey to the forests nor collecting tools. Gatherers are given cash in advance for food and other provisions needed during forest work, in addition they are supervised in order to deliver to the concessionaire the whole amount of rattan (Palis, 2004). Although this kind of credit puts concessionaires and traders in a position of advantage, local collectors earn 25% of their total income with rattan, which is 60% of their cash income. Harvesting is normally followed by primary processing, carried out in the cutting areas for the initial scraping and drying, and terminates in the concessionaire warehouse for the shipment towards main cities. License agreements are usually issued by local authorities that recognize to local minorities their right to utilize resources in their areas. In general government releases extraction concessions providing that an annual allowable cut limit is respected by the applicant.

The general market channels for rattan are as follows:

For poles/splits: Gatherer → Permittee → Trader → Semi-processor/retailer → Manufacturer
For furniture/handicrafts: Manufacturer → Trader → Local customer/Importer

On average, gatherers' share of product value ranges between 5-21%, manufacturer-exporter about 64% and the rest to traders belongs to traders. The second stage of the processing chain is mostly done by processors who buy raw materials from provincial/city traders. Gatherers within the locality of the concession area may sell raw materials directly to local manufacturers, who in turn sell to local consumers. Some rattans are also used by gatherers themselves as tying materials and to make baskets for household use. Local markets are, however, of low quality (Pabuayon, 1998).

Percentage of total revenue among stakeholders

	Philippines	Indonesia
Gatherer	5-11	5
Raw material trader	1-8	9.7
Semi-processor	-	22
Manufacturer-Exporter	63.8	64

Source: Astana (1998), Pabuayon (1998)

As far as the forestry policy is concerned, special rules regulate rattan harvesting, and special permits and priority are given to local communities. In the Philippines harvests in forest area are allowed upon a 3-5-year license, which determines the quantities of products to gather (Palis, 2004). Although taxation and local rules differ slightly in Asian countries, the need of a license has been causing major problems to singles, as it is quite impossible to pay local authorities before collection. This situation is thus favoring big companies, though more recent rules are focusing on local population through Community Forest Management and joint partnerships.

Overexploitation is the main problem that is affecting South-East Asia in the last decades. Some bans and/or severe taxations have tried to reduce the raw export quantities aiming at diverting production towards local processing/manufacturing industries. The impact of these bans, however are leading to uncertain outcomes. Local production has in fact been damaged by an initial oversupply of internal raw material with decreasing prices, which has pushed many farmers to different land utilizations. As for manufacturers companies the reduction of raw material availability in the international markets has pushed towards collapse several industries (lampit – rattan mat), due to diversions of international markets to similar commodities (splitted bamboo, raphia) (Pambudhi, 2004).

Constraints and Recommendations for the development of Asian rattan sector

Constraints	Recommendations
unstable export price	growth of medium and large scale firms
absence of direct export outlets	fair price mechanism
prices influenced by external broker	price stabilization through government policies
lack of rattan	Rattan plantation, enrichment planting, r. gardens
lack of support facilities for rattan trade	investments in infrastructures
low political7corporate power	creation/strenghten local associations/cooperatives to
low earnings for gatherers	empower cutters
High taxation (licence)	access to credit, posticipation of tax revenues
lack of credit	improvement in gatherers gains in order to maintain constant supplies
unstable export price	direct export outlets for price making
market demand changes	market intelligence
lack of access to market for off-license stakeholders	changes in licensing regulamentation to boost local stakeholders
non-competitiveness of wage rates with other jobs	increment in plantation as a way o improve incomes
low profitability of home-based manufacturers	improvement of access to raw material by home based manufacturers
internal trade restriction harm national production	reduction of internal trade limits
low level in rattan intercrops management regime	further research on an optimal management regime
need for basic inventory data	reform in the resource ownership
improvement in resource sustainably	long term land concession to local people
lack of technology	technical assitance
limited competition among buyers	Reduce export taxes/restrictions
low supply of good canes	selection of improved planting material
lack of quality	Improved grading standards

Source: Dwiprabowo (1998), Astana (1998), Pabuayon (1998), Belcher (1999)

PCs	Constraints	Causes	Data/findings/ Indicators	Opportunities	Interventions	Output
Collection	No proper preservation or grading of rattan after harvesting	Lack of knowledge about chemicals	Low price of rattan due to poor quality of rattan prone to fungal and insect damage	Technical know-how from organizations and producers	Provision of grading rules	Higher efficiency and higher price of harvested rattan offering income increase for collectors
	Depleting rattan resource	Improper harvesting Poor management Over exploitation	Increased transport costs Irregular supply Occasional shortage of stock	Technical knowledge from forestry institutions Desire of collectors to cultivate and manage Village unit committees and NGOs	Sustainable harvesting Nursery establishment Enrichment planting Plantation development	Sustainable rattan resource base
	Lack of an FD policy for a sustainable rattan resource base	Illegal harvesting and inflexible permit system	Evasion and extortion and confiscation of products		More realistic policy working towards a win-win scenario for rattan	A policy that focus on a sustainable management of the resource base
	Rudimentary harvesting techniques	Lack of suitable harvesting equipment and lack of expertise	Accidents and injuries and high wastage percentage	Availability of manpower/skills	Improve harvesting techniques and equipment	Improved harvesting efficiency, Accidents and injuries minimized
Processing	Poor processing methods	Inadequate technical know-how and working capital Lack of suitable equipment	Low productivity Accidents and injuries, poor quality and low quantity of raw material	Technical know-how from public and private institutions Availability of manpower/skills	Better processing tools Training/technology transfer	Improved productivity and quality of products
	Ineffective rattan Association	Poor organization and mobilization	Few members, In action of executive members	Existing association	Empowerment to mobilise active association	Active and effective association formed
	No investment capital available	Inadequate business capital	Problems with processing, storage, quality Resulting in fungal attacks Lack of machines and equipment	Existing associations Rural banks Selected NGOs National Board for Small Scale Industries	Establishment of an investment sector for small rattan manufacturers	Loans for the purchase of equipment and for construction of processing and storage facilities
	Low quality of processed products	No standards for which rattan to use Poor finishing methods	No standard products Defects in the products	Existence of standards used by the leading business companies	Official standards and body that certificates	Higher selling price benefit manufacturers Higher quality benefit client
	Inputs represent a high costs for manufacturers	Shortage of liquid assets	Not enough use of chemicals, bad quality of other inputs No money to pay extra workers when needed		Linking consumers' demand with processing capacity to shorten storage Higher selling prices Acquisition and usage of common facilities	Enough working capital available to manufacture high quality products
	Inadequate technical know-how	Lack of proper preservation and finishing methods and use of modern machinery	Poor quality raw material, i.e. insect and fungi attack infestation and finished products Machines not used in processing	Proper preservation methods available Use of modern machinery Existing educational level of the craftsmen	Technology transfer to Improve preservation and finishing methods for better quality	Improved technical know-how Improved quality of products
Marketing	Irregular demand and low selling price	Lack of marketing strategy - product quality, price, place and promotion	Too long storage of finished products	Existing marketing outlets Export Promotion Council	Improve marketing strategy	Constant demand enabling investments and business strategies
	Improper shelter for marketing products No `market place' where craftsmen and buyers can meet	Inadequate working capital Primary stakeholders not well organized	Deterioration of products being sold Selling along the road	Some form of association for primary stakeholders exist Rural banks	Establishment of display or marketing centres	Shelter for display and sale of products
	Low appreciation of rattan furniture	Consumers' preference for wood and plastic items	Rattan mainly for basketry		Advertising and promotion of rattan products	Development of a rattan furniture industry with major spin-offs for other rattan products

Rattan PCS Logical Framework Source: Oteng-Amoako (2001) - modified

CHAPTER 6

6.1 ECONOMIC EVALUATION

Many consider the extraction of NTFP to be economically interesting for its competitiveness with timber extraction and for its ecologically sound management (Van Valkenburg, 1997). Several studies have demonstrated that Net Present Value (NPV) for non-timber products is higher than those of timber or agriculture. Manipulation of forest can lead to higher yields, as in the case of selective promotion of specific species in primary forest through canopy clearing and/or using forest gaps or species plantation in logged over forests. In addition enrichment planting can increase the yield of fallow lands with a wide variety of species such as rubber, oil palm, rattan, and raise habitat's biodiversity. The economic value of non-timber products needs to be compared with other types of land systems in order to evaluate their economic potential, however in many cases only the gross revenue could be calculated because other inputs such as chemicals, labour, are not known.

Several studies on different land system in the South-East Asia are summarized in the following records (see table):

- Timber in a 35-year rotation. The Gross Revenue of a first felling in a dipterocarp forest of 70 m^3 is about 7667 US$/ha and a Net Value (Revenue - cost) of US$ 4517/ha. However, by considering the rotation the Net Annual Income is a mere 17 US$/ha (r=10%).
- A following timber extraction with a rotation of 35 years should take into account the damages of the previous harvest and the lower value of timber, thus resulting in a 8 US$/ha per year (r=10%). An optimistic discount rate of 5% would surge the Net Annual Income to 25 US$.
- Rattan plantation in alluvial areas with *C. trachycoleus*. This cultivation generated an average Net Annual Income of US$ 224/ha in 1987 at a discount rate of 10%. It results by far the most competitive land use option despite a tumble in farm gate price of 30-75% due international export ban of raw rattan ruled by Asian countries. Forest cover is maintained and the species result indigenous for the area.
- Rattan plantation under a 30-year rotation and first harvest at 10 years. It generates an average Net Annual Income of US$ 7-15/ha/year. The ecological impact is similar to a dryland rice farming.
- Rattan collected from natural forest would result in Gross Revenue of US$ 5/ha/year. Although the low revenue this land use has minimum impact on habitat and has a high return on labour spent.

- Traditional forest/home garden consist of a large number of different aged species and provide a Net Annual Income of US$ 50-150/ha (r=10%). Income is generated on harvest of fruit. The ecological impact is low due high diversity both in species and in age.
- Traditional mixed rubber garden would provide an average of 150-350 kg/ha of dried sheet rubber representing a Gross Annual Income of US$ 75-175/ha. Rubber, however, requires a large amount of work and chemical inputs to increase latex quality. High labour inputs make this cultivation not compatible with indigenous life. At present this species is gaining importance as timber and appropriate selection is carried to combine rubber and higher quality
- Illipe is a nut exported worldwide. In certain region of Malaysia it is reported that local communities had earned 600-2700 US$. The trees start fruiting at 20 years and an average of 100 trees/ha can yield 26 t of fruit for a total amount of 18000 US$ and a Net Annual income of 38 US$/ha (r=10%). In addition with a basal area of 12-26m^2/ha in a 40-50 years rotation the prediction for timber could be better than primary forest.
- Improved home gardens are managed as a two-layer system with an average of 100 trees/ha of large canopy fruit trees (illipe, *Artocarpus integer*, *Duio zibethinus*) and another 100 trees/ha of shade tolerant plants. Shade tolerant fruit trees start producing in 5 years; after 10 years the canopy will be totally overtopped by tall trees and cempedak and duriam start producing. In the end at 20 years illipe harvest starts. The Net Annual Income is US$ 28-127 after 20 years and 78-148 after 60 years.

As far as South America is concerned Peters (1989) calculates Net Annual Revenue by summing the value of most of the non-wood products present on an hectare of forest and rubber products. While the net income for the former is 400 $ (deducing a 30% of costs), rubber accounts an average of 22 $/year (deducing a 30% in costs). The NPV, calculated with a discount rate of 5% is reduced by 25% in order to maintain plant sustainability. Timber on the other hand is calculated with a maximum sustainable harvest of 30 m^3 in a 20-year rotation, which figures a NPV of 490 $.

Grimes (1994) in her figures takes into account a reduction of the harvestable quantities in order to maintain sustainability. The calculations consider a discount rate of 5% and range between a NPV of 1257$ to 2939$ for NTFP versus 188 $ for a 40-year rotation. Furthermore Grimes gives some estimates for different farming uses of forestland. Starting from cattle ranching gross revenues from which gross revenue costs are subtracted (veterinary, pasture maintenance costs) it results an annual net revenue of 2.9 $/ha. Alternatively the presence of a cow (given a carrying capacity of 1 cow for 2 ha), which gives 400 pounds of meat at 1 $ during 3 years, determines a net revenue of 40$ every 3 years (assuming the gross revenue costs ranging to 80%).

