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# Hidden economies, future options: trade in non- timber forest products in eastern Indonesia

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**77**

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# **Hidden economies, future options: trade in non-timber forest products in eastern Indonesia**

A.B. Cunningham, W. Ingram, W. Daos Kadati, J. Howe, S. Sujatmoko, R. Refli,  
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Cover: A palm sap tapper weaving a basket from a *lontar* (*Borassus flabellifer*) palm leaf. The basket is used to collect palm sap that drips from tapped flower stalks.  
(Photo: A.B. Cunningham)

## Foreword

For 25 years, the Australian Centre for International Agricultural Research (ACIAR) has worked in Indonesia with local partner organisations, carrying out adaptive research and extension in agriculture, forestry and fisheries to better link with major domestic and international markets. This report analyses a broad range of non-forest timber products to identify those that could be developed into a wider industry to improve the incomes and livelihoods of farmers and agribusiness in the East Nusa Tenggara (ENT) province of eastern Indonesia. It is the outcome of an ACIAR scoping study undertaken through the Support for Market-driven Adaptive Research (SMAR) program and will inform future targeting of research in this area.

Trade in wild-harvested plant resources from ENT is not new. Several products from local tree species have been part of a global trade for centuries, including sandalwood, once the major export from Timor, and *gaharu* (*Aquilaria*) resin, which has a long history of trade to the Arabian Peninsula, China and Japan, where it is prized as incense. Various introduced species have also contributed to successful local production systems, such as tamarind (pulp). But this report shows that there is also great potential to use the tamarind seeds to produce xyloglucan, which is widely used in the food and pharmaceutical industries. Currently, the seeds are fed to pigs or discarded.

There are three key aspects to this report. First, it uncovers the ‘hidden economy’ of informal-sector producers and traders. Unrecognised in official statistics, the informal sector is a significant source of income to millions of rural households. Second, it does not address mainstream commercial crop species like coffee, citrus, mangoes or mangosteens, which are a common focus of rural development. Instead, it examines a much wider diversity of plant products. Many of these plants—and particularly the deep-rooted local tree species—thrive in places where ‘standard’ crops would not survive due to the effects of droughts, long dry seasons, fire or browsing by livestock. Third, this study not only provides insight into the diversity of plant products in trade, but also the fortitude, resilience and local knowledge of the people who process or sell them.

Good examples of these trees are *lontar* palms (*Borassus flabellifer*) and *kesambi* (*Schleichera oleosa*). Able to survive in tough conditions, these and many other multi-use trees provide a ‘green social security’ to many people. Products identified here include oils, food and drinks, stimulants, fibres for basketry, textile dyes, and even a species that can garner a high price in bonsai form. This wide diversity of plant products also provides people—particularly

women—with an income which, although small, enables thousands to pay for household basics or children’s education. Blending primary research, field experience and an extensive literature review, this study provides an excellent synthesis of current uses and makes practical recommendations for the future.

A handwritten signature in black ink, appearing to read 'Nick Austin', with a long horizontal stroke extending to the right.

Nick Austin  
Chief Executive Officer  
ACIAR

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# Abbreviations

A\$	Australian dollar	NTFP	non-timber forest product
ACIAR	Australian Centre for International Agricultural Research	Rp	Indonesian rupiah
Al	aluminium	SADI	Smallholder Agribusiness Development Initiative
ENT	East Nusa Tenggara	t	tonne
EU	European Union	USA	United States of America
FORDA	Forestry Research and Development Agency (Indonesia)	USAID	United States Agency for International Development
GDP	gross domestic product	WATH	West Africa Trade Hub (program of USAID)
ha	hectare	YPBB	<i>Yayasan Pecinta Budaya Bebal</i> (Foundation for Sustainable Culture and Livelihood)
kg	kilogram		
L	litre		
NGO	non-government organisation		

# Introduction

Micro-enterprise development is widely recognised as important in many developing countries, where self-employment helps create economic opportunities for low-income households with limited employment options or earning power (Woller 2004). While most assessments of medium, small and micro-enterprises have dealt with the manufacturing, mining, agricultural or timber sectors, it is only recently that comparative studies have been carried out on the non-timber forest product (NTFP) sector. These studies of NTFPs commercially traded in Asia, Africa or Latin America have all cautioned against undue optimism (Ruiz-Pérez et al. 2004; Kusters et al. 2006; Marshall et al. 2006), with Belcher and Schreckenberg (2007) calling for a ‘reality check’ on what these micro-enterprises can, or cannot, deliver. Similarly, Wunder (2001) has suggested that forms of land use other than sustainable harvest of NTFPs from tropical forests may provide a better route out of poverty than forest-based enterprises. While this is likely on soils with high arable potential, land-use options in regions with low arable potential are more complex, with indigenous plants playing a crucial role as social safety net and source of income (Cunningham 1985; Shackleton 2005).

This technical report details the findings of an Australian Centre for International Agricultural Research (ACIAR) scoping study entitled ‘Enterprise development, value chains and evaluation of non-timber forest products for agroforestry systems in West Timor, Flores, Sumba and Savu, eastern Indonesia’ (Project No. SMAR/2006/011) and is relevant to several of ACIAR’s programs in Indonesia. While an important goal of the research was to identify community-based agroforestry systems for income generation in eastern Indonesia, it also has relevance to other ACIAR Indonesia program and subprogram priorities from the past and present. These include:

- **Subprogram 1 (*Improved policies to underpin agribusiness development*)**, with the SMAR/2006/011 study identifying some policy barriers and suggesting policy reforms that could improve entry of smallholder farmers into commercial markets

- **Subprogram 3 (*Research to underpin the development of competitive horticultural agribusinesses*)**, which has ACIAR funding for work on avocado varieties (with production of avocado oil as a niche-market export product being one of the recommendations of this study that gets around quarantine barriers a lot easier than fresh fruit)
- **Subprogram 4 (*Profitable smallholder aquaculture and agroforestry systems*)**, through recommendations for agroforestry species taking cultural preferences and local, inter-island or international markets into account
- **Subprogram 5 (*Sustainable use and management of fisheries and profitable utilisation of forestry resources*)**, through a link to decentralised community forest management
- **Subprogram 6 (*Profitable agribusiness systems for eastern Indonesia*)**—this research complements the overall Smallholder Agribusiness Development Initiative (SADI) program (part of the Australia–Indonesia Partnership of Reconstruction and Development), which has focused on ‘mainstream’ products, whether in horticulture (cashew nut, cocoa, coffee, mango, citrus, passionfruit) or mariculture (lobster, seaweed). In contrast, through studying products sold in local marketplaces, plus other NTFPs in national and international trade, this study identifies a range of products for industry development that have not received much attention in the SADI program.

This report presents the results of a 2-year study conducted in East Nusa Tenggara (ENT), Indonesia’s driest and poorest province. Most of the province’s 4.3 million people (2004 population) are involved in small-scale farming, which accounted for 35% of provincial gross domestic product (GDP) in 2003 (Barlow and Gondowarsito 2009). Spread across 17 districts (*kabupaten*), 194 subdistricts (*kecamatan*) and about 2,600 villages (*desa*), ENT is culturally diverse, with 40–50 local languages (Lewis 2009).

In the past, studies of policies, trade and price reforms have focused on short-term crops rather than trees, despite the fact that agroforests in humid

tropical forests of Brazil (Vosti et al. 2001), Cameroon (Gockowski et al. 2001) and Indonesia (Tomich et al. 2002) were found to provide some of the most profitable land uses. Given short-term crop vulnerability to climate change, commercially valuable products from deep-rooted, longer lived trees in dry forests and woodlands may be even more significant. Barlow and Gondowarsito (2009) point out that there are two complementary paths to poverty alleviation in ENT: first, to improve infrastructure and services; and second, to improve production techniques and marketing.

Economic links to global markets through trade in natural products from trees are not a recent development in ENT. Maritime trade routes integrated high-value NTFPs into the world economy from at least the 12th century, with the sandalwood (*Santalum album*) trade to China. Trade in *Aquilaria malaccensis* (*gaharu*) resin-impregnated wood has a long history in the region. The sandalwood and *gaharu* trade were both built on 'resource mining' what were then substantial wild stocks of these species. Only remnant populations remain today, offering useful lessons from history and the need to shift from weak tenure and wild harvest to agroforestry production or, in some cases, community-based forest management. The management plan developed for the forest with remnant *Symplocos* populations (YPBB 2008) is a positive example of the latter.

Since at least the 19th century, development interventions in Indonesia based on trees for timber (such as the 1847 teak management system in Java) or the early introduction of tree crops (such as coffee, cocoa and tea) have undoubtedly played a critical role in economic growth in Indonesia. It is widely recognised, however, that a wider range of commercial products from trees needs to be considered, given overproduction and declining profitability of several mainstream commodities (Garrity 2004). Apart from a 1990 marketplace study of fruits sold in Pontianak, West Kalimantan (Arman 1996), we are not aware of other ethnobotanical studies conducted of informal-sector trade in forest and agroforestry products in local marketplaces in Indonesia. The flora of ENT is poorly known and undercollected by botanists. In the Wallacea biogeographical region within which ENT is located, Conservation International (2008) estimates that there are about 10,000 species of vascular plants, with roughly 1,500 endemic species (15%) and at least 12 endemic genera. From a biogeographical perspective, the largest island (Timor)

has the highest endemism (10.3%; Monk et al. 1997), but how much of this is split between West and East Timor is unknown. What is known is that, in addition to these indigenous species, there has been a very long history of introduction and adoption of plants into farming systems in ENT. *Areca catechu* (*pinang*), *Piper betle* (betel vine, *sirih*), *Aleurites moluccana* (candlenut or *kemiri*) and *Inocarpus* (Polynesian chestnut), found in archaeological remains in a cave on Timor dated at 5,000–14,000 BP (Glover 1977), are all likely to have been pre-colonial introductions. *Psidium guajava* (guava), *Anacardium occidentale* (cashew) and *Zea mays* (maize) were introduced into ENT by the Portuguese in the 1500s (Fowler 2005). The overarching question behind this study was which plant species, among this diverse indigenous flora, supplemented by a long history of species introductions, have the most potential for enterprise development today?

After outlining the study's objectives and the methods we used, we start by providing the background context to the study from an economic geography perspective. This categorises different types of trade in the non-timber products from forests and agroforestry systems in ENT. With this background, the main body of the report presents the 'winning' categories of plants. These are forest and agroforestry species in five product categories: plant oils and polysaccharides, food and drinks, stimulant plants, cultural arts products (basketry and textile dyeing) and horticultural plants.

## Objectives

This scoping study had two overall objectives:

- identify NTFP species whose economic and production (growth, silvicultural) characteristics make them suitable for incorporation into agroforestry systems
- assess the economic potential of the most promising products, prioritising species with potential for incorporation into agroforestry systems.

These objectives were achieved by focusing on four research goals:

- gain a better understanding of which wild, managed and domesticated species have 'winning' characteristics and are (or can be) produced and processed into products with local, regional or international market potential
- identify a short list of the most viable species linked to a short-term production and marketing

strategy so that high-quality products are also available in sufficient quantity based on smallholder production

- develop medium- and long-term strategies that surmount barriers to trade and engage smallholder farmers, both men and women, into strategies which, in the case of external markets, also link to certification systems—these are discussed within individual categories of products, such as palm sugar and honey
- provide training and capacity building in quantitative ethnobotanical surveys of markets as a basis for product selection. This was carried out during a training workshop in Kupang (the provincial capital of ENT) at the start of the research study, followed by back-up support during field visits.

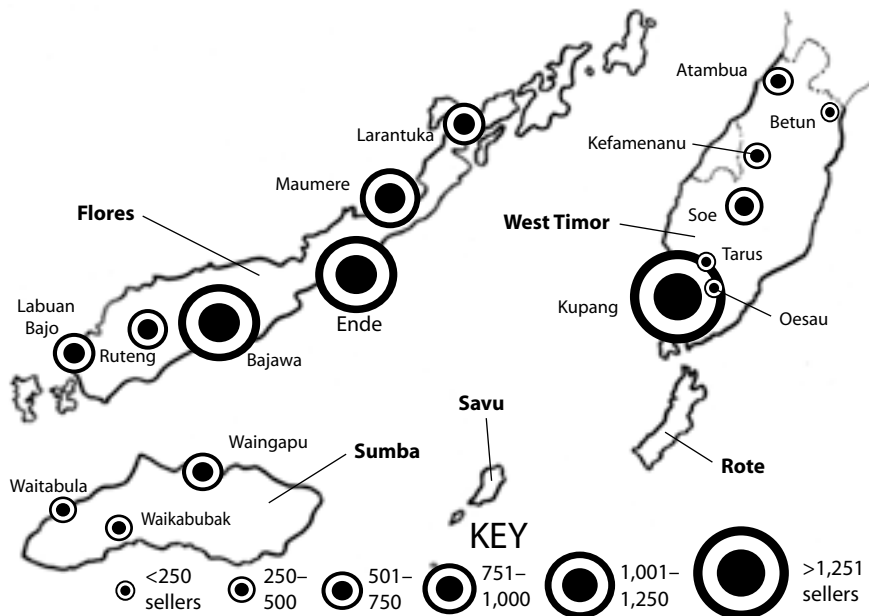
# Methods

Systematic surveys of local markets are widely acknowledged to be a good way of identifying and gaining insight into plant species that have commercial value in local livelihoods (Leakey and Ladipo 1996; Cunningham 2001). These may have already been domesticated or may be wild species with a high potential for domestication. The methods used in this study followed those described in Cunningham (2001), making an effort to understand the trade in forest and agroforestry products from a systems perspective.

International trade data were obtained from published literature. As project partners, the staff of the Forestry Research and Development Agency (FORDA) office in West Timor collated official statistics on agroforestry products and NTFPs (such as

honey and lac) for which data were available. In addition, Threads of Life—an organisation that supports and promotes Indonesian textile weavers—provided access to their data on sales of high-quality baskets and handwoven textiles.

We also collected primary data on the informal-sector trade in local marketplaces on Flores, Savu, Sumba and in West Timor. These data were collected by young graduates from Universitas Nusa Cendana, supported by two of us (Refli Refli and Willy Daos Kadati), all of whom attended a training course in marketplace survey methods and the field-testing of questionnaires. The process of mapping and classifying markets was used to guide research design, providing a basis for deciding on which marketplaces we could afford to sample in terms of the time and



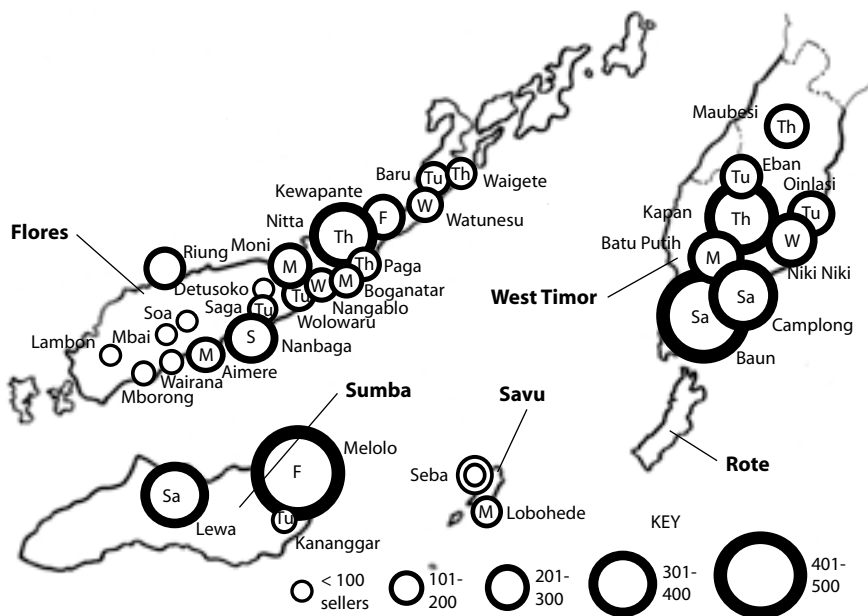
**Figure 1.** The relative sizes (by number of sellers) of informal-sector daily markets on Flores, Sumba and West Timor. Together with the periodic (weekly) markets shown in Figure 2, these form a major outlet for informal-sector marketing of agricultural surplus, agroforestry and forest products other than sandalwood and *gaharu*.

funding available. These are shown in Figure 1 for permanent (= daily) markets and include counts of the numbers of sellers in the different marketplaces. Due to likely differences between wet-season and dry-season production of forest and agroforestry products, surveys were done of the same markets during both seasons.