Comparison of the economic aspects of various forest use systems with trees as a major structural component. Numbers in US$

	Rotation (years)	NPV*	NPV (r = 5%)	NPV (r = 10%)	Net annual income/ha r=5%#	Net annual income/ha r=10%#	Env. costs	References and comments
South East Asia – Kalimantan								
Timber 1st harvest		4250	819	160	(50)	(17)	+++	Lammens ITCI mixed dipterocarp forest, excluding overhead
Timber 2nd harvest	35	2116	408	80	(25)	(8)	+++	De Kock (unpublished)
Multiple extraction forestry		460	44	42	(46)	(46)	+	Van Valkenburg, Primary forest Apo Kayan (extraction costs 30%)
Rattan plantation periodically flooded		500				224	++	Godoy & Tan (1991)
Rattan plantation Barong Tongkok	30		290-460	65-140	(19-30)	(7-15)	+	Priasukmana (1989)
Traditional home garden		500-1500	48143	45-35	(50-150)	(50-149)	+	Sardjono (1990). Excluding establishment costs
Traditional mixed rubber garden					75-150**		++	Dove (1993)
Illipe plantation	60		2373	480	(125)	(48)	+	Van Valkenburg, Establishment costs as in Priasukmana (1989), harvesting costs 30%
Improved home garden	60						+	Van Valkenburg, Establishment costs twice as in Priasukmana (1989), harvesting costs 30%
After 20 years			667-2077	241-1081	(54-167)	(28-127)		
After 60 years			3159-3857	778-1473	(167-204)	(78-148)		
South America								
Ecuador timber	40	188					+++	Grimes *et al.* (1994)
Ecuador NTFP		1257-2939			63-143		+	Grimes *et al.* (1994)
Peru timber		490					+++	Peters *et al.* (1989)
Peru NTFP		6330		380	422		+	Peters *et al.* (1989)

*For annual yielding systems: Net Present Value = Net Annual Value/ r (r= real discount rate; South East Asia r = 10%. for South America r = 5%).
*For non-annual yielding systems: Net Present Value= Net Value/(1 – e^{-rt}) (for South East Asia r = 10%, for South America r = 5%; t =rotation time in years).
#In parentheses: Net Annual Income = NPV * CRF (Capital Recovery Factor).
**Gross annual income/hectare
NPV = Σ $(R-C)_t$ $(1/1+r)^t$. (R: revenue: C: costs: r: real discount rate: t: year of rotation).

Matius (2004) in his studies on rattan gardens evaluates the incidence of timber production in different land systems. He estimates that Dipterocarp logs, with a diameter of 50 cm and more, range from \$ 14.31 to \$ 15.81 per m^3, while Borneo ironwood costs € 14.31 per m^3. In logs of mixed non dipterocarp species the cost of timber with a diameter of 50 cm and more is \$ 12.05 per m^3 and \$ 4.51 per m^3 for small sized logs (Ø < 50 cm). Mixed garden should then take into account only a share of timber with higher potential value.

As for rattan the harvested rattan potential per harvesting period (3 years) ranges from 2000 to 4000 kg for *Calamus caesius* (wet), 2,000 to 5,000 kg for *Calamus trachycoleus* (wet) and a year value of 70.28 – 140.56 \$/year for *C. caesius* and 50.20 – 125.50 \$/year for *C. trachycoleus.*

Estimated Potential yield ranges of two species of rattan per ha per harvesting period (3 years)

Species	Potential yield ranges per ha for wet rattan (kg)*	Price per kg (\$)	Value ranges per year (\$/ha)	Average Potential values (\$/ha)
C. caesius	2000-4000	0.1	70.27-140.5	105.43
C. trachyloeus	2000-5000	0.075	50.2-125.5	87.85

Yields and prices are based on interviews (€/\$ rate of 1.25)

Source: Matius (2004) - modified

In alluvial Rattan garden the potential timber value ranges from 266.26 \$/ha in 50-year old plots with moderate treatment to 2356.03 \$/ha in 80-year old plots (less treatment) resulting in an average of 848.65 \$/ha. On the other side timber in terrestrial rattan gardens ranges from 180.73 \$/ha in 15-year old plots to 1711.90 \$/ha in 60-year old plots and an average of 873.63 \$/ha. (A more detailed table is in Annex III)

Potential Value of timber + rattan within rattan gardens in Muara Bomboy calculated on the base of local prices in West Kutai

Site	Timber average PV/ha/year (\$)	Rattan average PV/ha/year (\$)	Total Timber + Rattan PV/ha/year (\$)
Alluvial	**12.98**	**87.85**	**100.84**
Terrestrial	**18.4**	**105.43**	**123.83**

Source: Matius (2004) - modified

Assuming the same Matius's (2004) prices for rattan, which are 0.1 $/kg and 0.075 $/kg per wet cane (*C. caesius* and *C. trachycoleus* respectively) and accepting his converting rate of 50% between wet/dry stems, it could be possible to cross-check Wan Razali's models for *C. caesius* and *C. trachycoleus* to standardized, current farm gate prices (Price from: West Kutai Regency Forestry Office 2002 – Matius, 2004).

C. caesius and _C. trachycoleus_ Estimated Yield and Gross Income per hectare (9th year, 12th onward)

	C. caesius		***C. trachycoleus***	
	1st harvest (year 9)	**4th harvest onward (year 12 →)**	**1st harvest (year 9)**	**4th harvest onward (year 12 →)**
Total cane length - m/ha	17500	52500	16000	80000
Total weight of wet canes - kg/ha/year	972	2916	762	3810
Total market value /metric tonne ($)	**97.2**	**291.6**	**57.15**	**285.75**

Source: Wan Razali (1992)

Wan Razali's estimations result superior in terms of gross revenue per year/ha to those of Matius due to superior yields. However, similar figures are confirmed by Godoy (1990), who estimates a net return in 224 $/ha/year (gross 313 $) for *C. trachicoleus* for an average yield of 3.5 mt/year from 12-14 year onward.

As far as *Calamus manan (*Rotan Manau) is concerned prices refer to diameter as rattan is sold in 3m sticks. Some quotations have been taken from FAO (Fui, 1995) for 5 diameter classes and two quality levels (higher – 1/3; lower 4/5).

C. manan quotations for sticks of different diameter

	Processed US$/stick		**Unprocessed US$/stick**	
Quality Grades →	1/3	4/5	1/3	4/5
Diameter (mm)				
18-24	0.6	0.3	-	-
25-29	1	0.6	-	0.3
30-34	1.7	1.3	-	1
35	2.2	1.6	-	1.4

Data Source: Fui (1995) - FAO

By adding these numbers to Wan Razali's yield estimation and considering the same price of 2.2 US$/stick for all the sticks exceeding 35 mm in diameter, it is possible to have *Calamus manan* estimated gross income at 12th and 15th year harvests.

C. manan Estimated Gross Income at 12th year harvest

Diameter (mm)	Total (per ha)	Price/ stick	Total revenue ($)
No. of stick - 18-24	192	0.6	115.20
No. of stick - 25-29	384	1	384.00
No. of stick - 30-34	192	1.7	326.40
No. of stick - 35-39	752	2.2	1654.40
No. of stick - 40 & above	92	2.2	202.40

Odd length 25-29			
30-34			
35-39	156	0.73	113.26
40 & above	36	0.73	26.14
	revenue at year 12		**2821.79**

Source: Wan Razali (1992) - modified

C. manan Estimated Gross Income at 15th year harvest

Diameter (mm)	Total (per ha)	Price/ stick	Total revenue ($)
No. of stick - 18-24	478	0.6	286.80
No. of stick - 25-29	904	1	904.00
No. of stick - 30-34	426	1.7	724.20
No. of stick - 35-39	1428	2.2	3141.60
No. of stick - 40 & above	366	2.2	805.20

Odd length 25-29	52	0.33	17.16
30-34	195	0.56	109.40
35-39	156	0.73	113.26
40 & above	387	0.73	280.96
	revenue at year 15		**6382.57**

Source: Wan Razali (1992) - modified

Synoptic readings between different land systems can highline interesting revenues for Asian areas. Rattan appears profitable both for high gross incomes and for reduced production costs. Although numbers are not present in the table Godoy (1991) mentions another study of him in which he empathizes rattan plantation as more profitable than coconuts hybrid monocrops and intercrops, on the contrary palm oil seems to be more profitable both in term of time (kernels are produced since 4th year from plantation) and on a financial aspect (gross revenue 1500 $/ha/year) resulting comparable with the whole rattan production of a year in a rattan garden (about 1250 $/year). Arguably it is of some interest the evaluation that Sunderland (2000) makes on rattan fruit production for seed purpose as a female plant (in a plantation of the whole population 20% the plants are females, 35% males and 45% undifferentiated due to early harvest) can produce 3000 seeds per year, that are sold at 0.02 $/fruit or 0.06 $/cleaned seed.

Some doubts, however, arise when some African figures are analyzed (Defo, 2000 – data from La Voix du Paysan, 1998). As the same author mentions there are some difficulties to consider rattan plantations profitable due to competitiveness of other crops (poor, intensive management?) and African rattan price weakness. Local rattans are in fact cheaper par rapport to Asian prices (the author estimates a ratio of 1/7), which makes it difficult to give priority to long lasting plantations.

To summarize different land systems' revenues can be gathered as follows:

Land system	Country	Gross Income $/ha/year	Net income $/ha/year	Present Gross Value	Present Net Value	Research	Discount rate - notes
Cattle pastures	Brasil	148	-	2960	-	Peters (1989)	
Cattle ranching	Ecuador	-	2.9	-	57	Grimes (1994)	r = 5
Cow (1 cow/2ha, 400 pounds of flesh at 1$/pound, 3 year of husbandry, 80% of costs from total)		200 (in 3 years)	40 (in 3 years)	-	287		r = 5
Extimated earning in agriculture		-	25	-	500		r = 5
Rubber (0.25 t/ha)	Indonesia	44.7	15	-	-	Godoy (1991)	r = 10
Rice (1.5 t/ha)		295	27	-	-		r = 10
Rambutan (28400 fruits/ha)		423	384	-	-		r = 10
Palm oil	Indonesia	1500				Purnama (1998)	1 US$ =1675 Rp
Rattan fruit (3000 fruits/plant/year)	-	60				Suntherland (2000)	0.02 $/fruit
Rattan seeds (3000 fruits/plant/year) (germinability 100%)	-	180				Suntherland (2000)	0.06 $/seed
Ananas comosus About 15 months	South Cameroon	3477	-	-	-	Defo (2000)	Convertion rate 100 CFCA = 0.19 $
Banana 16 months and above		671	-	-	-		
Yam (*Dioscorea*s) 7 -12 months		1275	-	-	-		
Maize (*Zea mais*) 3 - 4 months		326	-	-	-		
Tomato (*Solanum lycospersicum*) 4 - 5 months (1000 m^2)		335	-	-	-		
Calamus trachycoleus (1.5 t/ha)	Indonesia	313	224	-	-	Godoy (1991)	r = 10
Calamus trachycoleus - green canes	Indonesia	-	-	-	494	Godoy (1990)	r = 10
Calamus trachycoleus - processed canes		-	-	-	564		r = 10

CHAPTER 7

DISCUSSION

The various data collated in the present study show that rattan production systems can be considered valuable on both ecological and economic terms.

Rattan is widely present in all the equatorial and tropical areas as a consequence of its high adaptability in different ecosystems. Although a large number of species has been recorded, only the commonest are object of general studies. The lack of specific analysis devoted to taxonomic and biological data, together with defects in information sharing, do not allow a fully understanding of the Calamoidae family potential. This incompleteness reflects negatively especially in a long-term strategy of natural resources conservation. On the contrary a wide basis of knowledge could help indicating species adaptability to many different environmental condition, as well as genetic improvement could strengthen palm resistance and improve quality, widening market possibilities.

As the previous chapters show it is clear that NTFPs could represent a prudent strategy for forest conservation both for their ecological and local populations' livelihoods benefits, providing that a sustainable management is maintained. As different studies have shown (Arifin, 2003; Matius 2004) rattan not only is harvestable in natural forests but also can be part of a strategy of conservation managed by local people. The Diversity Index of tree species in rattan gardens (Arifin, 2003) shows a large presence in natural and rattan species within the fallow period of shifting cultivation, simulating natural forest ecosystems for a large extent. Matius's (2004) analysis of complexity grade between monocrops, rattan gardens and primary forest in Borneo empathizes the raising in level of complexity and the consequent increased possibility of ecosystems to heal within the same habitat. In fact while in oil palm crops an average of 15 species are supported, and just few animals can cope with lack of resources (mainly rats and snakes who predate the rodents) on the other hand, in primary tropical forest, there is plenty of autochthonous species gathered both in space and in time: at least 10000 flowering plants and 3000 trees and hundreds/thousands of animals species. Rattan gardens, like semi-natural gardens, can provide many niches for different animals, and represent a compromise between specialization and natural land management, averaging a ratio of 15.2% from the natural forest's 100%.

Rattan has demonstrated that its harvest is more sustainable than logging both for a reduced nutrient removal, due to different allocations in the plant components, and for the maintenance of forest canopy and soil cover, which prevent runoff and mineralization. Some concerns arise when rattan light requirements are analyzed: a 50% in light means in fact a significant reduction in natural forest cover through felling, girdling and pruning, which can be incompatible with conservation issues. Furthermore major casualties in seedling and young plants occur (-40%) whenever forest management tend to give priority to timber in all those areas where high quality timbers are planted or grow (forest and enrichment planting).

in his ecologic analysis suggests that rattan is indeed an ideal plant for swidden rainforest. Rattan rotation fits perfectly the ecological and timing requirements of fallow periods.

It is important however to point out that every sustainable management is possible whenever certain harvesting rules are attended. However, since the empirical management of certain indigenous populations, who used to cut no more than 10-20% of the total stems, not many studies have been carried out in identifying sustainable harvest levels that could maintain an undisturbed environment and a bio-ecological equilibrium of the plants as well. Grimes (1994) in her studies recognizes a reduction of 25% from the total harvestable forest products as a way to maintain a tolerable ecological equilibrium, this level has however to be ascertained as sustainable limits vary among different areas and ecosystems.

Management systems depend on rattan species. Different diameters and stem number per plant determine the way plants are cultivated and harvested. *C. manan*, a single stemmed large diameter rattan cane, is more suitable in interplanting systems such as oil palm or rubber plantations. It does not disturb in fact hosting plants too much, does not interfere with plants' canopy and is generally harvested at the end of the rotation (12 or 15 years), preferably in coincidence with main plant's clear cut. As far as the clustering small diameter canes are concerned, they result to be the ideal candidates in fallow lands with reduced maintenance. Continue production of suckers and stolons, makes it possible to harvest clumps every 1-3 years guarantying thus a continue cash flow.

On the economic level rattans in Asia present interesting revenues in comparison with other land uses. Figures show that rattan production is by far more interesting than logging as shorter rotations and/or repeated harvests allow continue cash flows. Matius (2004) in his rattan garden studies shows a profitability ratio between rattan and timber of 1/5-1/6 and a rattan annual gross revenue ranging from 50 to 140 US$/ha versus a mean timber annual gross revenue of 13-18.4 US$/ha. Such data are confirmed also in other studies such as Lammens, with a net annual income for 1st harvest timber of 17 US$ and De Kock with a 2nd timber harvest on a 35-year rotation of 8 US$. Regarding further rattan annual incomes, prices vary slightly as different studies do not analyze similar planting conditions. However, both Godoy (1991) and Wan Razali (1992) estimate clustering rattans (*C. caesius* and *C. trachycoleus*) for a gross revenue of 290-330 US$/ha/year.

As far as single stemmed large diameter canes are concerned Wan Razaly estimates a gross revenue of 2821 and 6382 US$/ha respectively for a 12 or 15-year rotation.

Feaw (1992) in his evaluation figures that an hectare of rattan needs 94 man-days in the establishment year and 66 man-days from the 12th year onward for *C. caesius* or 93.5 man-days/ha for *C. trachycoleus*, which means that a 4-member family enterprise could manage respectively 10 ha or 7 ha with no external workforce.

Comparisons between other plantation systems show alternate gains: while rubber plantation, rice crops, and even cattle ranching (calculated on a per hectare basis) are less profitable than rattan, some other fruit plantations and oil palm have higher cash flows and, in certain cases, a shorter rotation (oil palm).
Africa, on the contrary, shows different figures that make rattan apparently less profitable, both for its cheap prizes (due to unjustified quality assessment), and for other crops' revenues pull factor. Lack of land and diffuse poverty do not make this kind of cultivation fit for shorter cycles, resulting in low farmers' interest in venturing.
In Asian countries rattan is a strategic way to differentiate incomes: smallholders tend to have different source of cash for their livelihood disregarding sometimes the level of profitability of other alternatives (Dove, 1993). The example of Indonesia, where local population resulted not keen on oil palm land conversion (Pambudhi, 2004), shows how people consider rattan palm a steady growing investment to convert in cash whenever they need some extra money. Annual crops are in fact not so flexible both in harvesting and collection, due to their short rotation and their need to allocate manpower in specific periods of the year already reserved to other farming activities (Godoy 2000). Rattans instead allow people to cover any risk from crop failures and to feed the family till the following harvest. This strategy prevents thus people from diverting the necessary workforce for core farming activities in external ones for the unique aim of gaining some money to feed the family. Interestingly in many Asian countries rattan is no longer considered a "modern" crop, due to its lower value if compared to oil palm or other plantation systems. It is to say however that in a conservation strategy rattan is still worth growing for its low management needs, its adaptability in marginal lands, and its minimal disturbance to the environment or existing forest with limited amount of tree felling for canopy openings. Question arises whenever lack of land does not allow crop coexistence. To a certain extent it is true that plantation crops are more profitable, but like many commodities prices vary depending on regions and on offer/demand.
Arguably, in evaluating the potential value of NTFPs in the forest rattan represents only a part of the innumerable species that can help in improving farmers' livelihoods. Figures from NTFPs revenues in Ecuador (Grimes, 1994) show that if all the potential products per hectare were sold the gains from logging would be worth neglecting. However, according to the author not all the products can reach external markets due to a multitude of reasons including - unexplored market opportunities, lack of market information, and the technical know how to meet market specifications.
What is more, the economic rather than financial aspects in evaluating the potential of NTFPs invite to consider all the innumerable externalities concerned to forest environment. There is no doubt that an overall value calculation would privilege rattan and NTFPs rather than logging for its lower impact on the environment, which can maintain in the long run a better accessibility to all local resources involved in livelihood.

A holistic approach towards sustainability not only implies economical and technical issues but also focus on further aspects such as policy, land tenure rights, market information and access, gender and ethnic matters as well as stakeholders empowerment.
A common strategy for keeping forest intact reside certainly in the improvement of stakeholders' sense of security, which is at least the key factor that prevent from exploiting forests for survival reason. As the previous chapters have demonstrated, in rattan production-to-consumption-system farmers and gatherers are always the weakest subjects in the chain. Low decisional power, and low revenues, in comparison with those of the manufacture sector, boosts the search for better incomes, which in the end turn in a worse forest exploitation.
On an institutional level licensing policies represent a major constraint as the mounting bureaucratic difficulties prevent smallholders from applying. Lack of legal licenses in harvesting not only puts farmers and collectors under the risk of harassment for illegal levies, but also does not develop a safe economic tissue that could increase people livelihood. What is more the paucity of formal regulations both in harvesting and in land tenure divert present management systems to short term achievements instead of long term ones. Indiscriminate harvestings carried out by villagers or external collectors is in fact the consequence of open access resource management (and a common belief of the inexhaustible availability of rattan as well) that does not make people responsible for looking after forests. Rattan cultivation would certainly receive a boost if governments allowed land use rights: direct management would guarantee minimal damage in harvesting, reduction in wastage, as landowners would be more attentive, and minimization in forest spoliation, as holdings would be managed and controlled by owners themselves.
Certain Asian countries, like the Philippines, have indeed started to use part of their harvesting taxes to replanting campaigns by providing incentives to farmers, but most of these initiatives have been disattended due to lack of controls. As far as timber companies are concerned the lack of selective logging and indiscriminate cuttings not only reduce forests' regeneration potential but also minimize their richness in biodiversity due to major damages in forest population, which in the long run affect local dwellers' possibilities to live.
The lack of credit to apply for harvest licenses and too complicated bureaucracy stop smallholders from being more active in the chain and in the end force them to be price takers. The need to pay levies in advance while applying for a license does not make small stakeholders able to harvest with no third party constraints. Furthermore, specific government rules, as in the case of certain Asian countries, require a high level of ability and organizational capacity to determine the exact quantity of harvestable material and a tight timing to operate, which are insurmountable barriers for those that do not have specific skills in estimate rattan volumes or cannot afford the collection/workforce expenses even for a limited period of time. Lack of financial resources and adequate legislation aiming at facilitating smallholders' accessibility to forest products often put

smallholders out of the “active” market: the resulting outcome is thus the acceptance of unfavorable economic conditions like the “credit contracts” among shopkeepers and harvesters, in which the real rattan market value is not considered due to their characteristic of being more likely a way to “pay in kind” for store supplies purchased rather than an economic agreement.

Participatory approach, community based management, local associations/cooperatives, are on the other hand all strategies aiming at regulating rattan and NTFPs management systems and a wise way to empower smallholders rights. A proper control and resource optimization by local people could not only increase yields and quality, avoiding thus the risk of overexploitation and senseless harvesting by external subjects, but also make stakeholders able to plan constant output levels that overturn seasonality in supplying. What is more bigger institutional subjects like associations or cooperatives would shorten the production chain leading to increase fair incomes and better market relationships with manufacturers or exporters.

Better knowledge of the market, improved pre and post harvest technologies can help stakeholders to raise products’ quality levels, though lot of work has to be done on standardization and post harvest processing knowledge. The lack of information sharing on market requirements result in fact in products’ low values, as materials do not fulfill market demand. In addition limited knowledge on processing methods and storing/transport facilities prevent people from adding extra value or at least avoiding major damages to already harvested canes.

Previous chapters have fully investigated the high profitability that basic processing tasks can provide. However, it is important to consider their applicability to local contexts without disrupting ethnic and gender equilibrium. Not all the jobs are in fact applicable by women, as in the case of Indonesia, where Chinese and Muslim women are not allowed to carry out labour intensive duties but trading job instead, and not all the processing tasks are carried out by local villagers (i.e. sulphurization) due to recognized insecurity. The empowerment of local production or the success in developing new strategies could be only attained by fully investigating the social tissue as well as the time needs of each individual within a group/village. According to Dillon (1976) “System performance must be judged not simply in terms on how each part work separately, but in terms on how the parts fit together and relate to each other, and in terms on how the system relates to its environment and to other systems in that environment”

To sum up author’s opinion, in a long term development strategy the first steps toward a sustainable management of forests should orient local policies firstly towards the empowerment of land tenure rights, and secondly by the reduction of the impact on natural forests by specific management systems like forest margins management or rattan gardens. Hunter’s (2003) analysis on plantations in the margins of the remaining natural forests in Hainan (China) clearly conjugates these two assumptions in a sustainable way: a major reversal in deforestation and overexploitation of forest products by giving people long term land use rights of marginal areas which integrates their low productivity agricultural systems. The cultivation of rattan or other products as cocoa and shadow coffee in these areas incentives communities to maintain forest cover, as trees are needed to support climbers and to supply shadow to valued crops. As for rattan gardens the length of rattan rotation (12-15 years) represents the ideal period of time for a land to recovery and a valuable method to use fallow land otherwise unutilized.

The recognition of ancestral domains or the temporal extension of land utilization can help people to invest and manage in forest products and maintenance. On the other hand a better quality product within a more integrated producing system could reduce negative impact and pressure on forest and improve productivity and gains.

RATTAN SUSTAINABLE FRAMEWORK

- SWOT Analysis* -

STRENGTHS	WEAKNESS
• Local knowledge – management skills • Species adaptability to local habitats • High level in biodiversity • Linkages among rattan and cultural or religious beliefs • Rattan as a saving resource • Rattan as a diversification strategy	• Open access resource • Lack of basic inventory data • Low yields - over harvesting • Irregular seasonal supply • Lack of standardization and knowledge • Lack of technology • Lack of storage and transport facilities • Low level of formal education • Ethnic and gender constraints • Little room for negotiation • Low organizational skills
• Enhanced methods for sustainable management • High profitability in plantations and transformation processes • Enhanced resource access and rights for indigenous people • Empowerment of local associations/cooperatives • Access to credit • Market intelligence • State support in sector (replanting policy) • Subsidies • Use in degraded, marginal areas, intercrops	• License accessibility • High taxations • Unofficial levies • Unsustainable harvesting regimes • Weak market information • Other land uses • Foreign migrants • Other competitive materials (plastic) • Inadequate level of scientific knowledge • High level in casualties if not properly managed or if high value timber production is given priority • competition with other land uses for surviving purposes, lack of lands
OPPORTUNITIES	**THREADS**

* Strength and weakness refer to community's internal resources while opportunity and threads to external ones

CONCLUSION

Rattan is an important mean of livelihood in almost all equatorial and tropical countries and one of the most important Non Timber Forest Product worldwide.

Despite this role it appears that local governments do not put much attention on rattan development plans or policies to better manage national forestal/silvicultural resources. Being considered as a minor forest product, rattan is not a priority issue in the political agenda due to low visibility (no lobbies, regional instead of international markets that are not eye-catching for main actors, difficulty in monitoring, data ignored in national accounting schemes) in comparison with other major commodities.