The market schedules were recorded for the weekly markets so that the timing of marketplace surveys could be planned properly (Figure 2). Local knowledge was very useful in this process. Systematic classification of these marketplaces, their schedules and the types of traders within them was an important step in understanding the network of harvesting and trade, such as trade in *Areca catechu* (pinang) and *Piper betle* (sirih).

Three markets were surveyed on Flores (Bajawa, Ende and Maumere); two on the small, remote island of Savu (Seba and Lobohe); six on Sumba (Waitabula, Waingapu, Waikabubak, Melolo, Lewa and Kananggar); and 17 in West Timor (Naikoten and Oeba markets in Kupang, Oinlasi, Oesau, Niki Niki, Maubesi, Kapan, Soe, Eban, Camplong, Batu Putih, and Baun).

Betun, Baun, Batu Putih, Baru Kefa and Lama Kefa in Kefamenanu, Atambua and Tarus). Counts of all the traders in different categories also provided a background context to the relative importance of forest and agroforestry products compared with other categories (such as vegetables, fish or second-hand clothes). In terms of this broader context, 11,428 market sellers were surveyed: 3,242 on Flores (28.4%), 2,192 on Sumba (19.2%), 5,874 in West Timor (51.4%) and 120 on Savu (1%). Data collection forms were developed, field-tested and then modified before use. All interviews with sellers and traders were conducted either in local languages or in Bahasa Indonesia.



**Figure 2.** The relative sizes (by numbers of sellers) and schedules of periodic (weekly) markets on the four islands where this study took place, indicating when the markets are held. On Savu, the Seba market schedule depends on the ferry schedule, so is more flexible.

Note: M = Monday, Tu = Tuesday; W = Wednesday; Th = Thursday; F = Friday, Sa = Saturday, S = Sunday

# Commercial enterprise and the importance of the informal sector in context

This report describes a range of enterprises based on forest and agroforestry products from four islands (West Timor, Sumba, Flores and Savu). Most are informal-sector ‘hidden economies’ that are not documented by official trade data. In several ways, we hope that this report adds to the work being done by the SADI program, a A\$38 million program (for Phase I) that has been taking place in South Sulawesi, South-East Sulawesi, ENT and West Nusa Tenggara. The World Bank’s International Finance Corporation, which works with the SADI program, aims to improve the incomes and living standards of rural households in eastern Indonesia through closer integration with the commercial sector. Their focus is on small–medium enterprises and mainstream agricultural products, such as coffee, cocoa and other fruits (banana, citrus, mango, mangosteen) and crops such as peanut, potato and chilli. These focal agribusinesses are then linked to leading formal-sector companies. By contrast, many of the enterprises that are the focus of this report are micro-enterprises. Some question, ‘Why bother with non-timber forest products and an informal-sector hidden economy?’ We suggest six reasons why this focus is worthwhile.

**1. There is a need for enterprise development models that are tailored to local conditions.** Resosudarmo and Jotzo (2009) point out in their recent book on environment and development in eastern Indonesia, ‘Rather than adopting the Java development model... eastern Indonesia needs its own development path—one that takes local conditions, local economic and social structures and local patterns of resource use and interaction with the local environment into account’.

**2. Looking beyond mainstream commodity crops like coffee, cocoa and citrus to a range of other commercial products for niche markets has at least three advantages in eastern Indonesia.** First, mainstream products that are the focus of rural development efforts in eastern Indonesia are all produced

by competitor countries. All have experienced major price changes due to altered patterns of global trade. Coffee is a good example: market liberalisation, corporate consolidation, breakdown of the International Coffee Agreement in 1989 and a worldwide coffee glut reduced coffee prices to their lowest levels in a century (Ponte 2002). Second, although trade volumes are smaller for niche-market products compared with mainstream agribusiness commodities, there can be higher growth potential in these niche markets. On a global scale, growth in markets for cosmetic oils (see the ‘Plant oils and polysaccharides’ chapter) is a good example. Within eastern Indonesia, the 67% annual growth in the market for handwoven, naturally dyed textiles is another (see the ‘Cultural heritage and arts’ chapter). Third, the harvest and sale of non-timber products from agroforestry systems and forests are more flexible in terms of local livelihoods and much less capital intensive than commercial coffee or cocoa production. This fits into a common household strategy in drought-prone areas where farmers often prefer to minimise risk through being involved in a range of activities rather than maximise gain by focusing on one commodity. Over 30 years ago, Fox (1977) pointed this out in terms of the *Borassus flabellifer* (lontar) palm economy:

A lontar economy, by contrast, is unusual not only because of its special mode of production but because of its diversity. Most Rotinese and Savunese simultaneously are tappers, farmers, fishermen and herders, while Ndaonese are tappers and goldsmiths. The lontar is the pivot. Without it, subsistence would be as precarious as on Timor. But lontar production provides (a) time to engage in a variety of activities, (b) the ability to alter, at some risk, other aspects of the economy and, with this ability, (c) the means to adapt these subsystems, in a reasonably short time, to changing conditions. Rather than some monolithic whole, a lontar economy comprises a series of related but relatively independent subsystems, any of which may be modified or developed provided that the pivotal lontar production is not altered. This is in fact

the case on the islands of the outer arc. Roti [Rote], Ndao and Savu have developed different subsystems of their lontar economies. The same is true of the various states [regencies] of Roti. The states [regencies] accord varying emphases to their economies, and individuals may, to a certain extent, gauge their pursuits to meet their needs by choosing from a range of subsistence activities. This diversity, though difficult to summarize, is the key to Rotinese and Savunese adaptiveness.

**3. Informal-sector enterprises based on products from forests and agroforestry systems can be very significant in terms of their total value and the numbers of people involved.** This should be no surprise to those who have followed the history of the sandalwood trade from Timor, a centuries-old trade that even in the 1960s was exporting 30 tonnes (t) of sandalwood oil a year (worth US\$3.5 million at the time) (Oyen and Nguyen 1999).

To make this point further, it is worth giving examples from equally impoverished, low-agricultural-potential landscapes from other parts of the world. In Burkina Faso, West Africa, shea kernel and shea butter exports as a cocoa-butter substitute, from the woodland tree *Vitellaria paradoxa*, are the country's third-largest earner after cotton and livestock (Schreckenber 2004). Similarly, in Kalimantan, Indonesia, almost 14,000 t of *illipe* nuts (from about 20 *Shorea* species), worth an estimated US\$5 million (at 1987 values) (Peters 1996), were harvested for export as a cocoa-butter substitute. *Catha edulis* (khat) leaf exports are Ethiopia's second-largest export item, representing 13.4% of GDP and worth about US\$500 million/year (Green 1999; Feylsa and Aune 2003). Farmers in the Habro district of Ethiopia earn 70% their income from khat, as a maize–khat intercropping system is 2.7 times more profitable than maize mono-cropping (Feylsa and Aune 2003). In Malawi, if the domestic charcoal trade were equated with the country's exports, the annual foreign exchange value to the country would be more than sugar exports (the third-largest export earner) and slightly less than Malawi's tea export revenue (the second-largest export after tobacco) (Kambewa et al. 2007). In Zambia, the production and marketing of fuelwood and charcoal—largely an informal activity carried out by poor households—is estimated at US\$5 billion dollars, employs more than 400,000 people and contributes approximately 2.3% of GDP (Hibajene et al. 1993; Keddy 2003).

#### **4. Agroforestry and improved natural forest management can resolve resource depletion of 'natural capital' and offer opportunities for the future.**

From a forestry and enterprise perspective, the trade in charcoal (and fuelwood) mentioned above is as much an issue of concern in Malawi and Zambia as it is in ENT. Reasons for this are similar. Rural electrification is absent or rudimentary, kerosene prices are high, and fuelwood or charcoal provides a significant portion of rural energy needs. In addition, as we discuss later in this report, there is a thriving commercial trade in fuelwood for smoking piglets (for the booming *sei babi* industry—see the 'Food and drinks 4: Cinderella fruits' chapter) and for palm sugar and palm syrup production (see the 'Food and drinks 2: *Borassus flabellifer*' chapter). Poor resource management has similarly been an issue in ENT for high-value products such as sandalwood and *Aquilaria malaccensis* (*gaharu*) resin. At its heart, however, the problems of the trade in charcoal, fuelwood, *A. malaccensis* and sandalwood are not in the trade itself, but rather in how they are produced. For products like sandalwood, *A. malaccensis* and, in this report, *Symplocos* (*loba*) and *Morinda citrifolia* (*mengkudu*), the real question is 'How do we want to produce this product to meet this market demand in a better way?' Answers to this question vary. For most products, more intensive production in agroforestry systems is the best option. For *Symplocos*, however, the answer is wild harvest in the community forest, a management option that is possible under Indonesia's decentralised forest management policy (see '*Symplocos*' in the 'Cultural heritage and arts' chapter), giving an added incentive to conserve high-biodiversity natural forests instead of converting them to low-diversity coffee–candlenut agroforestry systems.

#### **5. Backing a diversity of products from forests and agroforestry systems can play an important role in poverty alleviation.**

ENT is the driest region of Indonesia, with rainfall restricted to 3 months of the year (December to February) and very dry conditions from May to November. Low rainfall, the long dry seasons and frequent fires also affect the soil fertility of large areas of ENT. Poverty levels are high (Table 1).

As a result, a development focus on capital-intensive crops such as coffee and cocoa is likely to bypass most poor farming communities in ENT, instead favouring wealthier farmers in areas with more water and better soils. It takes tough plants—and tough people—to survive, let alone thrive under the harsh conditions



**Table 1.** The per capita gross domestic product (GDP), human population numbers and extent of poverty by district in East Nusa Tenggara, 2003 (modified from Barlow and Gondowarsito 2009)

District	Average per capita GDP (Rp '000)	Population ('000)	Proportion of population in poverty (%)
Kupang municipality	6,373.9	255.5	11
East Sumba	2,411.1	195.3	12
Ngada	2,237.9	237.2	15
East Flores	2,370.9	213.6	16
Sikka	2,150.2	274.5	20
Belu	1,883.4	334.4	21
Ende	2,372.3	236.6	22
Alor	2,078.8	165.6	28
Rote and Ndao	2,074.7	included in Kupang district census data	29
North Central Timor	1,807.5	201.2	30
West Manggarai	1,942.9	included in Manggarai	30
Lembata	1,485.5	96.6	33
Manggarai	1,571.7	653.3	33
Kupang	1,785.5	430.2	35
South Central Timor	1,682.6	395.7	37
West Sumba	1,487.2	383.2	44

that occur in the dry island landscape common in ENT. *Borassus flabellifer* (*lontar*), *Schleichera oleosa* (*kesambi*) and various fodder plants are important to local livelihoods in these cultural landscapes with their diverse agroforestry systems (Figure 3). It is recognised that diversity and marketing opportunities for a wider range of products from these landscapes will benefit a wider number of households.

**6. The informal sector is extremely important in Indonesia.** Based on a review of the informal sector, Becker (2004) pointed out that most efforts to reduce poverty will fail if the vulnerable people in the informal economy and their employment needs are not addressed. It is useful, therefore, to take micro-enterprises into account rather than focus solely on commercial products for large-scale markets and deal only with large- or medium-scale agribusinesses and formal-sector companies. According to Blunch et al. (2001), the informal sector in Indonesia absorbs 77.9% of non-agricultural employment, while in other Asian countries, the contribution of this sector to employment is 73.7% (India), 66.9% (Philippines) and 51.4% (Thailand). The significance of the informal sector is most evident during bad times, such as droughts or economic downturns. The 1997 Indonesian economic crisis is a good example, as this affected the job-creation ability of the formal sector.

Natural products and those derived from them, such as textiles, basketry and snack foods, can play a significant role in informal-sector, off-farm income in villages, towns and cities.

## Trade sectors

The surveys of trade in products from forests and agroforests carried out during this study enable the characterisation of the different types of trade. In particular, this enables a far better understanding of the 'hidden economy' of the informal-sector trade. From an economic geography perspective, links between NTFPs and trade can be grouped into four main categories, as follow.

### Informal-sector trade in local marketplaces

Local trading comprises permanent and periodic (generally weekly) marketplaces or decentralised marketing of specialist products (such as honey, textiles and seasonal, higher value fruits) and low-value products (such as fuelwood).

### Inter-island trade within eastern Indonesia

Within eastern Indonesia, there are complex inter-island supply chains which occur either over short distances (such as trade in palm syrup from Savu to Raijua and Sumba) or over longer distances (such as



**Figure 3.** Steep, erodible soils and long dry seasons increase risk and reduce the options for farming families in Waimatan on the island of Lembata, East Nusa Tenggara, making flexibility through multiple activities—fishing, subsistence farming and dependence on tough trees such as *Borassus flabellifer*, *Schleichera oleosa* and *Moringa oleifera*—essential for survival

from Flores to Bali). Three examples of this longer distance trade are in: *Arenga pinnata* fibre (for ritually important thatch and rope); the climbing fern *Lygodium circinnatum* (for commercial basketry); and ritually important products, such as bananas and coconuts, wherein trade is dictated by the Balinese ritual calendar.

### Exports from ENT for national markets

Exports from ENT to other parts of Indonesia include trade in two main categories: first, the more ‘visible’ market chains, which are at least partially recorded in official statistics, such as trade in *Aleurites moluccana* (*kemiri*) and *Areca catechu* (*pinang*) fruits; and second, the ‘hidden’ market chains for high-value products. These are sold in the national market and internationally, including several products that have been traded from ENT for centuries through social networks dominated by Indonesian traders of Chinese descent. Good examples are the national and international trade in *Aquilaria* (*gaharu*) resin, sandalwood and birds’ nests.

### Exports for international markets

These include current exports of agroforestry products (such as *A. moluccana* seeds and seed oils) and promising new export products identified in this study and discussed in detail in following chapters of this report. In addition to the historical trade to China in the products mentioned above, *Aquilaria* resin, known in Saudi Arabia as *oud*, is also exported by traders with historical and cultural links to the Arabian Peninsula.

## Highlighting the ‘hidden economy’: trade in local marketplaces

Although the importance of the informal sector is recognised, most studies have been of the urban informal sector and, with one exception (Arman 1996), no quantitative ethnobotanical surveys have been conducted to assess the diversity and importance of plant products sold in local marketplaces in Indonesia. This ACIAR project studied NTFPs traded at different spatial scales in order to identify species with potential within agroforestry systems in ENT. This was done through assessing NTFPs from ENT that linked to international, national, regional inter-island and local trade. ‘Hidden economies’ are a feature of both ends of this spectrum of spatial scales of trade. At the international and national scales, high-value products such as *gaharu* (*Aquilaria*) resin, sandalwood (*Santalum album*), rattan (*Daemonorops* and *Calamus*) and *santigi* (*Pemphis acidula*) plants for the bonsai trade are traded ‘under the radar screen’. At the local level, informal-sector marketplaces are also part of the ‘hidden economy’ (Figures 4 and 5). In this chapter, we first give an overview of all products sold in local marketplaces, then focus on products from forests, agroforests and cultivated medicinal plants and spices.

### Characteristics of markets and sellers

Of the 11,428 market stalls surveyed, more were occupied by women sellers (53.8%) than by men (44.9%), and 1.3% were shared between men and women. Most of the stalls (9,365; 81.9%) were in permanent (daily) markets, characteristic of larger towns (Figure 1), and the rest (2,063; 18.1%) were in weekly markets (Figure 2) in more remote rural areas or rural villages (Figure 4).