As matter of fact it is quite difficult to obtain relevant or accurate data neither from international organizations, which do not carry out inventories and resource assessment on NTFPs, nor from government agencies that tend to analyze data within timber categories or final products (furniture, baskets, plaitable material). Present researches are indeed fragmented and are mostly carried out from national researches institutes or botanical gardens for the scientific aspects (Malaysian Forest Research Institute, Limbe Botanic Garden Cameroon, Royal Botanic Garden Kew) and from national/regional farming or manufacturing associations for the processing and economic aspects (i.e. ASMINDO).

More recently FAO and other international organizations are setting up an increased level of links among governments, private and not-for-profit sectors in order to implement a global agenda for the sustainable development of rattan. A lion's share is played by INBAR (International Network of Bamboo and Rattan) whose aim is to improve the social, economic and environmental benefits of bamboo and rattan.

The sustainable development of rattan implies thus not only the use of appropriate techniques but should take into account the national policies and the empowerment of the stakeholders. Every strategic decision, which affects national production and export, should analyze the socio-economic consequences of each choice. The Indonesian and South-East Asian export ban (1989) in raw material, while ruled for the preservation of natural resources did not consider the weakest layers of the population, causing drastic reduction in stakeholders' livelihoods.

Enabling people to obtain a fair income or support a fair policy in their favor is a must that should be attained by any Government. For what this statement regards, the agricultural and silvicultural policies, many recommendations should be considered. Generally speaking the most important among them will necessarily be concerned with the reform of land ownership and in a more equal licensing regulation. Determining and maintaining acceptable parameters for ecologically sustainable harvesting is also a starting condition to ensure production continuity and to protect landscapes. To boost local stakeholders, make easier access to credit, to maintain price stabilization, to create and/or strengthen local associations or cooperatives, would also be of great importance, as, eventually, to empower -and protect- the weakest rings of the production chain. Finally, making significant investments in technologies and infrastructures will certainly ensure a better quality of the output.

Rattan, being a commodity that grows mainly in developing countries, it seems important to improve and diversify local supply to the international market by shifting from commodity to high quality final output. To consider creating the conditions to enable these countries to participate on equal terms to the world trade means entering in the wider field of international policy and relationships: it is nevertheless the turning point in drawing together, negotiating and compromising the complex and diverse aspects of sustainable development from many territories.

According to Sachs (1998) the progressive reduction in croplands in developing countries due to overpopulation (Sub Saharan Africa, South Asia), to a minimum of 0.17 ha/pro-capita, does not allow farmland utilization for rattan plantations as well. Defo (2000) argues that relationship between rattan palms and other agricultural productions can essentially be a relationship of competition at almost every level, though he recognizes the importance of intercopping as a strategy to diversify production, integrate incomes and cover main crop's plantation costs. Many lands that can be possibly utilized for rattan are also suitable for other cultures. In those countries where subsistence cropping provides the back bone of sustainable local food supply, there is a resultant difficulty to establish single species rattan plantations, in place of annual or subsistence crops.

Rattan plantation shows to be more suitable in "marginal" habitats such as natural forests' openings, in logged-over forests, in abandoned tree plantations, in long-cycle fallows and in underutilized farmlands. These disturbed areas are the ideal environment for climbers, as a minor maintenance work is needed for the reduced canopy extension and because rattan represents a valid alternative means to rehabilitate areas no longer used for production purposes: periodical flooded riverbanks do not consent to cultivate rice, fallow land is a compulsory ecological strategy to reintegrate nutrient and carbon loss after a rice/crop cycle. Furthermore low economic value plantations can be revalued by rattan, which can take advantage of preexistent trees for tending and for more regular specie-specific cane production, in contrast to natural forest rattan where commercial species are too dispersed to be harvested on a sustainable or economical way.

As for intercropping some concerns occur when plantations present a high rattan density as palms' lush vegetation could interfere with main crop and damage branches, resulting in a sensible reduction in productivity. Although there are not many studies on competition among species for nutrients and light, rattan planting should be done with 1-year old seedlings in order to minimize competition problems with the vigorous logged-over vegetation or enrichment planting (Weinstock, 1983), though Bacilleri (1999) affirms that slow rattan growth rate at this stage can face some problems for a rapid canopy closure.

Rattan can help maintaining natural habitat in several ways. According to Matius (2004) rattan gardens keep a wide number of local species in quite similar conditions as those present in natural forest. Endangered species, can thus find shelter in these areas with no danger of extinction as they belong to the system itself. Mathius indicates that at least 35 plant and 8 mammal species, which have been found in rattan garden, are listed in the IUCN thread category. Hunter (2003) on the other hand describes the utilization of forest margins for rattan cultivation in Hainan (China) as an interesting strategy to reduce pressure on forestland and maintain crops for food production. Forest margins present all those environmental requirements needed by palms and at the same time prevent local population from going into the forest to gather forest products. Wienstock (1981)

BIBLIOGRAPHY

This bibliography lists the essays collected, reviewed and mentioned in the present study

ADU-ANNING, C., 2004	"The Rattan Industry in the Ashanti and Western Region of Ghana." In: SUNDERLAND, T., NDOYE, O. *Forest Products, Livelihoods and Conservation. Case studies of Non Timber Forest Products Systems*. Vol. 2 – Africa. CIFOR
ALI A. & BARIZAN, R., 2002	"Country Report on the Status of Rattan Resources and Uses in Malaysia." In: *Rattan Current Research Issues and Prospects for Conservation and Sustainable Development.* Non wood Forest Products 14. FAO, Rome
AMINUDDIN, M., 1984	"Performances of Some Rattan Species in Growth Trials in Peninsular Malaysia." In: WONG. K.M., MANOKARAN, N. *Proceedings of The Rattan Seminar* 2-4 October 1984 Kuala Lumpur, Malaysia
AMINUDDIN, M., NUR SUPARDI, M.N, CHUEN, W.W., 1992	"Economics of Cultivation of Large-Diameter Rattan." In: DRANSFIELD, J., RAZALI, W., MANOKARAN, *A guide to the cultivation of rattan*. Forest Research Institute Malaysia.
ANOM, 1981	*Report on the Forest Research Institute*, FRI Report no. 89 (9182). Forest Research Institute, Kepong
ARIFIN, Y.F. & MITLÖHNER, R. 2003	*Traditional Rattan Gardens in Central Kalimantan, Indonesia*. Paper submitted to the XII World Forestry Congress. Quebec City, Canada
ASTANA S., NASENDI, B.D., 1998	*Wild Rattan in Sulawesi: a Case Study of the Production-to-Consumption Systems*, INBAR Working Paper No. 11
BALAGOPALAN, M. & SANKAR, S., 1992	"Ecological Conditions of Rattan (Cane) Growing Areas with Special Reference to Soil Proprerties." In: BASHA, C. & BATH, K.M. *Rattan management and utilization*. Proc Rattan-India Sem. 1992
BARIZAN, R. & SULAIMAN, R., 1992	"Phenology of rattans." In: *A guide to the cultivation of rattan*. Forest Research Institute Malaysia
BARIZAN, R., RAZAK, A, OTHMAN, J., 2002	"Can Rattan Be Successfully Inter-planted With Bamboo On a Commercial Scale?" In: *Rattan Information Center Bulletin*. Vol. 13, n.1 January 2002
BASU, S.K., 1985	"The Present Status of Rattan Palms in India - An Overview." In: *Proceedings of The Rattan Seminar*. The Rattan Information Centre, Forest Research Institute, Kepong, Malaysia
BELCHER, B. M., 1999	*The Bamboo and Rattan Sectors in Asia: an Analysis of Production-to-Consumption Systems*, Working Paper No. 22
BHAT K.M., *ET AL.*, 1993	"Anatomy and identification of South Indian Rattans (Calamus species)." *IAWA Journal* 14: 63–76.
BINGSHAN Z., HUANGCAN, XU AND GUANGTIAN, YIN. 2000	"Areas of rattan cultivation in China." In: XU, H.C., RAO, A.N., ZENG, B.S. AND YIN, G.T. *Research on Rattans in China - Conservation, Cultivation, Distribution, Ecology Growth, Phenology Silviculture, Systematic Anatomy and Tissue Culture.* IPGRI.
BYSTRIAKOVA, N., DRANSFIELD, J., 2002	*Potential distribution of rattans in Asia-Pacific and Africa*. INBAR Working Paper 41. UNEP-WCMC Cambridge

CHING-FEAW, T., ZAKARIA, M., MAHYUDIN, A., 1994 — *Nursery Techniques for Rattan*. INBAR technical report.

CHUEN, W.W., FEAW, T.C., 1992 — "Economics of Cultivation of Small-Diameter Rattan." In: DRANSFIELD, J., RAZALI, W., MANOKARAN, *A guide to the cultivation of rattan*. Forest Research Institute Malaysia.

DEFO, L. & TREFON, T., 2000 — "Knowledge transfer in the context of conservatory management of non-wood forest product: potential advantages and socio-economic constrains to the introduction of rattan palms in the cropping systems of the forest region of Cameroon." In: *New research on African rattans*. The proceedings of the CARPE-funded International Expert Meeting on the Rattans of Africa held at the Limbe Botanic Garden, Cameroon. 1-3 February 2000

DEFO, L., 2004 — "Rattan Exploitation in the Yaoundé Region of Cameroon." In: SUNDERLAND, T., NDOYE, O. *Forest Products, Livelihoods and Conservation. Case studies of Non Timber Forest Products Systems*. Vol. 2 – Africa. CIFOR

DILLON, J.D., 1976 — The economics of System research. Agricultural Systems, 1, 5-22

DONGMO, Z. L. N., NKONGMENECK, B. A. & FOTSO, R. C., 2002 — "Rattan Palms in the Dja Biosphere Reserve (Cameroon) and its Periphery: Distribution and Density of Commercial Species." In *Rattan Current Research Issues and Prospects for Conservation and Sustainable Development*, FAO Rome

DOVE, R.D., 1993 — "Smallholder Rubber and Swidden Agriculture in Borneo: a Sustainable adaptation to the ecology and economy of the tropical forest." *Economic Botany* 47 (2) 382-396

DRANSFIELD, J., 1977 — "*Calamus caesius* and *C. trachycoleus* compared." *Gard. Bull. Sing*. 30: 75-78.

DRANSFIELD, J., 1979 — *A manual of the rattans of the Malay Peninsula*. Malayan Forest records No 26 Kuala Lumpur.

DRANSFIELD, J., 2001 — "Taxonomy, biology and ecology of rattan." *Unasylva (*205) Vol. 52-2001/2 FAO, Rome

DRANSFIELD, J., 2002 — "General introduction to rattan - The biological background to exploitation and the history of rattan research." In: *Rattan Current Research Issues and Prospects for Conservation and Sustainable Development.* Non wood Forest Products 14. FAO, Rome

DRANSFIELD, J., RAZALI, W., MANOKARAN, N.1992 — *A guide to the cultivation of rattan*. Forest Research Institute Malaysia.

DWIPRABOWO H., IRAWANTI, S., SUPRIYADI, R., NASENDI, B.D., 1998 — *Rattan in Java, Indonesia: a Case Study of the Production-to-Consumption Systems*. INBAR Working Paper No. 13 Forest Products and Forestry Socio-economic Research and Development Centre Bogor, Indonesia INBAR

ESEGU, J. F., 2000 — *Rattan and Bamboo in Uganda: A Study of the Production to Consumption Systems*. Forestry Research Institute Kampala, Uganda. INBAR

FEAW, T.C., 1992 — "Plantings Systems for small diameter canes." In: *A guide to the cultivation of rattan*. Forest Research Institute Malaysia

FUI, L.H., NUR SUPARDI, M.N.,1995 — "Social, economic and cultural aspects of Rattan in Malaysia" Forest Research Institute Malaysia. In: *Beyond timber: social, economic and cultural dimensions of nonwood forest products in Asia and the Pacific*. FAO, Bangkok

GNANAHARAN, R., 1993 — *Local Tools and Equipment Technologies for Processing Bamboo &Rattan. An Illustrated Manual*. Forest Research Institute Peechi, Kerala, India.

GODOY, R. & TAN, C.F. 1989 — "The profitability of smallholder rattan cultivation in Southern Borneo." *Human Ecology* 17(3):347-363

GODOY, R. & TAN, C.F., 1991 — "Agricultural diversification among smallholder rattan cultivators in Central Kalimantan, Indonesia." *Agroforestry Systems* 13: 27-40

GODOY, R., 1990 — "The economics of traditional rattan cultivation." *Agroforestry Systems* 12: 163-172

GRIMES, A. ET AL, 1994 — "Valuing the rainforest: the economic value of non-timber forest products in Ecuador." *Ambio* 23 (7): 405-410

GUANGTIAN, Y., & HUANGCAN, X., 2000 — "Suitable storage conditions for seeds of *Daemonorops margaritae.*" In: XU, H.C., RAO, A.N., ZENG, B.S. AND YIN, G.T. *Research on Rattans in China - Conservation, Cultivation, Distribution, Ecology Growth, Phenology Silviculture, Systematic Anatomy and Tissue Culture.* IPGRI.