In terms of types of seller, the majority of sellers in all markets were middlemen (9,512; 83.2%), followed by producer-sellers (in other words, farmers marketing their own farm products) (1,639; 14.3%). There were relatively few bulk sellers or travelling

merchants (who move from one weekly market to another (236; 2.1%) and virtually no itinerant sellers (only 5 people). We suggest that the lack of itinerant traders in the sample is due to the survey method, which was focused on local marketplaces, while most itinerant sellers market farm products (such as vegetables) or fresh *Borassus flabellifer* (*lontar*) palm wine by doing the rounds of local neighbourhoods in larger towns (Figure 5).

In both the wet and dry seasons, the focal categories of interest in this study (forest and agroforestry products) were outnumbered by vegetable sellers and clothes sellers (Figure 6). The most commonly sold agroforestry products were the combination of *pinang* (*Areca catechu*) and *sirih* (*Piper betle*). Wild-harvested forest products were sold by spice and traditional medicine sellers (the *obat/bumbu* category in Figure 6), generally including bark of *kayu manis* (cinnamon, *Cinnamomum burmannii*) and *kayu hamoi* (a *Litsea* species). Throughout Sumba, sellers from Bima (in West Nusa Tenggara) generally sell clothes and everyday needs such as rice, sugar, cooking oil and salt from *sembako* stalls, while Savunese generally sell raw material for dyes and, in the Melolo area of Sumba, palm sugar (*gula lempeng*—palm sugar in flat rounds or discs). The term *sembako*, widely used in Indonesia, is a shortened form of *sembilan bahan pokok*. This refers to nine (*sembilan*) commodities that are considered basic household needs—namely, eggs, milk, salt, granulated sugar, kerosene (or alternatively, liquefied petroleum gas (LPG)), rice (or cassava), cooking oil (or margarine), beef (or chicken meat) and maize (or, in some areas, sago). Agroforestry products are also sold by ‘*sembako*’ sellers).

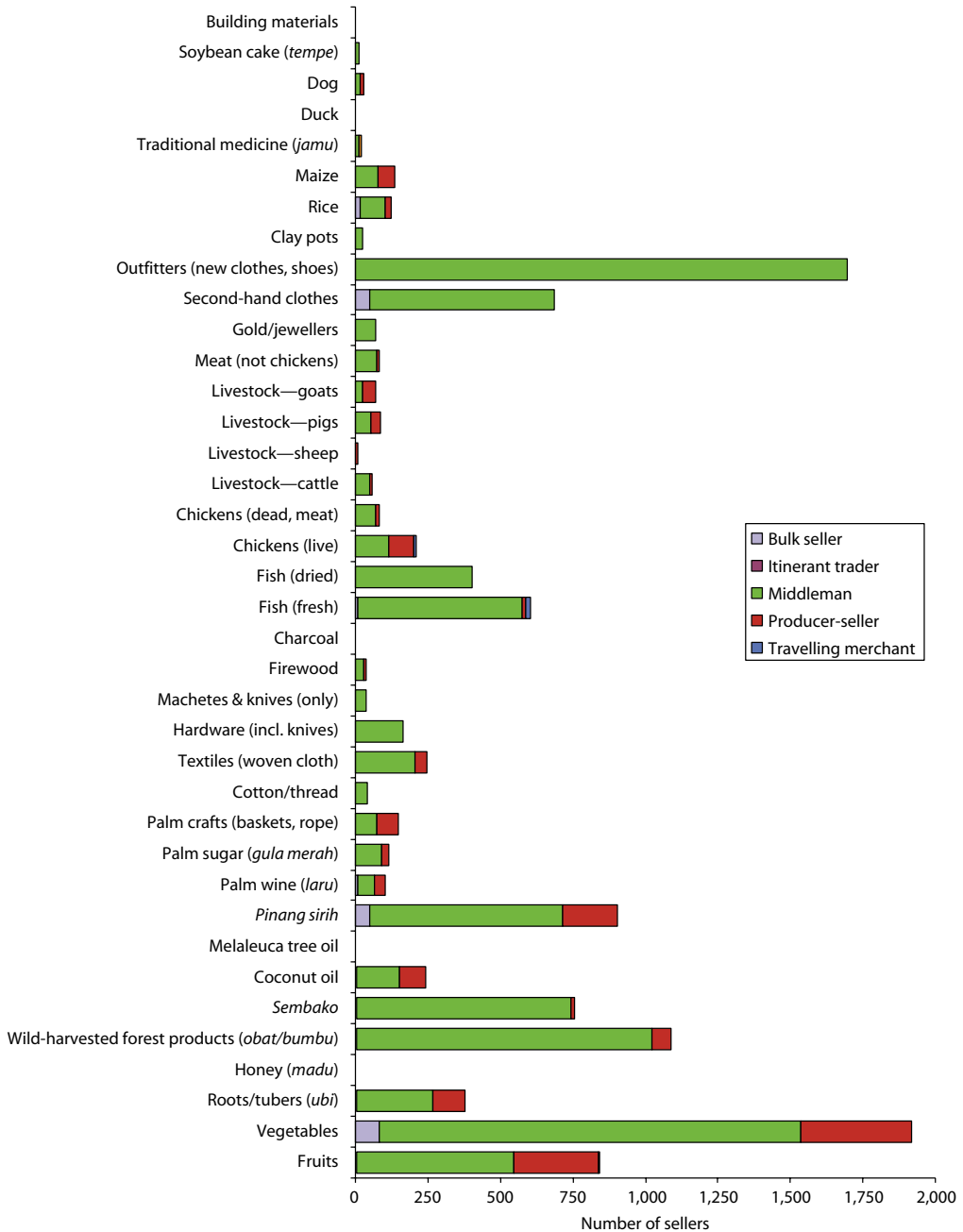
In Waingapu market (on Sumba), traditional textiles generally come from weavers in the East Sumba region, such as Rindi and Lemba Napu, even though there are also weavers from the West Sumba area, south-western Sumba and even Savu. At Waitabula market, the textiles generally come



**Figure 4.** The weekly market in Oinlasi, South Central Timor, which has the atmosphere of a country fair and provides an opportunity for local producer-sellers to get much needed cash through the sale of market crop surplus or for craft-workers to sell basketry, textiles and carvings



**Figure 5.** Fresh *Borassus flabellifer* (lontar) palm sap is commonly sold door to door in larger towns of West Timor (such as Kupang) and other islands (such as Seba, on Savu, in this case)



**Figure 6.** The numbers of sellers of different products in local marketplaces surveyed on Flores, Sumba, Savu and West Timor, showing the frequency of forest and agroforestry products, such as *pinang sirih* palm sugar, palm wine and honey, compared with categories such as clothes and vegetables, for which there are a higher number of sellers, each subdivided according to the type of sellers involved in each category

from Kodi and Wajewa. *Areca catechu* (*pinang*) and *P. betle* (*sirih*) are prominent products in the Waitabula market that are transported there from Wajewa and south-western Sumba.

In West Timor, at Atambua market, apart from many local sellers, others originate from Rote (an island south of West Timor), Kupang, East Timor or Java; or are Bugis or Chinese Indonesians. Local people generally sell crop surplus from their home gardens as well as cassava, sweetpotato and various vegetables. Throughout Timor, local producer-sellers typically sell out in the open and are poorer farmers who make a subsistence income from sales (Figure 7).

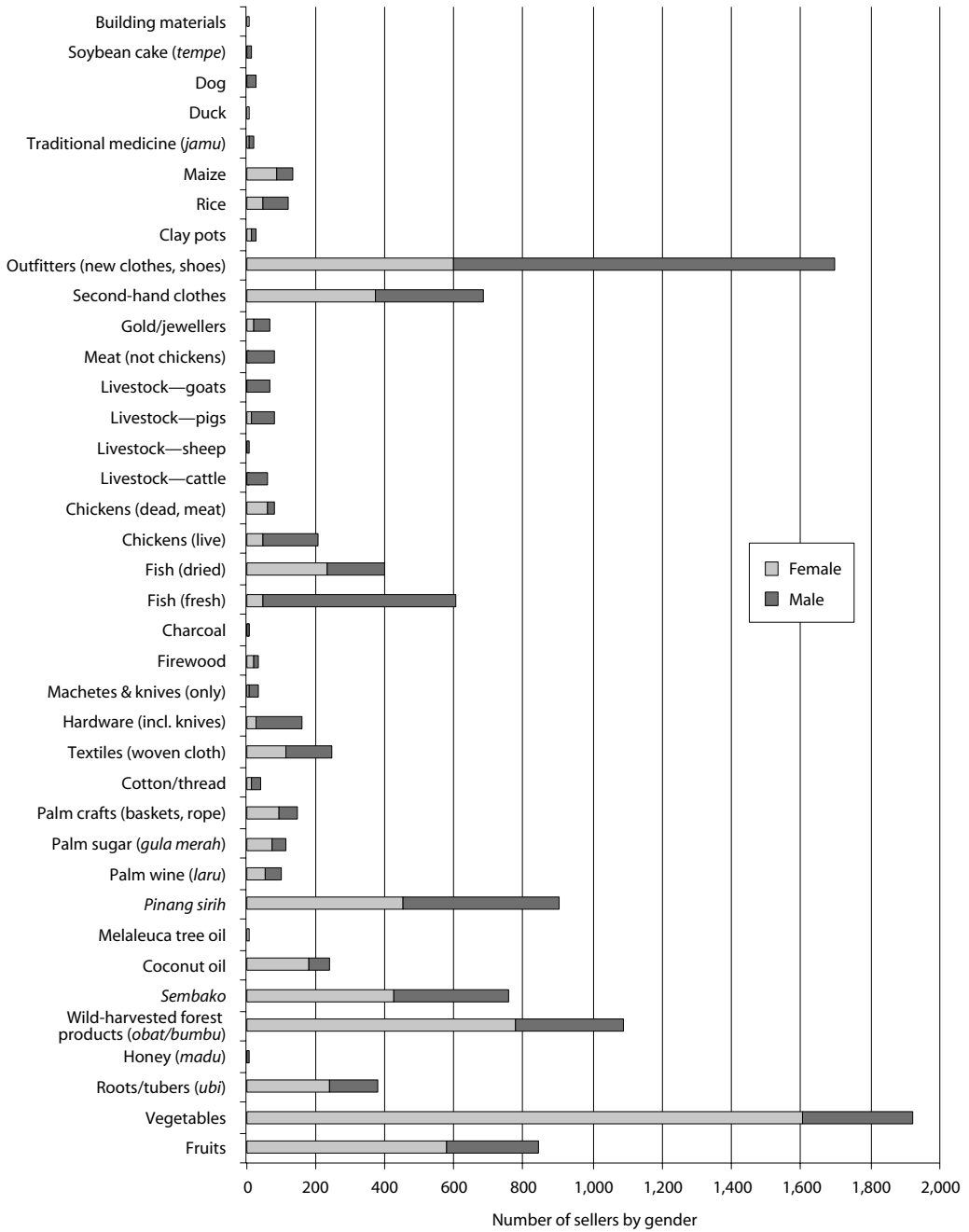
Sellers from Rote, Savu and a section of Bugis trade in semi-permanent areas and have more stock to sell, with a larger variety of products. A section of Bugis sellers and those of Chinese ethnicity are located/positioned in permanent selling places in kiosks as well as shops. Sellers at these permanent locations sell goods that are relatively long-lasting, like *sembako*, spices, salted fish and *pinang* (which comes to Atambua market from Kefamenanu).

Based on an analysis of variance, sales of particular seller categories differed across markets in

different locations. There were significant differences ( $p < 0.05$ ) in fruit sales, tuber crops (*ubi*), live chickens, goldsmiths/jewellers and second-hand clothes sellers. Goldsmiths have shops in big towns (such as Kefamenanu and Kupang). Root crop (*ubi*) production depends on altitude, with *ubi jalar* (sweetpotato), potato and taro (*Colocasia antiquorum*) occurring more in markets at higher altitudes. In contrast, cassava tubers were sold in coastal markets, but in lower quantities, as people tend to grow their own cassava, which is then dried and stored rather than being sold. Due to its long shelf life, there is less of a market for cassava. Fruit production also depends on altitude, with citrus and avocado more frequent in higher altitude markets. There also was a higher diversity of fruits for sale in the markets of large towns compared with smaller ones. In terms of the gender of market sellers, the proportion of women selling fruits, vegetables, *obat/bumbu* (medicines/spices), coconut oil (*minyak kelapa*) and dried fish was significantly different (see Figure 8). In terms of outfitters, most were men (many from Bima). Men also dominated the fresh fish trade and sales of livestock and hardware (such as machetes and other locally smithed tools).



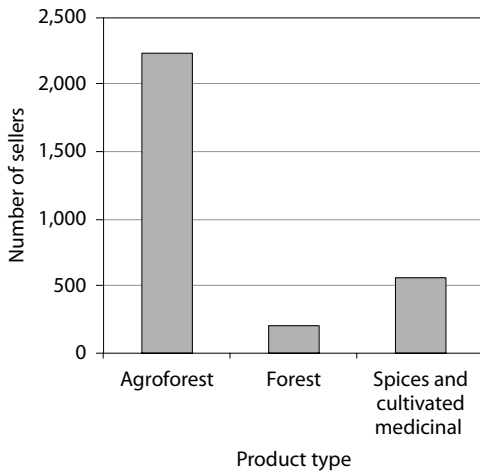
**Figure 7.** Producer-sellers, the local farmers who sell surplus cash crops at weekly markets (such as here at Kapan market, West Timor), generally cannot afford the higher price for renting a permanent stall and sell small quantities of goods for a subsistence income



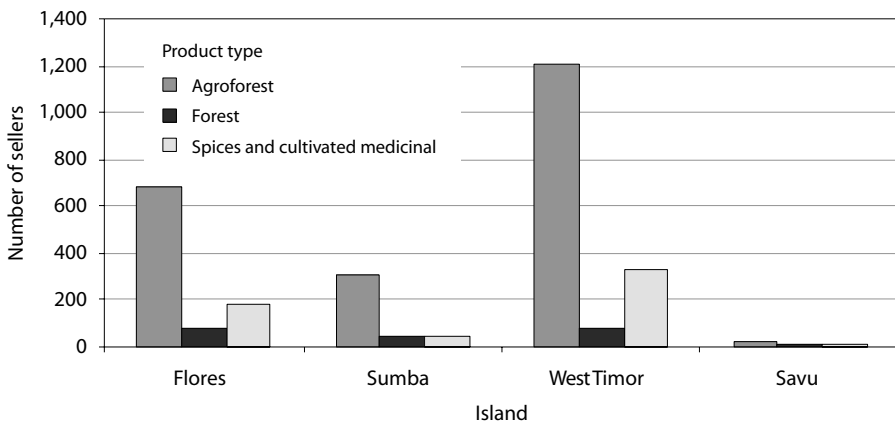
**Figure 8.** Different product categories in the marketplaces surveyed, showing the total number of sellers in each category, subdivided by the gender of sellers

## Sellers of products from agroforests, forests and spice/medicinal plants

Only a small proportion of the products sold in local marketplaces are wild harvested from natural forests, with most products being derived from agroforestry systems (Figure 9). The relative proportions of people selling these three product categories were similar across Flores, Sumba, Savu and West Timor (Figure 10).



**Figure 9.** Numbers of people surveyed selling agroforestry, forest and spices/cultivated medicinal products



**Figure 10.** Numbers of people selling agroforestry, forest and spices/cultivated medicinal products in marketplaces across the four islands in the study

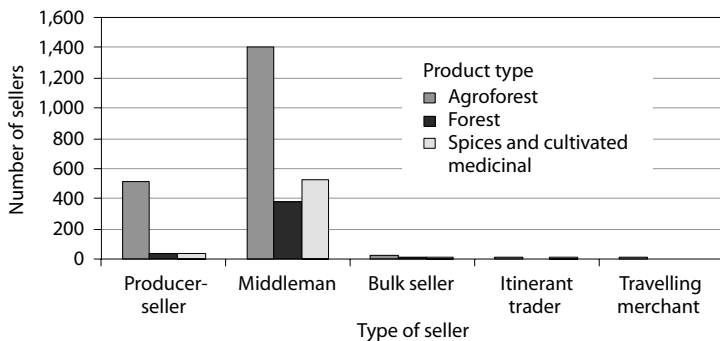
Most sellers of all three categories of products were middlemen, although a reasonable number of people selling agroforestry products were producer-sellers (Figure 11). In terms of their educational status, most sellers either had elementary school education or had not been able to attend school (Figure 12).

Based on field observations and discussions during this survey, where type of stall is an indicator of relative wealth, it is apparent that few people sell from permanent stalls, but instead are low-income earners with semi-permanent stalls or who make a subsistence income from temporary stalls out in the open (Figure 13).

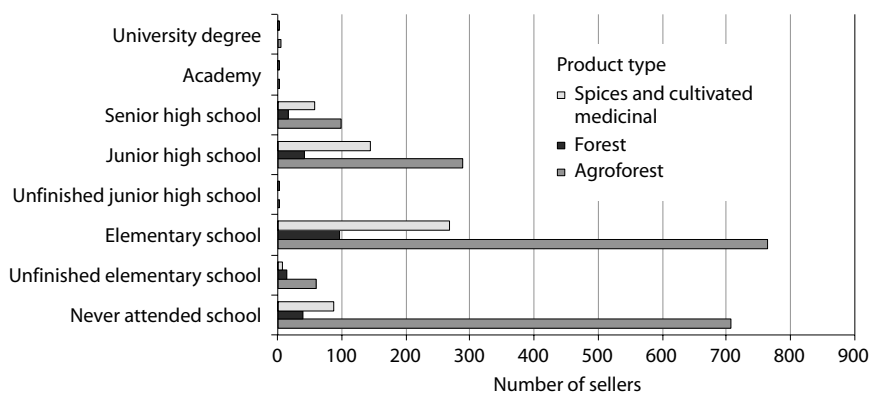
The most commonly sold items in each of the three product categories are shown in Tables 2, 3 and 4.

In the chapters that follow, we will focus on selected products in Tables 2–4; namely, honey, *sirih hutan* (*Piper* species), *Schleichera oleosa*, *Areca catechu*, *Piper betle*, *Aleurites moluccana* and *Tamarindus indica*.

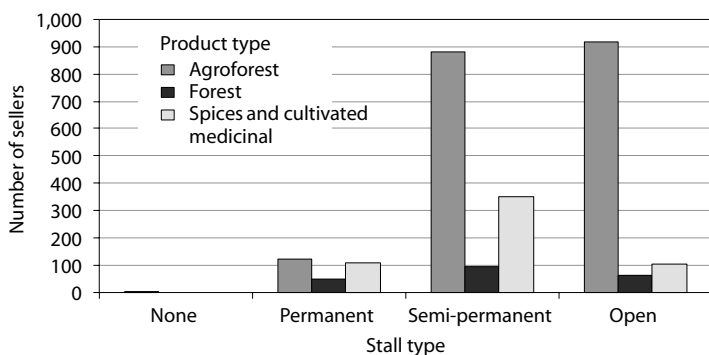




**Figure 11.** Numbers of different types of sellers in the three product categories



**Figure 12.** Educational status of people selling agroforestry products ( $n = 1,918$ ), forest products ( $n = 204$ ) and spices and cultivated medicinal plants ( $n = 563$ ), showing that the majority had either not attended school or had elementary school education



**Figure 13.** Numbers of people selling the three categories of products grouped according to types of stalls—the charge for use of these stalls varies, from the most costly (permanent stalls, with more storage space) to semi-permanent shelters and then open areas demarcated by local authorities for use during market days

**Table 2.** The top 10 most commonly sold spices and medicinal products within a sample of 2,808 informal-sector spice/medicinal plant sellers across markets on Flores, Savu, Sumba and West Timor

Rank	Name of product (clustering)	No. of sellers	Percentage (%)
1	Tumeric ( <i>kunyit/halus/mai/putih</i> )	381	13.57
2	Ginger ( <i>jahe</i> )	350	12.46
3	Pepper ( <i>lada/merica</i> )	329	11.72
4	Galangal ginger ( <i>lengkuas</i> )	289	10.29
5	Nutmeg ( <i>pala</i> )	276	9.83
6	<i>Eugenia</i> sp. ( <i>daun salam</i> )	250	8.90
7	Caraway seed ( <i>jinten</i> )	242	8.62
8	Cinnamon ( <i>Cinnamomum burmannii</i> ; <i>kayu manis/kulit manis</i> )	234	8.33
9	Cloves	199	7.09
10	<i>Acorus calamus</i> ( <i>akor/genoak/kaliraga</i> )	127	4.52

**Table 3.** The top seven wild-harvested forest products sold within a sample of 279 informal-sector sellers across markets on Flores, Savu, Sumba and West Timor

Rank	Name of product	No. of sellers	Percentage (%)
1	Honey ( <i>madu</i> )	36	12.90
2	Firewood ( <i>kayu api</i> )	34	12.19
3	Vegetables ( <i>paku</i> )	26	9.32
4	<i>Litsea</i> species ( <i>kayu hamoi</i> )	23	8.24
5	<i>Puriwu 'di</i>	12	4.30
6	<i>Piper</i> species ( <i>sirih hutan</i> )	12	4.30
7	<i>Schleichera oleosa</i> ( <i>kayu kusambi</i> )	11	3.94

**Table 4.** The top seven agroforestry products sold within a sample of 3,525 informal-sector sellers across markets on Flores, Savu, Sumba and West Timor

Rank	Name of product	No. of sellers	Percentage (%)
1	<i>Piper betle</i> ( <i>sirih mentah/segar/buah</i> )	593	16.82
2	<i>Areca catechu</i> fresh fruits ( <i>pinang mentah hijau</i> and <i>pinang muda</i> )	518	14.70
3	<i>Areca catechu</i> dry fruits ( <i>pinang kering</i> )	467	13.25
4	<i>Aleurites moluccana</i> ( <i>kemiri/biji/kemiri dengan kulit</i> )	306	8.68
5	<i>Tamarindus indica</i> ( <i>asam</i> ) fruits	284	8.06
6	Bananas ( <i>pisang</i> )	240	6.81
7	<i>Piper betle</i> leaves ( <i>daun sirih</i> )	168	4.77

## Trade linked to culture and religion

It is clear that cultural preferences are an important driver of local and inter-island trade in many products from forests and agroforestry systems. Trade in textiles, *pinang sirih* and plants used in traditional medical systems (such as *Acorus calamus* rhizomes and *Litsea* bark (*kayu hamoi*) are good examples.

### Cultural food preferences and trade

Cultural food preferences were also evident during this survey. *Metroxylon sagu* (sago palm), *Canarium* (*kenari*) fruits and *Corypha utan* (*gewang*) starch provide good examples to illustrate this point. Small quantities of *M. sagu* starch are sold at the Kupang market. ENT is a long way from where sago palms grow, but this long-distance trade is in response to demand from the Ambonese community living in Kupang. In particular, this sago is used to make a dish called *papeda*, which consists of sago mixed with fish. In April, the Ambonese living in Kupang have a feast together, usually at the beach, where they eat *papeda*, socialise and play music. *Canarium* fruits are also in seasonal demand, mainly at Chinese New Year, when cakes called *bagia* (Figure 14)—made from *Canarium* nuts mixed with starch from *Amorphophallus* tubers (*tiro*)—are popular.

The *Canarium* nuts are imported into West Timor mainly from Alor, through the port at Atapupu, although there is also *Canarium* production on Flores. The *tiro* is made into powder by people gathering *Amorphophallus* tubers from the forest during the early dry season (June–August), for example, in villages around Kefamenanu, Kapan and Niki Niki. The *tiro* starch is bought by Chinese processors who also buy the *Canarium* nuts, particularly those living in Niki Niki, Kefamenanu, Kapan, Besikama, Betun and Atambua. In Sulawesi, the same cakes are made with sago palm starch instead of from *Amorphophallus* tubers—unlike *tiro*, sago starch is not toxic and does not require labour-intensive leaching. *Canarium* nuts may also have been traded from Flores in the past. In Ende regency, *Canarium* is locally known as *koja*

and used to be abundant in the forest until the 1990s, when chainsaws became available and the trees were felled by local villagers to sell the timber. In retrospect, local villagers suggest that this was a poor decision economically, as they have lost access to the annual yields of the fruits (from the female trees). *Canarium* seeds were used in two important *adat* (traditional) ceremonies. First, the seeds were the first gift at the start of the bride-price ceremony. Second, *Canarium* seed oil was mixed with rice and eaten as part of an *adat* ceremony to mark the end of the harvest season. Traditionally, nobody could process (pound, winnow) or eat the newly harvested rice until this closing ceremony took place. The last *Canarium* trees were felled in about 2005. Now, no *Canarium* trees are available and coconut oil is used in the *adat* ceremony instead.

When there were *Canarium* trees in the forest, wild pig hunting was more successful—when the *Canarium* fruits were on the ground, this guaranteed that pigs would be around. In addition, because *Canarium* trees are favoured roosting sites for hawks and other birds of prey, they were the place to hunt raptors that became a problem killing chickens. Two ‘types’ of *Canarium* are recognised locally: those that bear fruit and those that do not. This fits with the dioecious nature of *Canarium*, where there are separate male and female trees. This species has tri-loculate fruits (with three seeds). People did not plant *Canarium*. Fruits were gathered in the forest by both men and women. *Canarium* resin was not used for medicine, but instead was burnt for lighting in people’s homes. The aromatic resin was also burnt in the home garden to chase away bad spirits. These values have been lost due to uncontrolled logging of *Canarium* in the remaining forests on Flores. In the past, various forestry research organisations, including ACIAR, have funded work on *Canarium*, mainly in the Pacific (Fiji, Solomon Islands). With its multiple-use values for timber, oil seeds and resin, *Canarium* has potential for agroforestry in ENT in the future as part of a longer term strategy that will better protect wild stocks and bring *Canarium* trees into local agroforestry systems.



**Figure 14.** *Bagia*—cakes made from *Canarium* seeds and detoxified starch from *tiro* (*Amorphophallus*) tubers

In contrast to *Canarium*, which has been depleted due to overexploitation of the trees, the use of *Corypha utan* as a food eaten by people has declined due to changing food preferences. Unlike *Canarium*, *C. utan* palms are a common component of agroforestry systems across ENT. In West Timor, one of the ways of preparing a traditional famine food from *C. utan* (*gewang*) is to pound the stem and form it into large balls, locally called *putak*. These would traditionally be mixed with palm sugar and eaten during famine periods. To reduce preparation times today, the powdered *C. utan* stem is compressed into the shape of a dish, to which is added grated coconut and *Borassus* palm sugar. A second ‘plate’ of powdered *gewang* stem can be placed on top of the first, and then they are baked before consumption. Although some households in remote areas still use this famine food, the most common use and trade in *C. utan* palm starch today is for pig food. This is not sold in village or town marketplaces, but from roadside stalls in areas where *C. utan* agroforestry systems are common (Figure 15).

### Traditional medical systems

Reflecting its cultural and linguistic diversity, ENT has many diverse medical traditions. These form the basis of both self-medication using well-known local

medicinal species such as *Acorus calamus* (Table 2 and Figure 16B) and of herbal mixtures dispensed by traditional healers. In terms of trade, however, the value of local sales of medicinal plants is small compared with the trade in *jamu* (traditional medicines; Figure 16), all of which are brought into ENT from Java. There is no doubt that the *jamu* trade is a lucrative one with further growth potential. Although the history of investigations into local medicines and *jamu* has recently been reviewed (Pols 2009), relatively few studies have been conducted of the *jamu* trade compared with trade in Chinese and Indian traditional medicines (Cunningham et al. 2008). In one of the few assessments, Afdhal and Welsch (1988) suggested that 8 million t of material were used in the *jamu* industry, which at the time was produced by 350 factories that ranged from small to large. Today, there are reported to be 997 *jamu* manufacturers, 98 of them producing *jamu* on an industrial scale. In the 1980s, Afdhal and Welsch (1988) suggested that powdered *jamu* (*jamu bubuk*) represented 70% of *jamu* products and accounted for about half of the income earned. Common ingredients in powdered *jamu* such as ginger (*jahe*) are widely cultivated, but, according to Erdelen et al. (1999), one-quarter of the 55 most important plant species used for *jamu* are still collected from forests. There are opportunities for bringing new *jamu* ingredients into agroforestry



**Figure 15.** *Corypha utan*—from people’s famine food to pig food: (A) *C. utan* stems are cut and split for sale at roadside stalls in West Timor as a supplementary food for pigs; (B) the nutritious, starchy stems are a popular pig food in more remote areas

and farming systems. A good example is *Pimpinella pruatjan* (*purwaceng*), which is used as an aphrodisiac, a use of *jamu* that is particularly popular. Cultivating this herbaceous species (which is in the carrot and celery family) would be a good idea from a conservation perspective as, according to Erdelen et al. (1999), it has become rare or even locally extinct due to overexploitation of wild populations. Due to the scarcity of seed, *P. pruatjan* has been successfully propagated by tissue culture (Roostika et al. 2007), a process that may be necessary for other rare *jamu* ingredients as well.

### Potential for *jamu* production in ENT

Does the *jamu* trade represent a good enterprise opportunity for farmers in ENT? Despite the scale of the industry and growing demand, we suggest that this is unlikely for several reasons. First, production is limited largely to Java (such as in Surabaya and Semarang), where well-known *jamu* producers, such as Nyonya Meneer, are located. The majority of the ingredients can be produced by farmers in Java, or at least closer to Java than ENT. Second, although there are some large *jamu* processors outside Java (such as PT Tawon Jaya in Makassar), production of *jamu* ingredients in ENT (which has 1.5 million pigs) will face concerns about the fact that the ingredients are not halal. This is an important issue in an industry which has Malaysia, Pakistan, Singapore and several

Middle-Eastern countries as export markets. Halal certification is certainly possible, but can be costly—and why should industries pay that cost when the products can be bought through social connections in Java? Thirdly, marketing of *jamu* in Indonesia, including in ENT, is done through tight social and cultural networks of door-to-door sellers, the majority of whom are from Solo (Java) (Figure 16A). Even if farmers in ENT can get around concerns about product quality and price, it would be extremely difficult to break into this market.

### Inter-island trade in ritually important agroforestry products

Bali’s Hindu tradition is famous for its colourful ceremonies and rituals that have attracted tourists from around the world for almost a century. Balinese ceremonies follow one of two calendars: a solar–lunar calendar and a 210-day numerological calendar. The intercalation between the 3-day, 5-day and 7-day weeks in the numerological calendar and the full moons and new moons of the solar–lunar cycle produce a series of predictably auspicious and inauspicious days on which ceremonies are performed and offerings made. Assuming that there are approximately 60,000 households on Bali and that a typical set of offerings made for each rite can be determined, an annualised demand for each offering component can



**Figure 16.** Traditional medicines (*jamu*) trade in East Nusa Tenggara (ENT): (A) *jamu* sellers in Soe (West Timor), all of whom are from Solo in Java; (B) *Eugenia* sp. leaves (*daun salam*) and *Acorus calamus* rhizomes, commonly sold in markets through ENT; (C) ginger (*jahe*) is a common ingredient in *jamu*; (D) packaged, powdered *jamu* is a major component of the trade

be calculated at rupiah (Rp) 404,675,957,143 (equivalent to US\$43,624,100 per year) (Table 5). Noting the variation in price for offering components between regular days and high days, the incremental market value of ceremonial days can also be estimated.