GUANGTIAN, Y., HUANGCAN, X., WEILIANG, Z., JINGGANG F., AND BINGSHAN Z., 2000 — "Cultivation of rattan species." In: XU, H.C., RAO, A.N., ZENG, B.S. AND YIN, G.T. *Research on Rattans in China - Conservation, Cultivation, Distribution, Ecology Growth, Phenology Silviculture, Systematic Anatomy and Tissue Culture.* IPGRI.

HONG, L.T., RAO, R. 2001 — "Research on rattan genetic resources conservation and use: the perspective and strategy of the International Plant Genetic Resources Institute." *Unasylva* (205) FAO

HUANGCAN, X., GUANGTIAN, Y., BINGSHAN Z. AND JINGGANG F., 2000B — "Growth of *Daemonorops margaritae.*" In: XU, H.C., RAO, A.N., ZENG, B.S. AND YIN, G.T. *Research on Rattans in China - Conservation, Cultivation, Distribution, Ecology Growth, Phenology Silviculture, Systematic Anatomy and Tissue Culture.* IPGRI.

HUANGCAN, X., HUIFU, Z., AND SHISHENG F., 2000A — "Growth and phenology of *Calamus tetradactylus*." In: XU, H.C., RAO, A.N., ZENG, B.S. AND YIN, G.T. *Research on Rattans in China -Conservation, Cultivation, Distribution, Ecology Growth, Phenology Silviculture, Systematic Anatomy and Tissue Culture.* IPGRI.

HUNTER, I., VON HAHN, C.G., 2003 — "Stabilizing forest margins by growing non-timber forest products: a novel example from Hainan Island, China." *Land Use Policy* 20 (2003) 225-230

INBAR, 2001 — *TOTEM - Transfer of Technology Model. Interplanting Rattans in Tree Plantations*. Forest Research Institute Malaysia, Kepong, Kuala Lumpur Malaysia. INBAR

IQBAL, M., 1993 — *International Trade in Non-Wood Forest Products: an Overview*. FO: Misc/93/11 Working Paper. FAO, Rome

JOHARI, B., 1982 — *An assessment on the growth and survival of 13 years old Rotan Manau plot in ungei Buloh Forest Reserve*. Paper presented at Eighth Pan-Malaysian Forestry Conference. Sabah. 2-8 August 1982. 6p

KANGLIN, W., 2001 — "Rattan Resources and Sustainable Development in Yunnan Province." In: Zhaohua, Z. *Sustainable Development of the Bamboo and Rattan Sectors in Tropical China.* Proceedings No.6. China Forestry Publishing House

LAMMENS, E.P.C., (forthcoming) — MSc Thesis, Department of Forestry, Wageningen Agricultural University. The Netherlands.

LAWRENCE, M. J., RAO, J.T, 1995 — *Approaches to Genetic Enhancement of Bamboo and Rattan In: Williams,., Genetic Enhancement of Bamboo and Rattan*. Report of an Expert Consultation held at Los Banos, Philippines, 8-11 May 1995. INBAR

LUCAS, E.B. & DAHUNSI, I.O. 2004 — "Characteristics of three western Nigerian rattan species in relation to their utilization as construction material." In: *Journal of Bamboo and Rattan* Vol.3 No.1 pp 45-56 (2004)

MANOKARAN, N. & K.M. WONG, 1983 — "The silviculture of rattans - an overview with emphasis on experiences from Malaysia." *Malay Forester* 46: 298-315.

MANOKARAN, N., 1981 — "Survival and Growth of *C.Caesius* at Two Years after Planting. I. Line-Planted in Poomrly Drained Soil". *Malay Forester* 44(1): 12-22

MANOKARAN, N., 1981 — "Survival and Growth of *C. Caesius* at Two Years after Planting. II. Line -Planted in well Drained Soil." *Malay Forester* 44(4): 464-472

MANOKARAN, N., 1982 — "Survival and Growth of *C. Caesius* at two years after planting. III. Group -Planted in Poorly Drained Soil." *Malay Forester* 45(1): 36-48

MANOKARAN, N., 1982 — "Survival and Growth of *C. Caesius* at 5 1/3 Years After Planting." *Malay Forester* 45(2): 193-202

MANOKARAN, N.,1984 — "Biological and Ecological Considerations Pertinent to the Silviculture of Rattans." In: WONG. K.M., MANOKARAN, N. *Proceedings of The Rattan Seminar* 2-4 October 1984 Kuala Lumpur, Malaysia

MATHEW A. AND BHAT, K.M., 1997 — "Anatomical diversity of Indian rattan palms (Calamoideae) in relation to biogeography and systematics." *Botanical Journal of the Linnean Society* (1997), 125: 71–86

MATIUS, P., 1981 — *Suatu Gagasan Tentang Kemungkinan Pembinaan dan Pengembangan Budidaya Rotan Rakyat di Kecamatan Damai Kabupaten Kutai. Fakultas Kehutanan UNMUL Samarinda*. Bachelor Thesis of Forestry. (Unpublished) 106 pp.

MATIUS, P., 2004 — *Plant Diversity and Utilization of Rattan Garden a Contribution to Participatory Biodiversity Conservation within the Benuaq and Tunjung Tribe in East Kalimantan, Indonesia*. Tropical Ecology Support Programme (TOEB). Eschborn

MINGQIN, G., FENGZHEN, W., AND YU C., 2000 — "Effectiveness of VA mycorrhizal fungi associated with rattan." In: XU, H.C., RAO, A.N., ZENG, B.S. AND YIN, G.T. *Research on Rattans in China - Conservation, Cultivation, Distribution, Ecology Growth, Phenology Silviculture, Systematic Anatomy and Tissue Culture.* IPGRI.

NAINGGOLAN, P.H.J., 1984 — "Preliminary Observations on the Effect of Different Canopy and Soil Moisture Conditions on the Growth of Calamus Manan (Manau)." In: WONG. K.M., MANOKARAN, N. *Proceedings of The Rattan Seminar* 2-4 October 1984 Kuala Lumpur, Malaysia

NAINGGOLAN, P.H.J., 1985 — “Canopy and soil moisture conditions on the growth of calamus manan (manau). Overview” In: *Proceedings of The Rattan Seminar*. The Rattan Information Centre, Forest Research Institute, Kepong, Malaysia

NUR SUPARDI, M., AMINUDDIN, M., 1986 — *The effect of different degrees of canopy manipulation on the growth of* Calamus manan (unplubished)

OLUBANJO, O., 2002 — *Extensive Rattan Production to consumption Systems in southern Nigeria: A Case Study*. Olabisi Onabanjo University, Ago-Iwoye, Nigeria. INBAR

OTENG-AMOAKO, A. & EBANYENLE, E., 2000 — “The Anatomy of Five Economic Rattan Species from Ghana”. In: *New research on african rattans*. The proceedings of the CARPE-funded International Expert Meeting on the Rattans of Africa held at the Limbe Botanic Garden, Cameroon. 1-3 February 2000

OTENG-AMOAKO, A. & OBIRI-DARKO, B.,2000 — “Rattan as a sustaninable cottage industry in Ghana: the need for development interventions.” In: *New research on African rattans*. The proceedings of the CARPE-funded International Expert Meeting on the Rattans of Africa held at the Limbe Botanic Garden, Cameroon. 1-3 February 2000

OTENG-AMOAKO, A. 2001 — *A study of the Production-to- Consumption System of Rattan in Ghana*. Forest Research Institute of Ghana and INBAR

PABUAYON, I. M., RIVERA, M. N., 1998 — *The Philippine Rattan Sector: a Case Study of the Production-to-Consumption Systems.* INBAR Working Paper No. 14

PALIS, H.G.,2004 — “Rattan (*Calamus* spp.) extraction in the Philippines: the case of Manggapin and Kalakwasan watersheds, Palawan.” In: KUSTERS, K., BELCHER, B., *Forest Products, Livelihoods and Conservation. Case Studies of Non-Timber Forest Product Systems.* Vol. 1 – Asia. CIFOR

PAMBUDHI, F., BELCHER, B., 2004 — *Forest Products, Livelihoods and Conservation Case Studies of Non-Timber Forest Product Systems*. Vol. 1 - Asia CIFOR

PAMBUDHI, F., BELCHER, B., LEVANG, P., DEWI, S., 2004 — “Rattan (*Calamus* spp.) gardens of Kalimantan: resilience and evolution in a managed non-timber forest product system.” In: KUSTERS, K., BELCHER, B., *Forest Products, Livelihoods and Conservation. Case Studies of Non-Timber Forest Product Systems.* Vol. 1 – Asia. CIFOR

PELUSO, N., 1991 — “Case Study One, Rattan Industries in East Kalimantan, Indonesia” In: CAMPBELL, J. *Case Studies in Forest-Based Small Scale Enterprises in Asia. Rattan, Matchmaking and Handicrafts*. FAO Bangkok.

PETERS, C.M., ET AL 1989 — “Valuation of an Amazonian Rainforest.” *Nature* 339: 655-656

PRIASUKAMA, S. 1986 — Kajan ekonomik Pembududayaan rotan komersial di Kalimantan. Timur. Sinopsis Lokakarya Nasional Rotan. 15-16 Dec 1986. Manggala wanabakti, Jakarta.

PRIASUKAMA, S. 1989 — “Rattan for Economic Development in East Kalimantan”. In: Rao, A.N. et al. *Recent research on rattan*. Proceedings of the international Rattan Seminar. Nov 12-14, 1987. Chiangmai, Thailand. Faculty of Forestry Kasetsart University & IRDC Canada, pp. 248-257

PROFIZI, J. P., 2000 — "Morphology of the Aerial Axis of Some Rattan Palms of West Africa." In: *New Research on African Rattans.* The proceedings of the CARPE-funded International Expert Meeting on the Rattans of Africa held at the Limbe Botanic Garden, Cameroon

PURNAMA, B. M., NASENDI, B.D., 1998 — *Rattan in East and South Kalimantan, Indonesia: a Case Study of the Production-to-Consumption Systems*. INBAR Working Paper No. 2. Forest Products and Forestry Socio-economic Research and Development Center Bogor, Indonesia

RAJA BARIZAN, R.S., ABD RAZAK, O. & OTHMAN, J. — "Can Rattan Be Successfully Inter-planted With Bamboo On a Commercial Scale?" In: *RIC Bulletin* vol 13 n° 1 Jan 2002 - Forest Research Institute Malaysia (FRIM), Kepong, 52109, Kuala Lumpur, Malaysia pp. 18-22

RAO, A.N., RAO, V. R. & WILLIAMS, J.T., 1998 — *Priority species of bamboo and rattan - IPGRI* - International Plant Genetic Resources Institute

RICKSON, F.R. & RICKSON, M.M., 1986 — "Nutrient acquisition facilitated by litter collection and ant colonies on two Malayan palms." *Biotropica* 18(4): 337-343

RODRIGO, V.H.L., SILVA, T.U.K., 2004 — *Improving the Spatial Arrangement of Planting Rubber (Hevea brasiliensis Muell. Arg.) for Long-Term Intercropping*. Field Crop Research 89 (2004) 327-335

SACHS, W. LOSKE, R. 1998 — *Greening the North. A post-industrial blueprint for ecology and equity*. Zed Books, London

SARDJONO, M.A., 1990 — *Die Lembo-Kultur in Ost-Kalimantan*. PhD Thesis, Universitat Hamburg, Germany

SASTRY, C., 2000 — *Bamboo in the new millennium: Opportunities and challenges*. Paper presented at the XXI IUFRO World Congress 2000. Kuala Lumpur, Malaysia.

SASTRY, C., 2002 — "Rattan in the twenty-first century - an outlook." In: *Rattan Current Research Issues and Prospects for Conservation and Sustainable Development*, FAO Rome

SHIM, P.S. & TAN CHING-FEAW, 1984 — *Developmment of Rattan Plantation in Sabah: a Case Study of Rotan Irit Plantation in Seasonally Flooded Areas*. Paper Presented at the Seminar on Forest Plantation Development in Malaysia. Kota Kinabalu/Kudasang, Sabah. July 1984, 21 pp.

SHIM, P.S., 1995 — *Domestication and Improvement of Rattan*. SAFODA, Sabah, Malaysia INBAR Working Paper No. 5 1995

SHIRAI, 1997 — *Peran Pengusahaan Rotan Dalam Pelestarian Sumber Daya HutanTropis*. Master Thesis at Mulawarman Univ., Samarinda. 133 p.