Many of the products used in Balinese ceremonies are bought from farmers in Bali or imported from islands that are closer to Bali than those of ENT. During this study, however, it seemed that there may be potential for trade in the black fibre from *Arenga pinnata* palm stems from ENT to Bali. This is locally known as *ijuk* and has an important ceremonial and symbolic value. In Bali, the primary use of *ijuk* is for temple roofs for both family and community temples. Given that it is used for temple roofing, it may be used for the trim on homes in family compounds but is not considered proper to be used below that level.

### Potential for trade in *ijuk* from ENT to Bali

Based on interviews and market information obtained during this project by *Yayasan Pecinta Budaya Bebali* (YPBB, or Foundation for Sustainable Culture and Livelihood), we estimate that the wholesale market value in Bali of the *A. pinnata* fibre trade is worth about US\$1 million per year. Our assumptions are based on the population of 3,000,000 Balinese practising Hindus and an estimated 50 family members belonging to one family temple. We have estimated

that there are roughly 9,000 other temples on Bali. A family temple generally only uses *ijuk* on three shrines: the *pihasan* or preparation pavilion; the *taksu*, which is where the spirit of creativity resides (which helps professionals such as carpenters or teachers); and the *kemulan* with three doors, where the ancestors reside. A family temple will require 600–1,000 kg of *ijuk* depending on the family's economic situation. If a family has sufficient funds, they will always prefer *ijuk* due to it being more long-lasting and more beautiful, and it is considered to be more worthy of a temple, as *alang alang* grass (*Imperata* sp.) grows on the ground and *ijuk* is gathered from high trees. A temple roof lasts 30 years, so if 3.3% of the family temples are being renovated each year, more than 1,600,000 kg of *ijuk* are required. Village temples use approximately 10 times the amount of *ijuk* as a family temple.

Over a dozen interviews were conducted in April, November and December 2008 by I Made Maduarta and I Wayan Sukadana (also from YPBB) with *ijuk* retailers, wholesalers, contractors and harvesters. Some respondents were not willing to discuss the detailed financial information related to *ijuk* trade, although they did provide less sensitive information. An exception to this was the information on harvesting from an interview with a YPBB staff member's father who is a harvester. The data in Table 6 only include interviews with wholesalers.

**Table 5.** Values of plant products used in ceremonies in Bali (values in Rp)

Product	Species	Ceremonial day market value (annualised)	Rank	Incremental market value of ceremonial days (annualised)	Rank
<i>Manggis</i>	<i>Garcinia mangostana</i>	83,112,857,143	1	20,042,142,857	1
<i>Mitir</i> (flowers)	<i>Calendula officinalis</i>	59,170,000,000	2	17,122,857,143	3
<i>Jeruk</i>	<i>Citrus</i> sp.	53,640,000,000	3	20,002,285,714	2
<i>Salak</i>	<i>Salacca edulis</i>	47,352,857,143	4	13,715,142,857	5
<i>Sawo</i>	<i>Manilkara kauki</i>	42,047,142,857	5	8,409,428,571	6
Banana (fruits)	<i>Musa</i> sp.	41,274,285,714	6	16,046,000,000	4
Coconut (leaves)	<i>Cocos nucifera</i>	40,356,071,429	7	7,986,428,571	7
Bamboo <i>semat</i>	<i>Phyllostachys aurea</i>	28,077,285,714	8	7,053,714,286	8
Pandanus	<i>Pandanus amaryllifolius</i>	27,797,714,286	9	6,774,142,857	10
<i>Anggur</i>	<i>Vitis vinifera</i>	25,023,571,429	10	7,037,571,429	9
Bamboo <i>betung</i>	<i>Dendrocalamus asper</i>	12,842,857,143	11	5,137,142,857	11
<i>Daun pisang</i> (leaves)	<i>Musa</i> sp.	9,068,428,571	12	3,387,071,429	12
Sandalwood ( <i>cendana</i> )	<i>Santalum album</i>	6,073,000,000	13	1,735,142,857	15
Bamboo <i>tali</i>	<i>Bambusa</i> spp.	5,063,428,571	14	2,048,000,000	14
<i>Cabai</i>	<i>Capsicum annuum</i>	4,967,142,857	15	2,318,000,000	13
<i>Majagau</i>	<i>Dysoxylum densiflorum</i>	4,337,857,143	16	1,735,142,857	15
<i>Bawang putih</i> (garlic)	<i>Allium sativum</i>	4,304,857,143	17	331,142,857	22
<i>Bawang merah</i> (onion)	<i>Allium cepa</i>	2,814,714,286	18	496,714,286	19
Coconut (fruits)	<i>Cocos nucifera</i>	2,595,214,286	19	860,071,429	17
<i>Daun lontar</i> (leaves)	<i>Borassus flabellifer</i>	2,423,000,000	20	346,142,857	20
<i>Cempaka</i> (flowers)	<i>Michelia champaca</i>	1,497,107,143	21	656,164,286	18
<i>Sandat</i> (flowers)	<i>Cananga odorata</i>	742,950,000	22	322,478,571	23
<i>Daun enau</i> (leaves)	<i>Arenga pinnata</i>	692,285,714	23	346,142,857	20
<i>Kamboja</i> (flowers)	<i>Plumeria acuminata</i>	420,471,429	24	210,235,714	24
		505,695,100,001		144,119,307,142	

Based on the interviews, it was apparent that:

- *Ijuk* is wholesaled for Rp2,200–4,000/kg and that Bali is not self-sufficient in its production of *ijuk* as it is being brought in from as far as Lampung, Sumatra, and Central and East Java, as well as from Central and East Lombok.
- A harvester contracts trees from a farmer and will pay, depending on the size of the *Arenga* palm, Rp2,000–10,000 per palm per day. A harvester can harvest the black *ijuk* fibre from 6–10 palms/day. Given the ceremonial calendar in Bali, we estimate that a harvester probably averages 9 months of work a year. Palms are harvested once, and then again after 2 years.
- A 20-m tree may yield up to 25 kg of *ijuk* per harvest. A roll of *ijuk* is known as a *geleng* and generally weighs 25–30 kg.
- *Ijuk* is sold cleaned and uncleaned. Often, uncleaned *ijuk* will be used in the bottom layering of a roof and then the finer, cleaned *ijuk* is used on the top layers. According to our staff

member's father, it takes one person 30 minutes to clean one *geleng*, and they are paid, on average, Rp15,000/day plus food.

Out of the four islands that were the focus of our study, *A. pinnata* was most abundant on Flores, where it is tapped for palm sugar as well as harvested for *ijuk* (Figure 17). In a study of household income in the Doromeli area, Flores, Russell-Smith et al. (2007) found that, in a sample of 27 households, 21% of the income from forest products was derived from palm wine (*laru*) production from *A. pinnata*. This was second only to income from construction timber harvested from the forest. No mention was made of income from the trade in *ijuk*, although their study area had a very high density of *A. pinnata* (733.6 palms/ha <2 m tall and 176 palms/ha >2 m tall).

**Table 6.** Information from wholesalers in Bali about the trade in *ijuk* (*Arenga pinnata*) fibre to Bali

Date of interview	Location of wholesaler	Tonnes/year	Harvested outside Bali	Harvested in Bali	Cost to wholesaler (Rp/kg)
April 2008	Kintamani	unknown	75% from Java	25%	2,200–4,000
April 2008	Petang, Denpasar	100	0%	100%	2,800–4,000
April 2008	Kintamani	<100	0%	100%	
December 2008	Mambal, Denpasar	170	100% from Central and East Lombok	0%	3,000–3,500
December 2008	Blahbatuh, Gianyar	unknown	100% from Lampung, Sumatra and East Java	0%	3,000–3,500

Notes:

1. In September 2008, an increase in oil prices increased most commodity values. This would explain why the December prices are higher than April prices.
2. Higher selling price per kilogram was said to be for cleaned *ijuk*. Transportation costs are covered by the wholesaler.

Although there may be a market for *ijuk* trade from Flores to Bali, which could be organised through producer associations linked to a bulking-up centre for *ijuk* at one or more of the ports on Flores, we have the following reservations about the trade:

- There is competition from harvesters on islands closer to Bali (such as Lombok).
- Collecting *ijuk* from these spiny palms is tough, labour-intensive work—income per day for collecting *ijuk* in Bali, closer to the large market for this product, is Rp2,000–10,000/day and is likely to be less on Flores, so it may not be worth it at this stage.





**Figure 17.** *Arenga pinnata* products and trade: (A) palm stem showing black fibre harvested for rope and thatch; (B) brooms made from *A. pinnata* fibre, which are commonly sold in local marketplaces in Flores, Sumba and West Timor; (C) cleaning *ijuk* that has been sold in bulk to a wholesaler in Bali; (D) twined rope from *A. pinnata* fibre for sale in Maumere market, Flores; (E) palm sugar in 'bricks' wrapped in banana fibre (Labuan Bajo market, Flores); (F) palm sap tapper, Doromeli area, Flores; (G) palm sugar, West Java

# Characteristics of potential winning categories and focal species

Despite their diversity, natural products produced for international export markets have many characteristics in common. Successful enterprises have concentrated on a few species that are potential winners instead of trying to do everything; aiming to get economies of scale where production is by small-scale harvesters by coordinating producers for the same market. Common weaknesses as enterprises grow include their inability to get the large volumes required to meet market demand; and paying attention to quality, quantity (Lovett 2005) and on-time production. The characteristics of winning products in successful enterprises that hold useful lessons for natural product development have been reviewed by Cunningham (in press) and can be summed up as follows.

## **Existing markets, information access and strategic choices**

In many cases across developing countries, well-meaning development workers with good intentions but without business acumen have started production of natural products in order to generate income for poor local people, only to see them fail and local hopes shatter. Unlike the movie *Field of Dreams*, this model ('build it and they will come' or 'produce it and markets will buy') rarely works. Today, more and more enterprises are first getting to know the characteristics of the market, then working from there—organising producers to get the right product to the appropriate partners in sufficient quantity, on time, and at the right price. Successful enterprises have taken business-oriented, strategic choices first, focusing on the commercial growth sectors (natural and organic cosmetics, flavours and fragrances, functional foods and the art/culture niche market).

## **Visionary champions: insight, innovation and staying power**

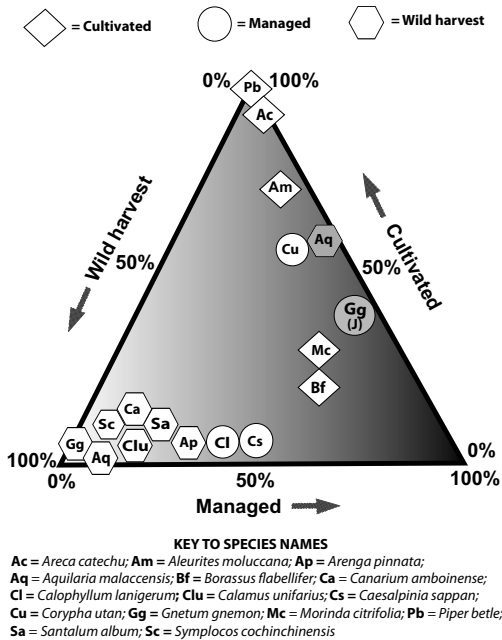
Visionary champions—often external actors—play a fundamentally important role, regardless of whether enterprises are family-owned companies, publicly

listed companies or a cooperative cluster of small businesses under one brand name.

## **Coordination and supply reliability: high quality in sufficient quantity, and on time**

Quality standards are crucial for natural product exports, particularly if they are used in cosmetics or as functional foods. Like any relationship, once a reputation is lost, it is difficult to regain. Guidelines for quality standards, such as those available for *Aleurites moluccana* (candlenut, *kemiri*) in Indonesia, are very useful in this regard. In West Africa, to avoid loss of reputation by shea butter producers, Lovett et al. (2005), on behalf of the West Africa Trade Hub (WATH), have similarly prepared an easy-to-use export guide on international quality standards for shea butter. These are useful tools to raise awareness among producers and exporters of which quality requirements are most important.

Developing and maintaining market share is not just an issue of quality. What is also required is getting sufficient quantity to the market on time. Reliability of supply is commonly affected by fluctuating yields from year to year, requiring an organisational structure to source products across a wide geographical area. Dealing with fluctuating yields effectively—in some cases backed up by decentralised tree planting in fields or enrichment planting in savanna, woodland or forest systems where tree tenure can be applied—has an added benefit (Figure 18). It avoids a situation where horticulture becomes a form of 'elite capture' by wealthy farmers with greater access to land and technology, cutting poorer farmers out of the supply chain. Harvest from wild or locally managed trees certainly offers opportunities for organic or fair-trade marketing, but harvesting sufficient quantities requires hundreds—or even thousands—of rural farmers to collect these products. Well-established and effective local institutions can use communications technologies such as mobile phones to coordinate 'bulking up' of resources, reduce transport costs and improve supply-chain capability.



**Figure 18.** Products in trade in Indonesia come from a mix of wild harvest, managed agroforests and more intensive cultivation systems in East Nusa Tenggara (ENT)  
 Note: shaded hexagon = *A. malaccensis* cultivated outside ENT; shaded circle = *G. gnemon* from Java

### Winning natural products built on maintaining or developing an abundant natural resource base

Interestingly, most successful enterprises are based on species that are widely distributed across South and South-East Asia (*Borassus*, *Schleichera*). This ability to grow in a wide range of soil types also reflects the abundance of these species, which means less of a supply problem compared with highly habitat-specific species with a restricted distribution and therefore limited supplies. This advantage is further enhanced in several cases by farmer-based selection of genotypes or chemotypes, such as with *Areca catechu* or *Piper betle*. How long this advantage is maintained depends on whether production shifts to other places and whether germplasm is exported or not: however, with abundant, relatively slow-growing tree species, at least small-scale producers in rural Indonesia have a head start. Any long-term advantages are lost, sometimes forever, when local

extinction of species or unusual genotypes occurs, such as has happened to sandalwood and *Aquilaria malaccensis* (*gaharu*), which have been plundered by commercial harvesters or, in the case of *Canarium*, by loggers.

### Clear land and tree tenure and user rights

Secure tenure is an important component of any strategy that aims to deliver fair and equitable benefits to Indonesian farmers from natural product commercialisation. In many Asian countries, communal land ownership is vested in the state, yet, under customary law, individual households have access to popular edible fruits in farmers' fields or near their homesteads. Based on studies in Africa, commercialisation has a positive effect through increasing incentives to conserve trees but, where tenure is unclear, can result in conflict (Wynberg et al. 2003).

### Local self-sufficiency not undermined

Sustainable harvest cannot be assumed, particularly with commercial harvest and where land and resource tenure is weak. There are many examples where this assumption has been made, with the result that local people have ended up walking further and further to get the same resource or paying more for a now scarce resource. Examples are not only well-known cases like sandalwood and *gaharu* but, in some areas, also *Symplocos (loba)* and *Morinda (mengkudu)*. Where necessary (e.g. in the forest area of Ende regency that is a source of *Symplocos* and other useful species), it can be beneficial to develop participatory management plans with simple, enforceable rules, with monitoring at a community level focused on only key issues, as people have many other things to do.

### Pricing: incentives to collect, incentives to buy—high price/volume

Poor Indonesian farmers generally are 'price-takers', with limited bargaining power. For some products, this remains the case in order for new enterprises to remain competitive; however, in several other cases, value-added processing and price negotiations by external brokers working with producer associations such as YPBB and Threads of Life enable producers to get a better price and returns well above average local daily wage rates. Prices also act as an incentive to harvest larger quantities of a product, such as *Morinda* roots, so this needs to be addressed through agroforestry interventions.

## Diverse niche markets to reduce competition

Niche markets can give producers an edge compared with mainstream crops.

### The power of strategic partnerships: business, producer associations and universities backed through policy support

Unlike natural products sold in local markets, local farmers cannot be expected to have detailed knowledge about export markets or their quality-control or research requirements. For this reason, the research and development (R&D) capabilities of national or regional universities, or R&D facilities of large firms with whom partnerships are formed, meet an important need once necessary intellectual property rights protocols are met. In West Africa, the shea nut (*Vitellaria paradoxa*) trade has been assisted through establishment of WATH, supported by the United States Agency for International Development (USAID) and expert advice, leading to greater efficiencies and the opening of a major shea-butter refining facility following recommendations by Addaquay (2004). A similar approach is worth testing for selected products in ENT.