SIEBERT, S.F., 2001 — "Nutrient Levels in Rattan Foliage and Cane, and Implications for Harvesting." *Biotropica* 33(2): 361-363

SIEBERT, S.F., 2004 — "Demographic Effects of Collecting Rattan Cane and their Implications for Sustainable Harvesting." *Conservation Biology* vol.18 (2) April 2004, pages 424-431

SONWA, D.J. ET AL, 2000 — "Management and conservation of forest resources of the Congo basin: preliminary Hypothesis of the domestication of rattan palms in the humid forest zone of south Cameroon." In: *new research on African rattans*. The proceedings of the CARPE-funded International Expert Meeting on the Rattans of Africa held at the Limbe Botanic Garden, Cameroon. 1-3 February 2000

SOON, P.S., & MOMEN, M. A., 1895 — "A Preliminary Report on the Growth Forms of *Calamus Caesius* and *C. trachycoleus* in Safoda's Kinabatangan Rattan Plantation." In: *Proceedings of The Rattan Seminar*. The Rattan Information Centre, Forest Research Institute, Kepong, Malaysia

SUNDERLAND T.C.H., 1999 — "Recent Research into African Rattans (Palmae): A Valuable Non-Wood Forest Product From the Forests of Central Africa." In: SUNDERLAND T.C.H., CLARK, L. E., VANTOMME, P., *1999 Current Research Issues and Prospects for Conservation and Development*. FAO 1999

SUNDERLAND, T.C.H. & DEFO, L., 2000 — *A socio-economic profile of the commercial rattan trade in Cameroon*. In: *new research on African rattans*. The proceedings of the CARPE-funded International Expert Meeting on the Rattans of Africa held at the Limbe Botanic Garden, Cameroon. 1-3 February 2000

SUNDERLAND, T.C.H. & NKEFOR, J., 2000 — "Technology transfer between Asia and Africa: rattan cultivation and processing." In: *new research on African rattans*. The proceedings of the CARPE-funded International Expert Meeting on the Rattans of Africa held at the Limbe Botanic Garden, Cameroon. 1-3 February 2000

SUNDERLAND, T.C.H., 2002 — "Status of Rattan Resources and Use in West and Central Africa." In: *Rattan Current Research Issues and Prospects for Conservation and Sustainable Development.* Non wood Forest Products 14. FAO, Rome

SUNDERLAND, T.C.H., BALINGA, M.B., DIONE, M.A., 2004 — "The Rattan Sector of Rio Muni, Equatorial Guinea." In: SUNDERLAND, T., NDOYE, O. *Forest Products, Livelihoods and Conservation. Case studies of Non Timber Forest Products Systems*. Vol. 2 – Africa. CIFOR

SUPARDI, N., AMINUDDIN, B.M., 1986 — "Intercropping of Rotan Manau (*Calamus manan*), with Rubber (*Hevea brasiliensis*)." *Pertanika* 9(2), 161-165 (1986)

SUPARDI, N., AMINUDDIN, B.M., 1991 — "Growth, Node Development and Estimated Yield of Calamus Manan Planted under a Rubber Smallholding". *Pertanika* 14(1) 21-25 (1991)

SUPARDI, N., AMINUDDIN, M.,1992 — "Plantings Systems for large diameter canes." In: *A guide to the cultivation of rattan*. Forest Research Institute Malaysia

SUPARDI, N., NOOR, M., 1992 — "Harvesting of rattans." In: DRANSFIELD, J., RAZALI, W., MANOKARAN, *A guide to the cultivation of rattan*. Forest Research Institute Malaysia.

SUPARDI, N., NOOR, MD., 2001 — *Some Considerations in Species Selection and Rattan Cultivation for Sustaining the Rattan Industry*. In: ZHAOHUA, Z. *Sustainable Development of the Bamboo and Rattan Sectors in Tropical China.* Proceedings No.6 China Forestry Publishing House

TARDJO, S., 1986 — *Pengalaman Pembuididayaan Rotan Dalam Praktek*. Sinopsis Lokakarya Nasional Rotan. 15-16 Dec. 1986 Manggala Wanabakti, Jakarta

UHL, N.W. & DRANSFIELD, J. 1987 — Genera Palmarum*, a classification of palms based on the work of H.E. Moore Jr.* L.H. Bailey Hortorium and International Pam Society, Kansas

VAN TUIL, J.H., 1929 "Handel en Cultuur van Rotan in de Zuideren Oosterafdeeling van Borneo" [Trade and Cultivation of Rattan in the Southern and Eastern divisions of Borneo] *Tectona* 22:695-717. [In Dutch]

VAN VALKENBURG J.L.C.H., 2002 "Rattan in East Kalimantan, Indonesia: Species Composition, Abundance, Distribution and Growth in Some Selected Sites." In: *Rattan Current Research Issues and Prospects for Conservation and Sustainable Development*, FAO Rome

VAN VALKENBURG, J.L.C., 1997 *Non-Timber forest Products of East Kalimantan. Potentials for sustainable forest use*. Tropenbos Series 16. Wageningen. The Netherlands

WEINSTOCK, J.A., 1981 "Rattan: ecological balance in a Borneo Rainforest Swidden". *Economic Botany* 37(1), 1983, pp. 58-68. New York botanical gardens, New York

WIENSTOCK, J., 1983 "Rattan: ecological Balance in a Borneo Rainforest Swidden". *Economic Botany*, 37(1), 983, pp 55-68

WILLIAMS, J.T., 1991 *Research Needs for Bamboo and Rattan to the Year 2000* Tropical Tree Crops Program, International Fund for Agricultural Research

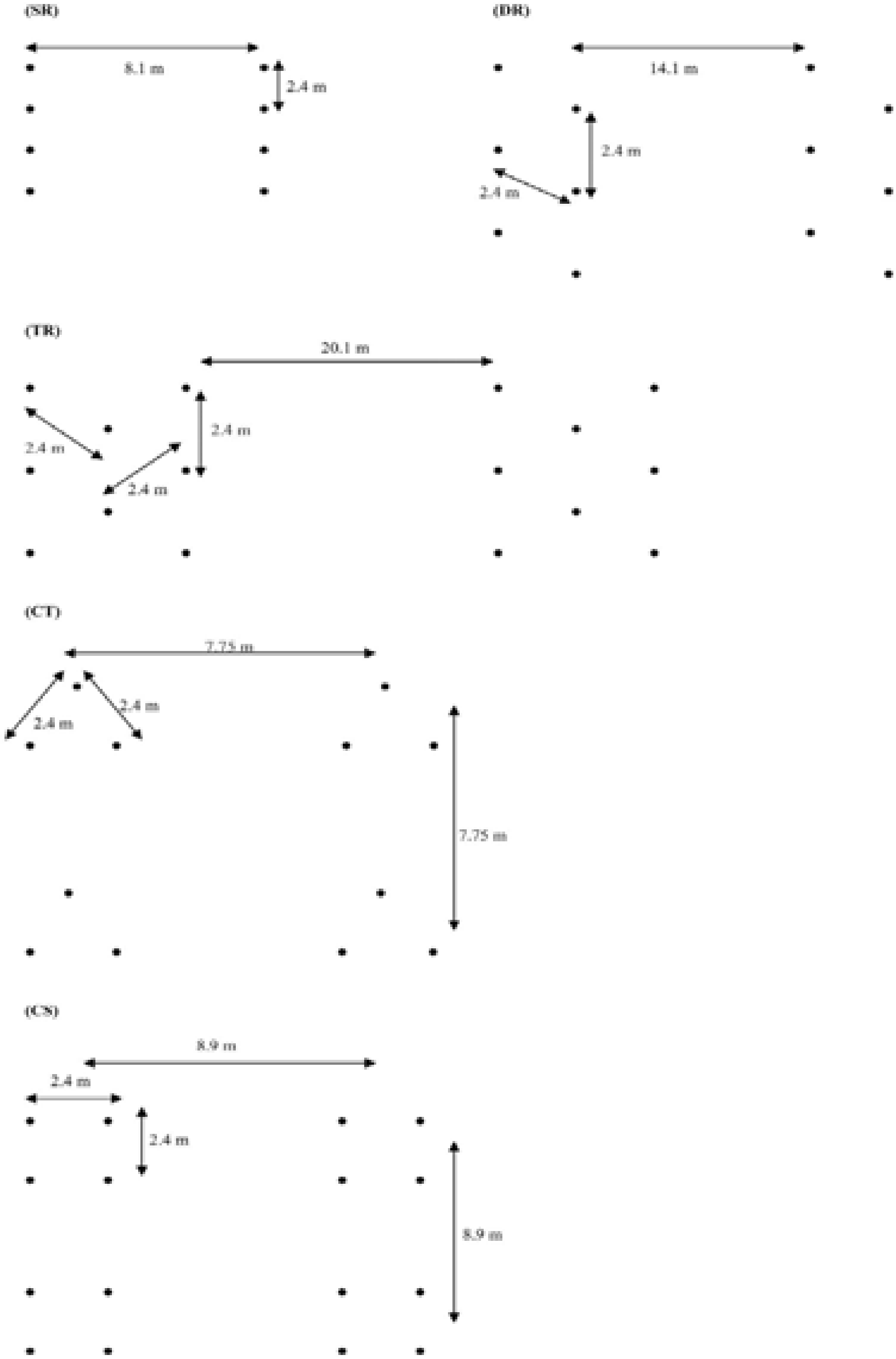
XU ET AL, 1990 *A financial appraisal of rattan plantation development*. Paper presented at the Technical Session of IUFRO XIX World Congress 5-11 August 1990. Montreal Canada.

YIDE, L., WEILIANG, Z., GUANGTIAN Y. & HUANGCAN, X., 2000 "Studies on rattan communities." In: XU, H.C., RAO, A.N., ZENG, B.S. AND YIN, G.T., *Research on Rattans in China - Conservation, Cultivation, Distribution, Ecology Growth, Phenology Silviculture, Systematic Anatomy and Tissue Culture.* IPGRI.

YUSOFF A.M., & MANOKARAN, N., 1985 "Propagation and Nursery Practices Seed and Vegetative Propagation of Rattans." In: *Proceedings of The Rattan Seminar*. The Rattan Information Centre, Forest Research Institute, Kepong, Malaysia

ANNEX I

Rubber Spatial Distribution and Relationship with Light Availability and Latex Production for Intercropping systems



Schematic diagram showing the layout of different spatial arrangements of planting rubber. Codes refer to SR: single row; DR: double row; TR: three row; CT: three plant triangular cluster; CS: four plant square cluster planting systems. Source: Rodrigo (2004)

A study by Rodrigo (2004) aiming at exploring possibilities to determinate suitable rubber spatial arrangements in order to facilitate long time intercropping systems has analized five systems of spatial arrangement with some planting density of rubber (500 plants/ha): (1) single row (SR); (2) double row (DR); (3) three row systems (TR); (4) three plant triangular (CT); (5) four plant square cluster systems (CS). Although in row plantings intercropping was possible only in the inter-rows, in clustering systems intercropping was possible at any side around the clusters. Studies showed that the mean percentage light penetration was 8.5 in SR, 35.3 in DR, 53.9 in TR, 11.5 in CT and 21 in CS. The TR system followed by DR system provided the highest unshaded area, allowing the greatest area for intercropping. However, growth of rubber, particularly in the TR system was reduced resulting in poor yields. In fact latex yield per tapping at individual tree level is significantly different among treatments, with highest values recorded in the SR and CT systems, though the data for CT may be affected by high casualties, which has diminished competition within trees. In the DR and TR systems, latex yield at individual tree level tends to decrease with increased planting density.