### Conflict resolution mechanisms

Although rural communities are widely spoken about as if they were cohesive, in many cases they are not. Instead, they are divided along the lines of families, clans and power relations. Natural-product commercialisation can widen these rifts, particularly where value chains are complex and neither costs nor export markets are well understood by producers. Profit-sharing within producer associations is another potential pitfall. In Mexico, for example, less than half (15 of 42) of the communities running community forest enterprises (CFEs) distributed profits (Klooster 2000). The decision to distribute all or part of the profits to legal members of CFEs depends on levels of trust, poverty and the probability of investing in other enterprises. Establishing transparent, acceptable and fair means of conflict resolution is therefore a good investment.

### Regional cooperation in order to compete

With endemic species, there are commercial advantages to maintaining germplasm within the single source country; however, for widely distributed species, commercial advantages have resulted through regional cooperation. *Uvaria rufa*, *A. catechu* and *P.*

*betle* would all benefit from sharing of germplasm within Asia. These advantages go beyond the obvious ability to harvest commercially viable quantities of fruits or seeds that was mentioned earlier, extending to shared R&D, and legal or coordinated, multi-country lobbying for policy change, such as for recognition in the European Union (EU) that baobab pulp is not a ‘novel food’ (Wilkinson and Hall 2007).

### Upgrading within value chains

As Giuliani et al. (2003) point out in their seminal paper:

‘upgrading within a value chain implies escalating on the value ladder, moving away from activities in which competition is of the ‘low road’ type and entry barriers are low. However, upgrading also has a sectoral dimension, and may differ depending on the specific features of different groups of industries.’

Some of the products we discuss in later chapters of this report could fit into the four types of upgrading identified by Humphrey and Schmitz (2000) and used by Giuliani et al. (2003), namely:

- **process upgrading**, where the transforming production process has been reorganised or improved processing technology introduced, such as *Calophyllum inophyllum* seed oils or *Morinda citrifolia* root-bark with a long shelf life
- **product upgrading**, where natural products are developed into diverse and more sophisticated product lines, with higher values per unit volume—for example, *Borassus flabellifer* (*lontar*) palm syrup from Savu or deodorised *A. moluccana* seed oil for the spa industry
- **functional upgrading**, which refers to cases where new, superior functions are developed in the value chain—examples are new marketing and packaging for giant honeybee honey or *lontar* palm syrup, packed in jars shaped like those used for maple syrup for sale in higher end outlets in Bali or internationally (see the ‘Food and drinks’ chapters)
- **intersectoral upgrading**, which occurs when new research or technology enables a product to shift from one sector into a different, new sector—for example, the potential for extraction of commercial products from tamarind seeds (see the ‘Plant oils and polysaccharides’ chapter), which would enable a shift into high-value pharmaceutical use (instead of being discarded or used as pig food); or production of niche-market food oils from avocados produced in Timor (which at the moment are sold fresh at a low price).

## **Strategies to reduce or avoid ‘elite capture’**

In her study of locally traded NTFPs in South Africa, Shackleton (2005) found little evidence of elite capture (where wealthy or powerful elites obtain benefits from products to the exclusion of the rural poor), perhaps due to their low value. As Mansuri and Rao (2003) point out, however, elite capture is almost inevitable:

Even in the most egalitarian societies involving the community in choosing, constructing and managing a public good is a process that will almost always be dominated by elites because they tend to be better educated, have fewer opportunity costs on their time, and therefore have the greatest net benefit from participation.

In these cases, elite capture of natural products occurs at various levels and in different forms (production, transport, processing and manufacture). In terms of permits and trade, well-connected Indonesian Chinese business people with access to transport dominate the trade in several agroforestry products.

Careful choice of the types and locations of processing technology is also required. Wynberg et al. (2002) point out, for example, that the introduction of new, mechanised technologies to assist with *Sclerocarya birrea* (*marula*) oil processing in southern Africa created a shift away from manual processing by women to a situation where men had control over processing technologies (the oil presses). Choosing the location of processing facilities also influences who benefits. In West Africa, for example, many large shea cooperatives are located in urban centres, disproportionately benefiting from donor support and benefiting urban rather than rural women (Elias et al. 2006). Even the use of processing patents can restrict high-value harvest for trade as a form of elite capture. Efficient coordination of producer association members is also needed to produce a high-quality product in sufficient quantity at a competitive price.

## **Traceability**

Unlike local informal-sector markets, the ability to trace where a product comes from is a necessary requirement in most export markets—particularly for foods such as palm sugar. From January 2005, for example, the EU required that all agricultural products, including shea nuts, be traceable from their source (Lovett 2004). New technologies such as bar coding offer opportunities for training producers to track products to meet these requirements. Although

certification is too costly to implement, as is discussed below, ‘chain-of-custody’ requirements are a useful form of traceability.

## **Strategic use of labelling, branding, trademarks and certification**

Product branding, trademarks and certification can play an important role in natural-product export markets. In Europe, farmer-owned brands play an important role across a range of products (Hayes and Lence 2004). For branding, trademarks or certification to work anywhere requires two things: first, a ‘caring’ market prepared to pay a significant premium for these products; and second, access to a wider share of the market due to consumer awareness. Although many consumers care about quality and price, they are often an ‘uncaring’ market. Export markets are increasingly interested in ‘clean, green’ products. If claims of sustainability are made, it is crucial to ensure that those claims can be backed up. This requires a system of traceability through chain-of-custody systems. If certification of forest products is to be successfully implemented in Indonesia, producers need to have the opportunity to weigh up the costs and benefits of different certification options in order to decide whether or not a particular set of standards is a good fit for their product, consumer market, budget and organisational capacity.

## **Effective trade fair participation**

This offers the opportunity to become fully familiar with the necessary knowledge, tools and skills to prepare and coordinate professional group/country presentations in international trade fairs in Europe.

## **Donor support to help level the playing field**

Although the Millennium Development Goal on the global partnership for development calls for an open trading system that is rule-based, predictable and non-discriminatory, yet recognises the special needs of the least developed countries in relation to tariff- and quota-free access for their exports, this goal is far from being achieved (IFAD 2004). In 2001, the Organisation for Economic Co-operation and Development (OECD) countries’ total public support for agriculture (US\$311 billion) was *six* times the total amount spent on official development assistance, while producer support (domestic subsidies, import tariffs and export subsidies) was estimated to equal nearly one-third of total farm receipts (IFAD 2003). Aside from mainstream farm crops,

private enterprises based on plant products for niche markets in OECD countries like Australia, including joint-ventures with major multinational companies, have received significant subsidies in the form of state research support (such as for *Macadamia* nut production or production of opium poppies for alkaloids). International donor support to level the playing field for small- and micro-enterprises can make a big difference if it is well directed.

### **Limited policy bottlenecks**

Although market demand is a key factor influencing growth of natural-product exports, export success is directly affected by government policies within producer countries as well as in importing regions such as the EU, Japan and North America. In the United States of America (USA), the *African Growth and Opportunity Act* (AGOA), for example, provides useful opportunities for African enterprises. Even seemingly small policy changes can make a big difference. Unlike the EU, which allows up to 5% of chocolate to consist of cocoa butter substitutes, thus expanding the market for shea butter trade, the USA does not permit non-cocoa vegetable oils in products labelled as chocolate. The EU, on the other hand, has recently allowed use of baobab (*Adansonia digitata*) pulp. In Australia, fruits of boabs (*Adansonia gregorii*) are not considered a novel food by Food Standards Australia New Zealand and were given food status in March 2005 (Wilkinson and Hall 2007). Strict Australian quarantine regulations are understandable, but pose a major barrier for farmers in West Timor who are tantalisingly close to Darwin. Technological interventions (such as production of avocado oil to enable Timorese farmers to add value and market a product that meets quarantine requirements) offer a useful solution.

# Plant oils and polysaccharides

## Background

Plants producing seed oils have a long history of production and use in eastern Indonesia for a wide range of purposes. *Moringa oleifera* (*kelor*) is widely cultivated for its edible leaves, but also produces seed oil. *Schleichera oleosa* (*kesambi*) seeds are the source of ‘Macassar’ (or *kusum*) oil, popular for men’s hair styling in Victorian Europe. Textile weavers have used the seed oils from *Pangium edule*, *S. oleosa* and *Sterculia foetida* for oiling cotton threads before dyeing. Today, the most commonly available oil is from the seeds of *Aleurites moluccana*, which is widely cultivated in ENT, mainly as an export crop, but is also used as a condiment and by textile weavers. These are important but relatively low-value markets. The chemical composition of seed oils determines their market potential (Lisa and Holcapek 2008). In this chapter, we focus on four tree species—*A. moluccana* (*kemiri*), *Calophyllum inophyllum* (*nyamplung*), *Tamarindus indica* (*asam*) and *Persea americana* (*avocado*)—that we consider have potential for three categories of use: first, the market for cosmetic oils; second, the potential of the seed oils for biofuels (*C. inophyllum*); and third, as a source of polysaccharides (*T. indica*). We have not included *S. oleosa* seed oils in this final selection, despite the fact that they are used as industrial oil in India. This is because of the reduction in seed and fruit production in ENT due to severe pruning to manage the insect lac industry (see below and the ‘Food and drinks 4: Cinderella fruits’ chapter).

## Cosmetic oils

Global sales of natural and organic cosmetics were worth almost US\$7 billion in 2007, and were predicted to reach US\$10 billion by 2010. This is driven by demand from Europe and North America, but India and China are the important emerging markets. Since buying Sanoflore and The Body Shop in 2006, L’Oreal is working with producers of cosmetic oils in a range of developing countries. Also, at the high end of the market, Origins Natural Resources,

part of Estée Lauder, has launched a certified organic cosmetic range called Origins Organics. In addition, European supermarkets are marketing natural and organic cosmetics under private labels. New product development has become a key feature of the natural cosmetics market. Certification is an important component of this market, with Ecocert and the United Kingdom (UK) Soil Association working closely with cosmetic manufacturers, who are innovative in developing new product formulations, including natural preservatives, surfactants and colourants, in a shift away from synthetic chemicals.

## Beyond *Jatropha*—oilseed trees for biofuel

Ratification of the Kyoto Protocol stimulated global interest in biofuels as a renewable energy source and a way of reducing greenhouse gas emissions. Despite the need for caution and good science called for by Achten et al. (2008), *Jatropha curcas* production has caught the imagination of investors, policymakers and donors, often based on ‘grey literature’ that overestimated oilseed yields. Indonesia has not escaped this trend. Since 2005, several major projects proposing to plant *J. curcas* for biofuel production have been proposed for ENT. Despite studies of *Jatropha* oilseed yields in India warning against overoptimism in projects projecting high yields (Behera et al. 2010), ambitious plans for *Jatropha* oil production have been suggested for West Timor. In 2007, an Israeli company, the Merhav Group, together with an Indonesian partner (PT Manhattan Capital), planned a US\$700 million *Jatropha*-cultivation project in West Timor. This was later rejected as not being strategic in terms of Indonesia’s foreign policy interests (Oktaviani and Irawan 2009). A further example is the proposal by a Singapore-based company (Mother Earth Plantations Pty Ltd) to invest US\$100 million through its Indonesian subsidiary (PT Buana Ibunda) to develop *Jatropha* plantations and a refinery in West Timor to produce 21 million barrels of biodiesel a year by 2013 (The Jakarta Globe 2009). Some areas of Lombok, Sumba and West Timor have been planted

with *J. curcas*, yet far less attention has been given to the biodiesel potential of oilseed sources from local tree species. Ironically, in the same landscapes being planted with *J. curcas* are tree species that could be an oilseed supply if decentralised harvests could be brought to a bulking-up centre and if prices/kg made this commercially attractive to local people. The two most promising species are *A. moluccana* and *C. inophyllum*. The biodiesel properties of both species have been studied in Indonesia (Sulistyo et al. 2008). Thirdly, *S. oleosa* could also be considered, if populations are able to recover from severe pollarding due to lac production as well as indiscriminate felling for the commercial fuelwood trade. *Schleichera oleosa* and the closely related *S. trijuga* are considered to be promising industrial oilseed sources in India (Anand et al. 2006).

#### *Benefits of local species*

Considering oilseed-producing tree species that already exist in ENT could have several advantages. First, it would avoid some of the concerns expressed about plantation development for new oilseeds, including increased carbon emissions, biodiversity loss and high impacts on local livelihoods (Achten et al. 2008; Fargione et al. 2008; Searchinger et al. 2008). Second, as oils from each of the three tree species have cosmetic uses as well, there is an opportunity for developing a 'two-tiered' marketing strategy, should production be commercially viable: large-scale oilseed extraction for biodiesel; and smaller scale, high-quality production for the cosmetic industry. This would be similar to *Vitellaria paradoxa* (shea butter) seed production in West Africa, where 95% is sold as a cocoa-butter substitute for the chocolate industry and 5% for cosmetic use.

At the moment, local people undervalue the dry woodlands and coastal forests containing oilseed trees, despite their multiple uses. More-detailed national forestry inventories of *C. inophyllum* and *S. oleosa* would be useful. Results would have both practical and policy implications in terms of land-use planning, including providing alternative options to clearing land for *Jatropha* plantations in ENT. Avoided deforestation through maintenance of these woodlands would also have wider benefits, such as carbon sequestration and reducing emissions from deforestation and forest degradation. *Calophyllum inophyllum* and *S. oleosa* in particular have dense wood and are efficient at carbon storage.

#### *Need for economic studies*

What is needed as a follow-up to this project are studies on the economics and efficiency of decentralised biofuel production from three tree species: *C. inophyllum*, an Indo-Pacific species common in Indonesian coastal forests and agroforestry systems; *A. moluccana*; and *S. oleosa*, which occurs through South and South-East Asia and is dominant in dry woodlands and forests of ENT. In the areas where these tree species occur, local farmers rely on imported, high-cost diesel to run generators, water pumps and the grinding machines used to improve the processing efficiency of farm products. Decentralised biofuel production, if commercially viable in Indonesia, would be a key factor in boosting farm incomes and reducing women's labour time (such as pounding seed crops by hand in wooden mortars). Low-cost, decentralised biodiesel production would reduce dependency on imported diesel for farm machinery. This has the potential to improve farm profit margins and decrease household costs.

#### *Aleurites moluccana*

High in polyunsaturated fatty acids (linoleic and linolenic acids) that promote wound healing (Ako et al. 2005), *A. moluccana* (candlenut, *kemiri*) seed oils have 75.8 mg/100 mg oil, comparable with better known cosmetic oils such as blackcurrant (*Ribes nigrum*; 74.2 mg/100 mg oil) and evening primrose (*Oenothera biennis*; 81.2 mg/100 mg oil).

The aim of this component of the study was to investigate the trade in *A. moluccana* seeds in order to better understand the enterprise potential of candlenut oils for local farmers in ENT. To achieve this aim, we set out to answer five questions:

- Which countries are the main competitors in the candlenut oil export market?
- What is the scale of the *A. moluccana* seed trade within Indonesia and which areas compete with ENT as candlenut seed producers?
- At a national level, what are the current value chains and the main trade destinations for *A. moluccana* seeds before export?
- Within ENT, which islands and regencies produce the most candlenut seed?
- How significant is the informal-sector trade in ENT for different purposes?

Based on this information, we then discuss the steps that need to be taken to improve income to local candlenut seed producers in ENT.



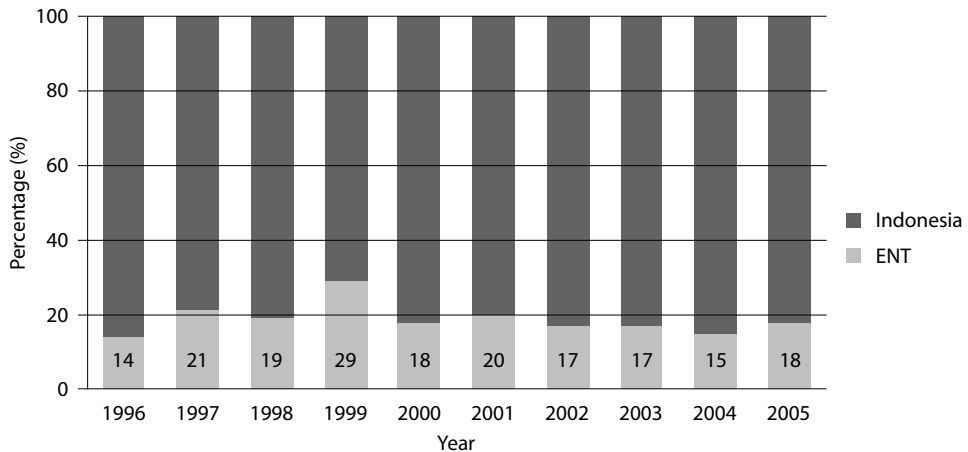
In terms of production area and quantity of seeds in trade, *A. moluccana* (Euphorbiaceae) is the most significant oilseed in eastern Indonesia, although, from a national perspective, more *A. moluccana* seeds are produced in other parts of Indonesia (Figure 19). In ENT, Ende regency on Flores is the major production area (Figure 20), with *A. moluccana* production a major driver of indigenous forest loss (Figure 21). *Aleurites moluccana* is a pre-colonial introduction to South-East Asia from Polynesia (Abbott and Shimazu 2005). In Indonesia, *A. moluccana* is a multipurpose species used medicinally (bark, leaves, seeds), in food, for lighting (seed oil) and for fuelwood. In eastern Indonesia, it is also used in handwoven textile production for oiling the cotton threads before dyeing and mordanting (Cunningham et al., in press).

Historically, *A. moluccana* seeds were sown into swidden farming systems. Once introduced, *A. moluccana* persists in moist valley systems, self-seeding, forming dense stands. In South Sulawesi during the 1920s and 1930s, Dutch colonial foresters encouraged planting of *A. moluccana* in ENT. Although Koji (2002) documented some aspects of *A. moluccana* production history and trade in Indonesia, he did not focus on the informal-sector trade in *A. moluccana* seeds, nor consider the potential of the cosmetic oil industry as a trade opportunity in ENT.

Despite very optimistic reports on *A. moluccana* oil exports from East Timor to Hawaii (Anon. 2006), there is little or no scope for *A. moluccana* oil sales

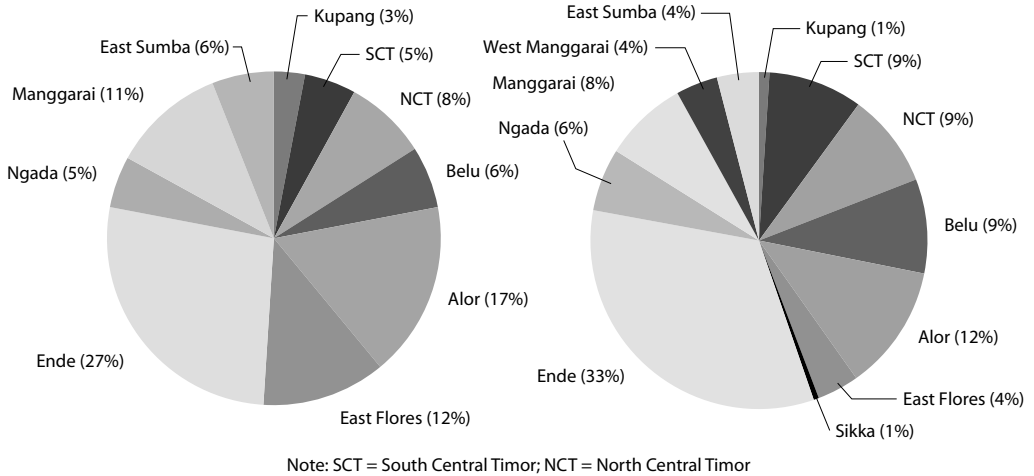
from Indonesia to the same buyer (Oils of Aloha, Hawaii). According to Richard Markowski, who works with small farmer groups other than the Acelda company in East Timor, two villages in the Venilale subdistrict of Baucau have an estimated combined production of over 100 t of *Aleurites* a year. Four villages included in the Acelda program in the Uatulari subdistrict of Viquegue produce a combined annual production of 1,000 t. The program involves 38 small farmer groups growing *Aleurites* organised into an association with some 1,338 direct members. At the village level, the local traders buy *Aleurites* nuts as low as US\$0.35/kg and as high as US\$0.70/kg (Oils of Aloha, pers. comm. 2008 to Threads of Life). This is equivalent to a price of Rp5,000–8,000/kg.

*Aleurites* seeds for the Indonesian market are transported by truck from Dili in East Timor to Atambua in West Timor, and are then shipped by cargo vessel to Surabaya. Figure 22 shows the amounts exported from East Timor to the Indonesian market by the different traders. The project in Bacau, East Timor, funded by Acelda, USAID and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) is included in the trade data as selling unprocessed nuts to Indonesia. This seems to be taking place despite their business agreement giving Oils of Aloha 5 years of full rights to all oil produced by the Acelda group. During this study, Life Force, a Bali-based producer of spa products, was approached by USAID to buy *A. moluccana* as an oil to use in spa products from

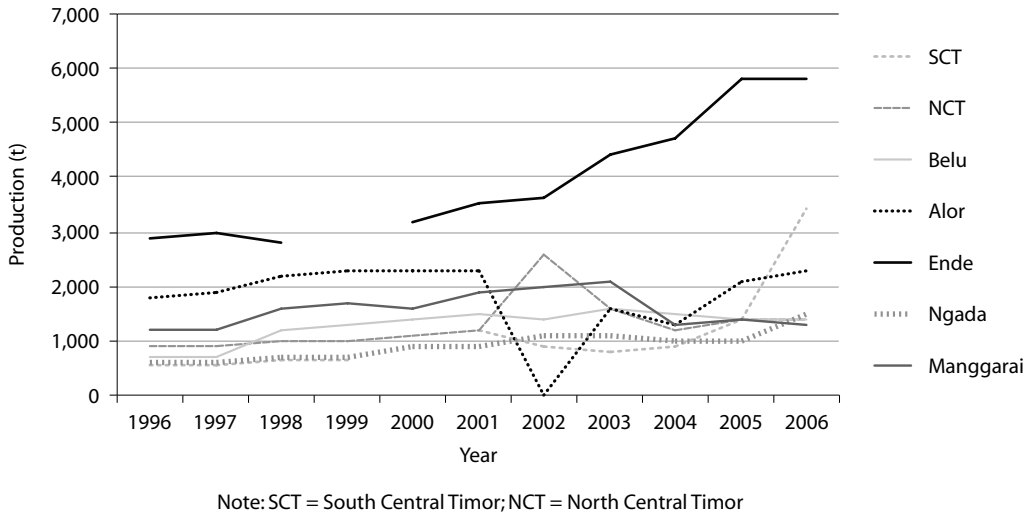


**Figure 19.** From a national perspective, between 1996 and 2006, a relatively small proportion of candlenut production (14–29%) came from East Nusa Tenggara (ENT), compared with Indonesia

East Timor. Nothing transpired but they are still interested in testing deodorised *A. moluccana* oil. Most *Aleurites* seeds from ENT are also shipped to Surabaya. The supply chain from Flores is a good illustration of this (Figure 23).



**Figure 20.** *Aleurites moluccana* seed production in East Nusa Tenggara (ENT) in 1996 (left) compared with 2005 (right), showing an increase in production in Ende regency from 27% to 33% of total ENT production



**Figure 21.** Within East Nusa Tenggara, Ende regency on Flores was the major producer of *Aleurites moluccana* seed, where it is widely cultivated as a shade tree for coffee trees. The expansion of this *Aleurites*–*Coffea* agroforestry system on Flores has been a major factor driving recent deforestation, including high biodiversity montane forests.

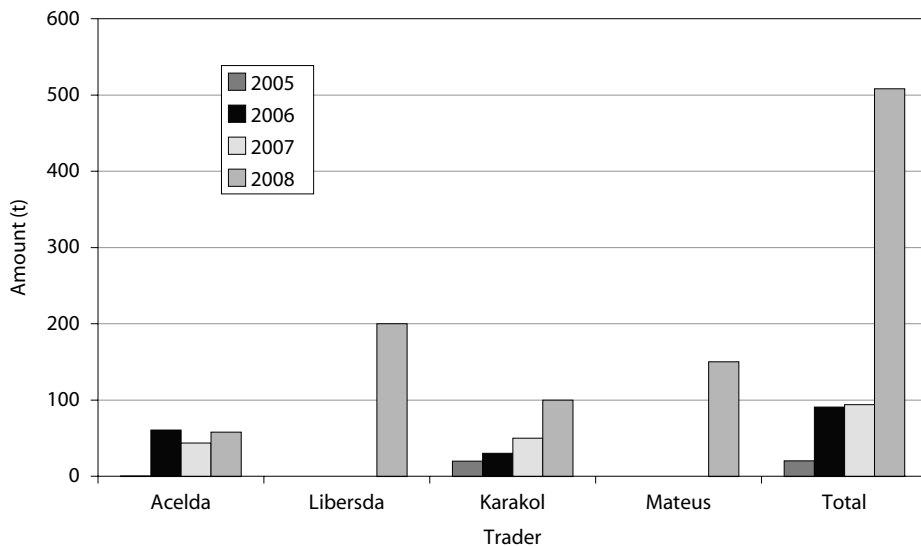


Figure 22. *Aleurites moluccana* seed exports from East Timor to Indonesia, 2005–08

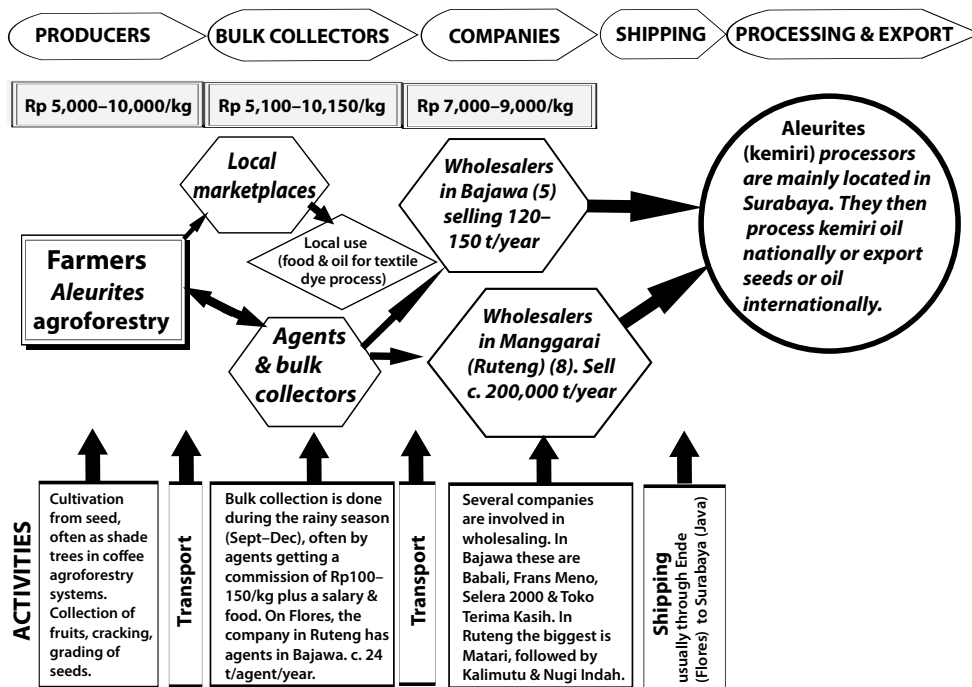


Figure 23. The *Aleurites moluccana* value chain on Flores

## *Calophyllum inophyllum*

### Cosmetic oil

*Calophyllum inophyllum* (*nyamplung*) is a multipurpose tree managed in agroforestry systems for branch wood, which is used as fuel (Figure 24). The seed oils were traditionally used as a light source before people had candles in ENT, and are a commercial source of cosmetic oil.

The seed oils have been recently shown to have value as a non-cytotoxic ultraviolet (UV) filter which could be used in skin creams (Said et al. 2007). Since the 1930s, *C. inophyllum* seed oils have been studied due to their efficacy in wound healing (Chevalier 1951). In addition, the seed oils have active ingredients that are anti-inflammatory (Gopalakrishnan et al. 1980) as well as anti-microbial, anti-fungal and anti-bacterial (Kilham 2004).

### Biodiesel from *Calophyllum* seed oil

Biodiesel production using *C. inophyllum* seed oil has already been successfully developed in Indonesia

(Susanto 2009) and India (Venkanna and Reddy 2009), with good results (Sahoo et al. 2007). In Indonesia, the Centre for Forest Products Research and Development has conducted research on manufacturing biodiesel since 2005. In 2008, as part of that research, *C. inophyllum* biodiesel was tested by Puslitbang Minyakdan Gas Bumi and met all the Indonesian biodiesel standards. In addition, *C. inophyllum* biodiesel was road-rally-tested three times over 320 km with good results (Sudradjat 2008).

According to Friday and Okano (2006), *C. inophyllum* trees produce c. 100 kg nuts/year, enough to extract 5 kg of oil. A recent survey by FORDA, as part of their research on biodiesel production from *C. inophyllum*, concluded that there were 103,316 ha (25,500 acres) of *C. inophyllum* forest in Indonesia (both inside and outside forest reserves) (Sudradjat 2008). Most of this is in West Papua (49,573 ha; 48%) and Kalimantan (12,686 ha; 12.3%), but a significant proportion is in Bali and Nusa Tenggara (11,816ha; 11.4%). In Pandes village, Java, villagers have been collecting and shelling 1.5–2.0 t of *C. inophyllum* seeds



**Figure 24.** *Calophyllum inophyllum* (*nyamplang*): (A) branches are lopped from *Calophyllum* trees to reduce shade effects on understorey crops and to get the hardwood branches for fuel; (B) the large seeds yield 60–75% oil

per day, earning Rp10,000–15,000 (c. US\$1.0–1.50) per day from this process (Susanto 2009). The biofuel production capacity of Pandes village is 600–800 litres (L) per day at a cost of Rp4,000/L, which is lower than the local gasoline price (Susanto 2009).

We suggest that a research study be conducted to assess the practicality, economics and efficiency of decentralised biodiesel production from *C. inophyllum*. This could be achieved through the:

- mapping and inventory of the *C. inophyllum* resource base at a national scale in more detail than the current FORDA estimates, distinguishing between the diverse range of tenure systems over these trees rather than the two-way division into ‘within forests’ and ‘outside forests’ in the initial FORDA survey
- overlay of towns, villages and farm centres within those areas
- mapping of the locations of diesel-powered machinery on farms, village centres, small businesses or at cooperatives within four pilot-study landscapes (of 100–150 km<sup>2</sup> in extent), and assessment of demand for diesel and costs within each site
- importation of two or three BioCubes—these have been developed in Australia for decentralised processing of biofuels (ABC 2008)—or an alternative technology developed in Indonesia, if this is available. The BioCube can process up to 2,000 L of biodiesel per day from a range of oilseeds.

Key research questions would be:

- What are anticipated oilseed and biodiesel yields per ha from these dry woodlands?
- What are current uses and who are the users of these oilseeds?
- What are the existing resource values of these areas (i.e. not just the biofuels, but the multiple other values—economic, social, environmental services—including carbon)?
- Who are the existing resource users of these areas and how are they affected by biodiesel expansion?
- What are the current direct costs (at the farm gate) and total ‘carbon costs’ (e.g. taking long-distance transport into account) of diesel in the study areas compared with decentralised biodiesel production at a village centre using BioCube technology? A cost–benefit analysis could be based on BioCube technology in 2–4 pilot-study sites (depending on free-on-board (FOB) costs of importing the BioCube).