Summary of canopy spread in different rubber planting systems

Treatment	7 YAP			8 YAP			9 YAP		
	Unshaded distance (m)	Shaded distance (m)	Unshaded area (%)	Unshaded distance (m)	Shaded distance (m)	Unshaded area (%)	Unshaded distance (m)	Shaded distance (m)	Unshaded area (%)
SR	0.75	3.68	9.23	0.68	3.71	8.41	0.54	3.78	6.72
DR	6.74	3.68	41.62	5.49	4.30	33.90	4.69	4.71	28.94
TR	12.65	3.73	52.05	11.41	4.35	46.95	10.66	4.72	43.86
CT	0.00	2.47	0.00	0.00	2.47	0.00	0.00	2.47	0.00
CS	0.13	3.18	2.86	0.03	3.24	0.51	0.01	3.24	0.31

SR: single row; DR: double row; TR: three row; CT: three plant triangular cluster; CS: four plant square cluster planting systems. Unshaded distance and area indicate the space available between rubber rows/clusters without the canopy cover, with respect to absolute distance and overall ground area, respectively. Shaded distance shows the distance covered by the canopy across the transect from the rubber trees. **YAP** = years after planting. Source: Rodrigo (2004)

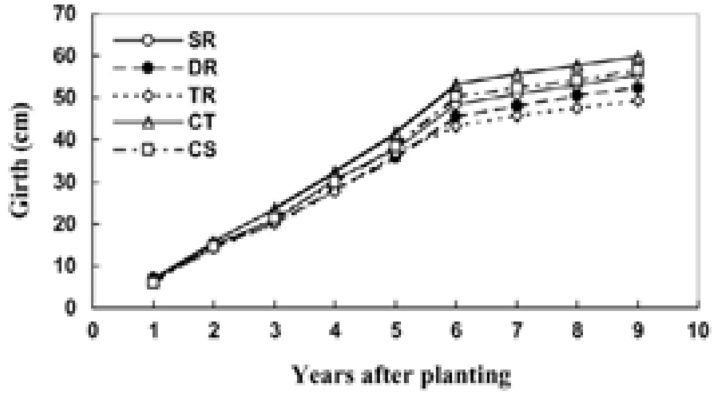
Effect of spatial arrangement of planting rubber on crop establishment and yield

Treatment	Casualties (%)	Weak plants (%)	Plants with TPD (%)	Trees in tapping (%)	Yield per hectare (kg/ha/year)	Yield per tree per day (g/t/t)
Single Row	0.00	0.00	9.29	90.71	1530.20	29.33
Double Row	11.43	2.56	0.00	86.00	1179.93	23.90
Triple Row	10.47	5.13	2.19	82.22	1063.70	22.65
Cluster Triangular	21.11	0.00	1.85	77.04	1379.63	31.12
Cluster Square	12.94	0.00	1.75	85.31	1368.32	28.34

TPD: Tapping panel dryness of rubber trees. Source: Rodrigo (2004)

To summarize, the best planting scheme for rattan seems to be the three row, as an average luminosity of 45-50% is guaranteed. The cramped planting scheme affects somehow latex production with an estimated reduction both in trees in tapping (-10%) and yield per hectare (about

– 30%). Spatial distribution also affects rubber tree growth as the following diagram on girth increase shows. Unfortunately the study does not make any estimate on rubber height, which could have helped in implementing the studies on plantation timings, though clones could be chosen to overcome some growth deficits.



In conclusion a triple row planting scheme seems to be the best compromise between light requirements and latex production. However further studies should verify rattan density within the rubber inter-row space and the potential reduction of latex production for nutrients competition with intercropped species.

ANNEX II

Yield Estimate of Most Diffuse Rattan Species

Calamus caesius (Rotan Sega) Yield and gross revenue per ha

Year after planting	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Surviving clusters	625	600	580	560	540	520	510	500	500	500	500	500	500	500	500
Accum. stem no./cluster	1	3	6	10	15	20	30	40	45	45	45	45	45	45	45
Harvestable stem no./cluster									2	3	4	6	6	6	6
Total harvestable cane length/stem-m									17.5	17.5	17.5	17.5	17.5	17.5	17.5
Total cane length – m/ha									17500	26250	35000	52500	52500	52500	52500
Total weight of dry canes - tonne/ha	0								0.486	0.729	0.972	1.458	1.458	1.458	1.458

Year after planting	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Surviving clusters	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Accum. stem no./cluster	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
Harvestable stem no./cluster	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Total harvestable cane length/stem-m	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5
Total cane length - m/ha	52500	52500	52500	52500	52500	52500	52500	52500	52500	52500	52500	52500	52500	52500	52500
Total weight of dry canes - tonne/ha	1.458	1.458	1.458	1.458	1.458	1.458	1.458	1.458	1.458	1.458	1.458	1.458	1.458	1.458	1.458

Source: Feaw (1992)

Calamus trachycoleus (Rotan Irit) - Yield and gross revenue per ha

Year after planting	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**I3**	**I4**	**15**
Surviving clusters	500	480	460	440	430	420	410	400	400	400	400	400	400	400	400
Accum. stem no./cluster	1	3	6	t0	20	30	40	50	60	60	60	60	650	60	60
Harvestable stem no./cluster								2	3	4	10	10	10	10	10
Total harvestable cane length/stem-m								20	20	20	20	20	20	20	20
Total cane length - m/ha								16000	24000	32000	80000	80000	80000	80000	80000
Total weight of dry canes - tonne/ha								0.381	0.571	0.762	1.905	1.905	1.905	1.905	1.905

Year after planting	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Surviving clusters	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Accum. stem no./cluster	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Harvestable stem no./cluster	10	10	10	10	10	10	10	I0	I0	10	10	10	I0	10	10
Total harvestable cane length/stem-m	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Total cane length - m/ha	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000
Total weight of dry canes – tonne/ha	1.905	1.905	1.905	1.905	1.905	1.905	1.905	1.905	1.905	1.905	1.905	1.905	1.905	1.905	1.905

Source: Feaw (1992)

Calamus manan (Rotan Manau) - Yield of Total Harvest – Year 12

Rotation of 12 years	Growth rate (m/year)								Total (per ha)
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	
No. of rattan harvested					104	52	26	10	192
length of rattan (m)					30.0	36.0	42.0	48.0	
Length of discarded stem (m)					8.0	8.0	8.0	8.0	
Length of stem collected (m)					22.0	28.0	34.0	40.0	
No. of sticks (3m length)					7	9	11	13	
Odd length rattan (m)					1.0	1.0	1.0	1.0	
Total no. of sticks/ha					**728**	**468**	**286**	**130**	**1612**
Total amount of odd length (m/ha)					104	52	26	10	192
Total marketable length (m/ha)					2288	1456	884	400	**5028**

Diameter (mm)									**Total (per ha)**
No. of stick - 18-24					104	52	26	10	**192**
No. of stick - 25-29					208	104	52	20	**384**
No. of stick - 30-34					104	52	26	10	**192**
No. of stick - 35-39					312	260	130	50	**752**
No. of stick - 40 & above							52	40	**92**
Odd length 25-29									
30-34									
35-39					104	52			156
40 & above							26	10	36

Source: Aminuddin (1992)

Legend

No. of rattan harvested	
length of rattan (m)	(12 years) x (growth rate)
Length of discarded stem (m)	8 m (standardized)
Length of stem collected (m)	(Length of rattan) - (discarded stem)
No. of sticks (3m length)	(Length of stem collected) / (3 m)
Odd length rattan (m)	(Length of stem collected) - (number of sticks x 3)
Total no. of sticks/ha	(No. of rattan harvested) x (No. Sticks)
Total amount of odd length (m/ha)	(Odd length rattan) x (No. Rattan harvested)
Total marketable length (m/ha)	(Total no. of sticks/ha) x 3

Calamus manan (Rotan Manau) - Yield of Total Harvest – Year 15

Rotation of 15 years	Growth rate (m/year)								Total (per ha)
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	
No. of rattan harvested	42	52	78	156	104	52	26	10	520
Length of rattan (m)	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	
Length of discarded stem (m)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	
Length of stem collected (m)	-	7.0	14.5	22.0	29.5	37.0	44.5	52.0	
No. of sticks (3m length)		2	4	7	9	12	14	17	
Odd length rattan (m)		1.0	2.5	1.0	2.5	1.0	2.5	1.0	
Total no. of sticks/ha		**104**	**312**	**1092**	**936**	**624**	**364**	**170**	**3602**
Total amount of odd length (m/ha)		52	195	156	260	52	65	10	790
Total marketable length (m/ha)		**364**	**1131**	**3432**	**3068**	**1924**	**1157**	**520**	**11596**
Diameter (mm)									**Total stick**
No. of stick - 18-24		52	78	156	104	52	26	10	478
No. of stick - 25-29		52	156	312	208	104	52	20	904
No. of stick - 30-34			78	156	104	52	26	10	426
No. of stick - 35-39				468	520	260	130	50	1428
No. of stick - 40 & above						156	130	80	366
Odd Length 25-29		52							52
30-34			195						195
35-39				156					156
40 & above					260	52	65	10	387

Source: Aminuddin (1992)

Legend

No. of rattan harvested	
length of rattan (m)	(15 years) x (growth rate)
Length of discarded stem (m)	8 m (standardized)
Length of stem collected (m)	(Length of rattan) - (discarded stem)
No. of sticks (3m length)	(Length of stem collected) / (3 m)
Odd length rattan (m)	(Length of stem collected) - (number of sticks x 3)
Total no. of sticks/ha	(No. of rattan harvested) x (No. Sticks)
Total amount of odd length (m/ha)	(Odd length rattan) x (No. Rattan harvested)
Total marketable length (m/ha)	(Total no. of sticks/ha) x 3

ANNEX III

Potential value of timber within rattan garden in Muara Bomboy calculated on the base of local prices in West Kutai. Source: Matius (2004) Modified

Timber					Rattan	
Site	Age and treatment	Diameter classes	Vol (m3/ha)	Average PV/ha/year ($)	Average PV/ha/year ($)	Total Timber + Rattan PV/ha/year ($)
Alluvial	LT (80-yrs)	50 cm up	160	-	-	
		10-49 cm	94.8	29.45	87.85	117.30
	MT (30yrs)	10-49 cm	80	12.05	87.85	99.90
	MT (50yrs)	50 cm up	2	-	-	
		10-49 cm	53.6	5.325	87.85	93.18
	HT (80yrs)	50 cm up	24.8	-	-	
		10-49 cm	24.8	5.13	87.85	92.99
	Average			**12.98**	**87.85**	**100.84**

Terrestrial	LT (15yrs, hill)	10-49 cm	40	12.05	105.43	117.48
	LT (35yrs, hilly)	50 cm up	51.4	-	-	
		10-49 cm	127.3	28.16	105.43	133.59
	LT (50yrs, flat)	50 cm up	86.2	-	-	
		10-49 cm	113	34.13	105.43	139.55
	LT (60yrs, hilly)	50 cm up	95.1	-	-	
		10-49 cm	125.3	28.54	105.43	133.96
	MT (60yrs, flat)	50 cm up	90.4	-	-	
		10-49 cm	60.4	24.76	105.43	130.19
	HT (30yrs hilly)	50 cm up	2.8	-	-	
		10-49 cm	33.2	6.13	105.43	111.55
	HT (60yrs, hilly)	50 cm up	3.1	-	-	
		10-49 cm	44.3	3.96	105.43	109.39
	Bo (45-60yrs)	50 cm up	27.1	-	-	
		10-49 cm	53.8	9.49	105.43	114.91
	Average			**18.40**	**105.43**	**123.83**

LT: Less treatment means the farmers only weed around the rattan clusters while harvesting the garden without cutting or only cutting one to a few trees that throw shade on the rattan. Less treated garden have many tall trees and closed canopy in old and young rattan garden. **MT:** Moderate treatment Farmers weed around rattan clusters, to cut or girdle more trees that are shading rattan clusters and remove invaluable trees (less than 20% of tall trees). **HT:** Heavy treatments Farmers cut or girdle more than 20% of the dense crown and invaluable tall trees. The garden are more open in upper layer, because the canopy of tall trees is decreased much. **(€/$ rate of 1.25** from Matius's figures**)**

Source: Matius (2004) - modified

ANNEX IV

Gross year revenue of most diffuse rattan species based on Feaw models

Calamus caesius (Rotan Sega) Yield and gross revenue per ha

Year after planting	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Total cane length - m/ha									17500	26250	35000	52500	52500	52500	52500
Total weight of wet canes - tonne/ha	0	0	0	0	0	0	0	0	0.972	1.458	1.944	2.916	2.916	2.916	2.916
Total market value /metric tonne ($)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	97.20	145.80	194.40	291.60	291.60	291.60	291.60

Year after planting	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Total cane length - m/ha	52500	52500	52500	52500	52500	52500	52500	52500	52500	52500	52500	52500	52500	52500	52500
Total weight of wet canes - tonne/ha	2.916	2.916	2.916	2.916	2.916	2.916	2.916	2.916	2.916	2.916	2.916	2.916	2.916	2.916	2.916
Total market value /metric tonne ($)	291.60	291.60	291.60	291.60	291.60	291.60	291.60	291.60	291.60	291.60	291.60	291.60	291.60	291.60	291.60

Dry canes weight 50% of the wet ones Price of canes 0.1 $/kg (Price from: West Kutai Regency Forestry Office 2002 – Matius, 2004)

Calamus trachycoleus (Rotan Irit) Yield and gross revenue per ha

Year after planting	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**I3**	**I4**	**15**
Total cane length - m/ha								16000	24000	32000	80000	80000	80000	80000	80000
Total weight of wet canes - tonne/ha	0	0	0	0	0	0	0	0.762	1.142	1.524	3.81	3.81	3.81	3.81	3.81
Total market value /metric tonne ($)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	57.15	85.65	114.30	285.75	285.75	285.75	285.75	285.75

Year after planting	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Total cane length - m/ha	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000
Total weight of wet canes - tonne/ha	3.810	3.810	3.810	3.810	3.810	3.810	3.810	3.810	3.810	3.810	3.810	3.810	3.810	3.810	3.810
Total market value /metric tonne ($)	285.75	285.75	285.75	285.75	285.75	285.75	285.75	285.75	285.75	285.75	285.75	285.75	285.75	285.75	285.75

Dry canes weight 50% of the wet ones Price of canes 0.1 $/kg (Price from: West Kutai Regency Forestry Office 2002 – Matius, 2004)

PLATE 1

Fig 1 – *Calamus manan* in a trial plot

Fig 2 - The sheaths of *Calamus manan*

Fig 3 – *Calamus manan* in logged-over forest

PLATE 2

Fig 4 - The stoloniferus habit of *Calamus trachycoleus*

Fig 5 - The close clumping habit of *Calamus caesius*

PLATE 3

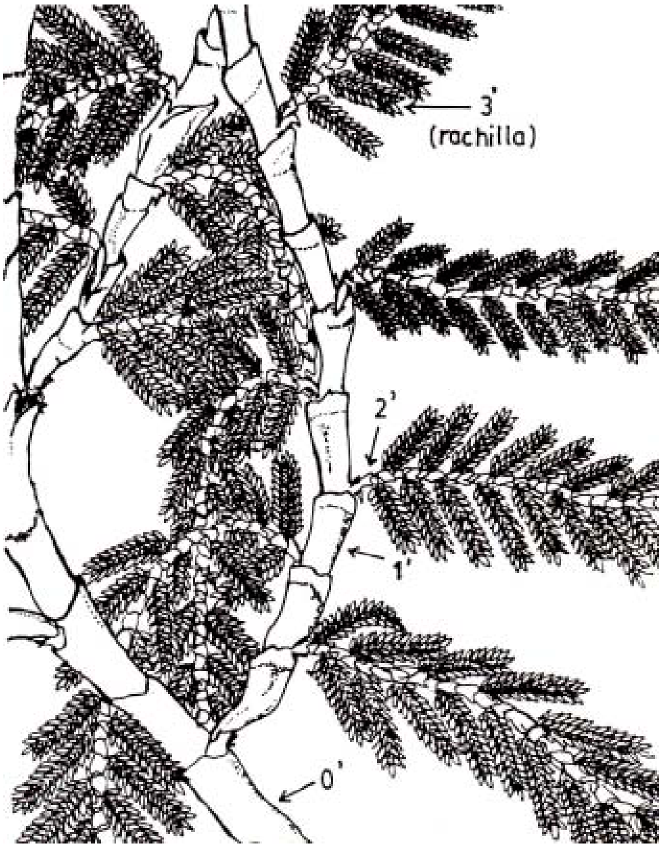


Fig 6 - *Calamus* sp. part of male inflorescence with three orders of branching

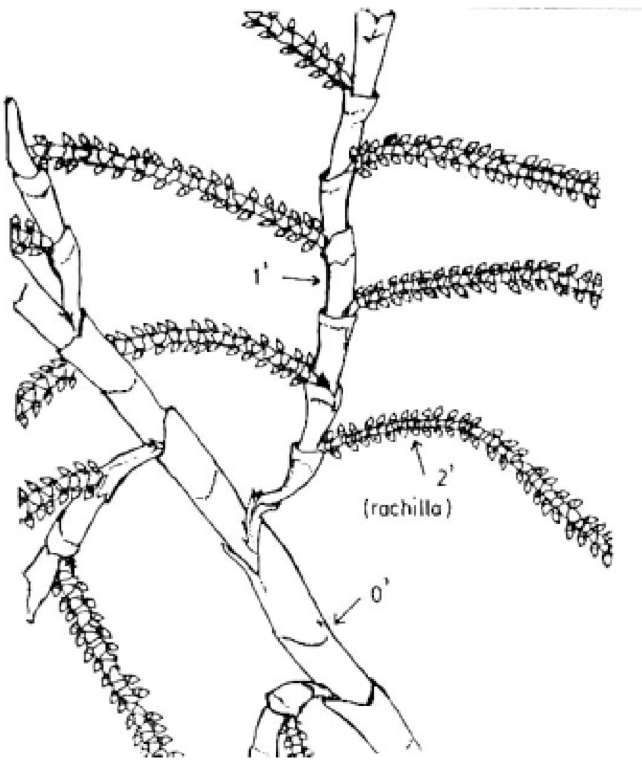


Fig 7 - *Calamus* sp. part of female inflorescence with two orders of branching

PLATE 4

Fig 8 – Part of the inflorescence of *Plectocomia dransfieldiana*

Fig 9 – *Ceratolobus subangulatus*: the inflorescence has only one bract

Fig 10 – Fruits of *Plectocomiopsis mira* with overlapping reflexed scales

PLATE 5

Fig 11 – Fruits of haxapantic rattan

Fig 12 – Fruits of *D. micracantha* covered in red resin (dragon's blood)

Fig 13 – rattan seedlings in seedbed ready for transplanting into polibags

PLATE 6

Fig. 14 – Polibags nursery with palm leaves as shade

Fig 15 – Field planted rattan

PLATE 7

Fig 16 – Rattan-rubber intercropping

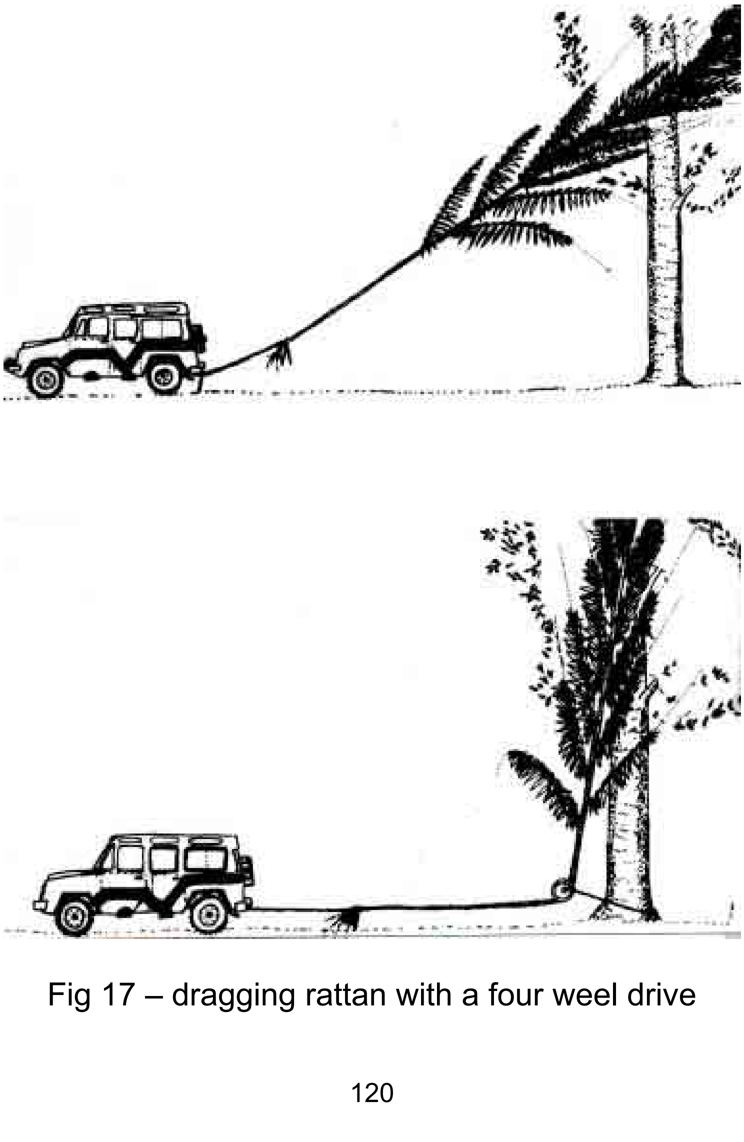


Fig 17 – dragging rattan with a four weel drive

PLATE 8

Fig 18 – removing the sheath using the chopper

Fig 19 – *C. caesius* being runtied through a block of wood

PLATE 9

Fig 20 – Drying canes

Fig 21 – Washing process

PLATE 10

Fig 22 – Grading

Fig 23 – Splitting

PLATE 11

Fig 24 - loading and transporting

Fig 25 – steaming process

PLATE 12

Fig 26 – Bending process

Fig 27 – Assembling process

PLATE 13

Fig 28 – Weaving process

Fig 29 - Rattan staff A.D. 1650 - 17.6 x 2.8 cm Musei Vaticani, Vatican City

PLATE 14

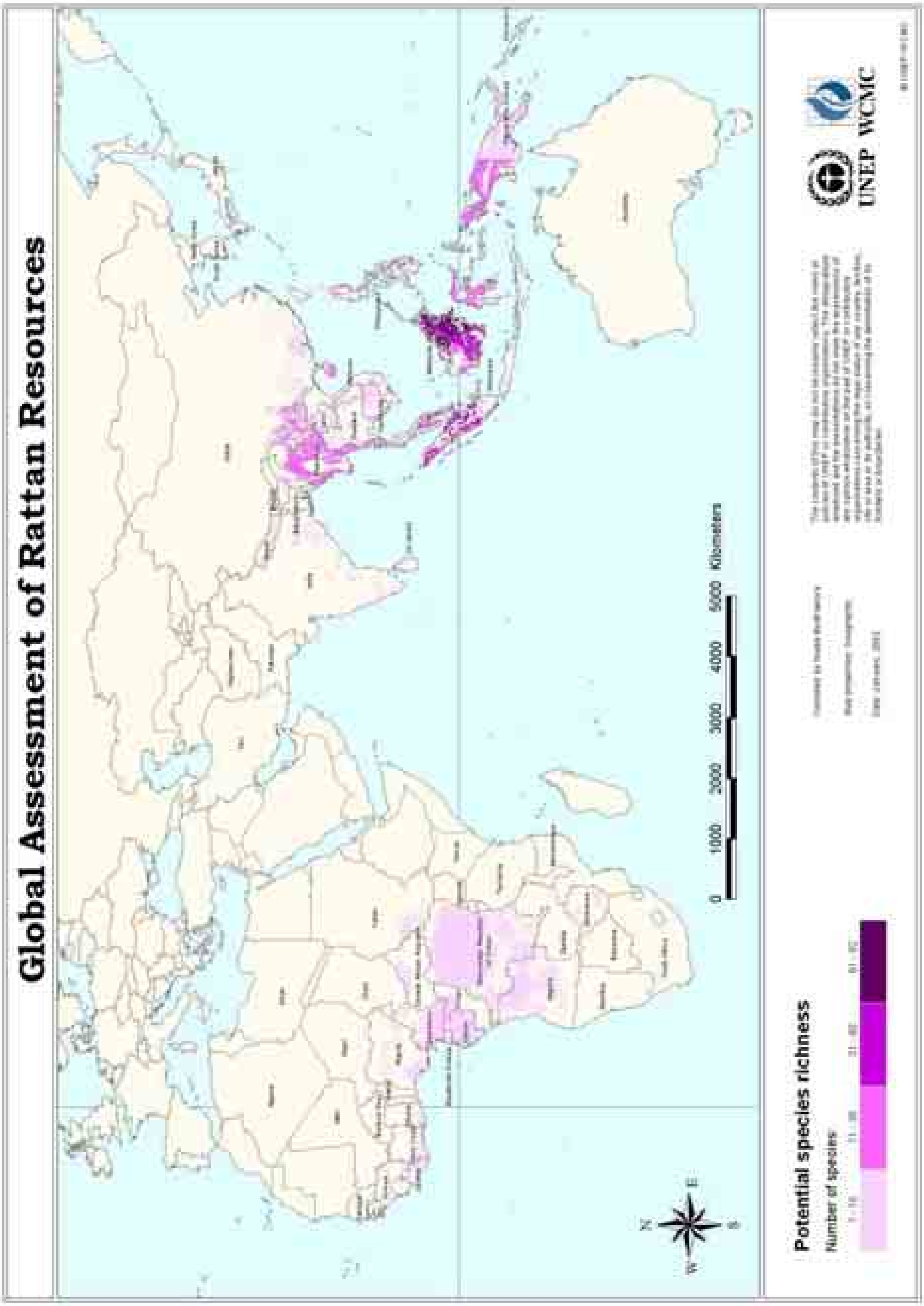


Fig 30 – Global assessment of rattan resources