- What are the appropriate scales of biodiesel production for different sites and which plant species could (or should) be used? The risk with big schemes is that local people lose out. There are winning inventions, such as the BioCube, that could be used at the local level.
- What are the strengths and weaknesses of current governance of decentralised diesel-powered machinery?
- Where and under what circumstances does governance work (or fail)?
- How can this inform the governance of a new technology such as the BioCube?

## *Tamarindus indica*

Tamarind (*asam*) is best known for its acidic fruit pulp, which is used in cooking fish, curries and sauces, and for flavouring confectionary as a juice component. This edible fruit aspect of *Tamarindus indica* (Leguminosae) is discussed in the ‘Food and drinks 4: Cinderella fruits’ chapter of this report. This section deals with a lesser known but, in terms of this project, perhaps more important aspect of *T. indica*: the oils and polysaccharide gums from the seeds. Based on Indonesia exporting about 20,000 t of tamarind fruit pulp, mainly to Australia (Vinning and Moody 1997), considerable quantities of seeds should be available. These seeds are an annual by-product of tamarind pulp production, but most are discarded or sold at low cost for pig food (Figure 25). There is a definite market opportunity here. Tamarind seeds are commercially valuable for the manufacture of tamarind seed kernel powder, polysaccharides (particularly xyloglucan), adhesives and for tannins. In fact, tamarind seeds are the only commercially available source of xyloglucans. These are used as a starch replacer in reduced-calorie food products, as well as in the pharmaceutical industry for controlling the release of drugs (Izydorczyk et al. 2005). At the moment, companies in India, such as Oriental Gums and Biopolymers (in Ahmedabad, Gujarat), are the major producers of tamarind seed products (xyloglucans and carboxy methyl tamarind). During the course of this study, however, an Australian company, Gum Guar Australia (Cronulla, New South Wales), that imports another plant polysaccharide from India (gum guar, from *Cyamopsis tetragonolobus*—also in the Leguminosae) was contacted and expressed an interest in possibly following up on tamarind seed products.

Use of tamarind seeds as pig feed by farmers in ENT makes nutritional sense. According to El-Siddik et al. (2006), whole tamarind seed and kernels are protein rich (13–20%), while the seed coat is rich in fibre (20%). Most of the seed carbohydrates are in the form of sugars (Panigrahi et al. 1989). In addition, tamarind seeds contain 4.5–6.5% of an oil that is rich in fatty acids: palmitic (14–20%), stearic (6–7%), oleic (15–27%), linoleic (36–49%), arachidic (2–4%), behenic (3–5%) and lignoceric (3–8%) (Andriamanantena et al. 1983). The seed oil is a golden-yellow, semi-drying oil that resembles linseed oil and is rich in unsaponifiables (low molecular weight fatty acids) and sterols (beta-amyirin, campesterol and beta-sitosterol). These unsaponifiables are an important attribute of commercial seed oils such as shea butter (WATH 2005) and may have commercial application from tamarind seeds as well.

Recommendations are made in the ‘Food and drinks 4: Cinderella fruits’ chapter for tamarind fruit pulp market development. The next step recommended for seed by-product markets is a research project with commercial partners from Indonesia and Australia that uses existing Indian technology for pilot-level processing and manufacture of tamarind seed kernel powder (TKP) and polysaccharides (particularly xyloglucan) that can be scaled up to meet national demand in Indonesia or export markets in Australia from Kupang. India produces about

20,000 t of TKP/year, worth an estimated Indian rupees 16–17 million/year (c. US\$340,000–360,000/year) (El-Siddik et al. 2006). Indonesia could do the same through improved postharvest and processing techniques.

### *Persea americana* (avocado)

Compared to fruits such as mango, avocado (*Persea americana*) fruit production has been poorly studied in Indonesia. No studies are known on the potential of avocado oil production in Indonesia, which is the focus of this section of the report. The most recent review, carried out by Harjadi (2000), considered that total annual avocado production in Indonesia was 71,001 t from Java and 46,471 t from other islands, but this was based on 1994 and 1996 production records, so may have increased substantially since then. Even less attention has been given to avocado production in ENT, yet significant quantities of avocado are produced by small-scale producers from agroforestry systems in mountain areas of West Timor and Flores. All avocado production in ENT is sold into the local market, a situation typical of the rest of Indonesia as well. Most avocado production is from Java, particularly the Garut, Sukabumi and Cianjur districts of West Java; and Ponorogo, Lumajang and Sidoarjo in East Java.



**Figure 25.** *Tamarindus indica* seeds: (A) an estimated 1.2 t of *Tamarindus* seeds for sale as pig food (Pasar Impres, Kupang, March 2008); (B) a sample of seeds cleaned for sale as pig food—these are likely to have a higher market value as a commercial source of xyloglucans

## Potential markets for fresh fruits

Avocado fruits are not well known or particularly popular in Asia, although there is a growing tourist market for avocado fruit shakes in restaurants in Bali. In the Soe and Kefamenanu markets of West Timor, local prices for avocado fruits are low, fruits are perishable and supply seasonally outstrips local demand. By contrast, avocado consumption in Australia is increasing and prices are high.

At a global scale, both Indonesia and Australia are relatively small-scale avocado producers. In terms of world production, Mexico is the major producer (at 36.8% of total world production), followed by the USA (7.9% of world production) (Timor Agri Group Limited 2010). Although producing about 2% of world production, Australia also imports up to 11,500 t of avocados per year from New Zealand. Shipping time from New Zealand is 3–4 days, with avocados shipped fresh in refrigerated containers (Dixon 2001). In contrast to the distance between Auckland, New Zealand, and Sydney, Australia (2,150 km), the port of Kupang (West Timor) is only 500 km from Darwin. The close proximity of West Timor to Darwin offers two potential opportunities to improve income to small-scale avocado farmers in West Timor.

The first idea is to consider grading and then exporting fresh avocado fruits to Darwin, competing with Australian domestic production and New Zealand imports. Promoting fresh avocado exports from East Timor to Australia has recently been considered in an initial public offering by Timor Plantation Limited, a subsidiary of the Timor Agri Group Limited, based in New Zealand (Timor Agri Group Limited 2010). Exporting high-quality fresh avocado fruits in refrigerated containers to Darwin may be an option, but at least two steps are required as part of a feasibility study: an import risk analysis, so that phytosanitary standards are met; and a cost-benefit analysis, including an assessment of the availability and costs of shipping refrigerated containers with fresh avocados through Australian ports.

## Oil for cosmetic and culinary uses

The second recommendation is to undertake a feasibility study for avocado oil production. The most likely production areas would be in Soe or Kefamenanu in West Timor. There are two different markets for processed avocado oil. One is the cosmetic oil market, which is a well-established market due to the beneficial effects of avocado oil on the skin

(Werman et al. 1991), and the second is the boutique culinary oil market (Eyres et al. 2001; Woolf et al. 2009). In the future, there may also be a market for: avocadins from avocado skins, which have antiviral and insecticidal properties; dry avocado leaves, which are a natural dye; and a potential market for the unsaponifiable components of avocado seeds and oil, which are used to treat osteoarthritis, but these are not further considered here.

The avocado oil market offers an opportunity for local value-adding and use of surplus good-quality fruits during the fruiting season in West Timor. Avocado fruit pulp contains up to 30% oil, with minimal oil in the seed ( $\approx 2\%$ ) or the skin ( $\approx 7\%$ ) (Woolf et al. 2009). Cold-pressed avocado oil is used as a culinary oil on salads and for cooking (Eyres et al. 2001) and there is a growing market for it. Good-quality avocado oil produced in West Timor could be exported to Australia or used within the restaurant industry in Bali. Avocado oil is also produced in other countries, for example, by commercial growers in Chile, Kenya, South Africa and USA (Human 1987; Woolf et al. 2009). There will be competition with production of extra virgin avocado oil from New Zealand, which has been pioneered since 2000 by two commercial companies, Grove Avocado Oil (in Tauranga) and Olivado (in Kerikeri). However, the proximity of West Timor to Australia gives it an advantage. Today, approximately 3% of the New Zealand avocado crop is processed for the oil, with over 150,000 L of extra virgin avocado oil produced in New Zealand during the 2008–09 growing season (Wong et al. 2010). Although avocado oil production in ENT would be smaller, this niche market has potential to add value to existing agroforestry systems and to household income.

# Food and drinks 1: edible mushrooms

## From wild harvest to cultivation

Local people collect and eat a diverse range of wild mushroom species in Indonesian rural areas and cities. In a study of the Habema area of West Papua, for example, Subomo (1992, cited in Walujo 2008) recorded 30 types of edible fungi collected by Dani people, 17 species of which were most favoured. In ENT, most local people consider mushrooms to be very delicious, but only eat them locally. In villages near montane forests in Ende regency, the deadwood of two forest tree species—*nionga'e* (*Polyscias*, Araliaceae) and an unidentified tree species known locally as *kayu molu*—were particularly favoured as substrate on which forest mushrooms grow. *Kayu molu*, unlike softwood *Polyscias*, is a hardwood tree species also favoured for firewood. Mushroom production is seasonal, with some mushrooms available at the beginning of the rainy season and others (such as *jamur kuping*) available at the end of the rainy season. According to local farmers on Flores, when lots of mushrooms are available, it means that there will be a very hot summer. During our surveys of local marketplaces in ENT, however, only one wild-collected fungus was recorded: *Auricularia* (wood-ear mushroom), widely known in Indonesia as *jamur kuping* (Figure 26), which was being sold in Bajawa market. If edible mushrooms are so scarce in local marketplaces, why have we suggested three species as potential winners worth considering for production in ENT?

## Benefits of mushroom cultivation

We have five reasons for recommending mushroom cultivation. First, there is a significant local market for mushrooms in thousands of food stalls (*warung*) and restaurants and, as Rifai (2004) has shown, a wide diversity of fungus species are consumed. Second, wood-ear (*Auricularia*), shiitake (*Lentinula edodes*) and oyster (*Pleurotus ostreatus*) mushrooms are suited to small-scale production units if producers are organised and linked to suitable markets (Figures 26 and 27). Both shiitake (Figure 27) and wood-ear mushrooms can be dried, making transport more

viable for farmers in more remote areas. In Shaanxi province, China, production of shiitake mushrooms has made a significant improvement to the income of small-scale farmers. With the right support and through careful site selection, as we discuss later, small-scale farmers in ENT can do the same. The most likely locations in ENT are in montane uplands such as Soe and Kefamenanu (West Timor) and Bajawa (Flores). Third, with a shift from wild harvest to mushroom cultivation, it should be possible to reach diverse markets. The easiest is a local trade to restaurants in towns, followed by inter-island trade (to larger markets in Bali and possibly Java). Fourth, the substrates on which fungi are farmed (such as rice straw, sawdust or logs from fast-growing tree genera such as *Polyscias*, which is suited to agroforestry systems) make a good link to existing production systems. Finally, there has already been successful technology transfer on *Auricularia* cultivation to small-scale farmers in Java (Box 1).

## Lessons from other countries

The best lessons for mushroom production in Indonesia are in China, which is the world's largest exporter and consumer of mushrooms. This has been achieved over the past 50 years through cooperation between the government, mycologists and 15 million local farmers. As a result, in 2002, China exported 6,648 t of dried *L. edodes* (80% of the world trade volume), which was worth US\$41.48 million. Dried *Auricularia auricula* quantities were even higher—7,767 t, worth US\$25.07 million.

In 1995, technology transfer from Taiwan to Indonesia enabled the establishment of the PT Indo Evergreen Agro Business Corporation and the commercial production of white mushrooms (*Agaricus*) and asparagus. By 2001, this company was exporting 95% of its mushroom production to North America and Japan, with 5% sold to the domestic market in Indonesia (Hsieh 2001). Today, along with PT Zeta Agro Corporation, PT Indo Evergreen Agro Business Corp. continues to be a major mushroom producer.



During this same period, a mycologist from Taiwan worked with small-scale farmers in Kabupaten Sleman, near Yogyakarta province, to initiate four steps in the *Auricularia* production process: (1) production of seed fungus growing bottles; (2) production of *Auricularia*-inoculated plastic bags; (3) supply of plastic bags to growers; and (4) marketing of dried mushrooms through farmers' cooperatives.

### Local prospects

While it is unrealistic to expect small-scale farmers in ENT to compete with large industries, there are

opportunities to learn from mushroom production by small-scale farmers and the experience of the training centre at Ngipiksari in Kabupaten Sleman. According to Hsieh (2001), 482 farmers participated in courses at the centre, plus 152 people from other parts of Indonesia, including university professors, extension officers and farmers. Initially, the full cost of the mushroom production houses was subsidised, but when they saw that the profits from *Auricularia* sales from one cultural house (78 m<sup>2</sup>) were the same as the annual profit of 1 ha of rice harvest, neighbouring farmers also joined in *Auricularia* production (Hsieh 2001).



**Figure 26.** Making the transition to *Auricularia* (*jamur kuping*, wood-ear mushroom) production: (A) wild-harvested *Auricularia* in the Bajawa market, Flores; (B) dried *Auricularia*, which is easy to transport; (C) one of two methods for intensive production—cultivation in Sichuan, China, on oak (*Quercus*) logs, showing black irrigation pipe used to keep moisture levels high (this method requires forest management planning to prevent unsustainable harvest of *Quercus* populations); (D) an oak log plugged after inoculation with pure, cultured *Auricularia* spores

Site selection would be an important part of successful pilot-project design in ENT. In Java, the technology-transfer extension project for *Auricularia* selected five *desa* (Gambretan, Cangkringan, Turi, Kalizrang and Kepoharjo) for several reasons. First, they were at a higher altitude (700–1,000 m above sea level, with a temperature range of 17–29 °C), making them suitable for year-round wood-ear mushroom

production. Second, these *desa* were on steep slopes unsuitable for crop production due to poor soils and limited water. Third, these villages were among the poorest in the area, so were suited to the objective of improving local income through commercial wood-ear mushroom production. Similar criteria could apply in ENT, with site selection near Bajawa (Flores) and in montane areas of West Timor.



**Figure 27.** Cooperation between small-scale farmers meets large-scale market demand for *Lentinula edodes* (shiitake) mushrooms: (A) low-cost tunnels (shade cloth over locally cut withies (slender flexible branches) and poles from agroforestry systems) used for intensive production in Shaanxi, China; (B) intensive production on sawdust or crop surplus within log-shaped plastic pouches inoculated with pure spores—this method was introduced to farmers in Java in the mid 1990s; (C) shiitake mushrooms ready for harvest; (D) and (E) in addition to sales of fresh mushrooms, appropriate technology dryers at each household enable surplus to be dried to prolong shelf life, increase the ease of transport and reach a wider market

### **Box 1. The economics of *Auricularia* (wood-ear mushroom) production in Java**

According to Hsieh (2001), the total cost for running one *Auricularia* culture house was Rp3,100,000 (in 1999), but annual profit per 78 m<sup>2</sup> culture house was US\$773. In terms of production costs, Hsieh (2001) reported:

A total of 300 kg of dried wood-ear mushrooms are produced from 5,000 plastic bags in one round of culture in nine culture houses. The total profit from sales of the product is 6,000,000 rupiahs per culture house. The net income from one culture house is 2,900,000 rupiahs. Since wood-ear mushrooms can be cultured twice a year, a net income per culture house per year is 5,800,000 rupiahs, which is equivalent to US\$773 (at the time, US\$1 = Rp7,500).

Four different units were necessary for production and marketing: (1) a seed fungus propagation unit; (2) plastic bag processing unit; (3) production at the culture house; and (4) marketing by the producers' association. According to Hsieh (2001):

the seed fungus stations produced a total of 70,000 bottles of seed fungus. The stations gained a net profit of US\$7,333 (55,000,000 rupiahs) from the

sale of seed fungus-containing bottles to the plastic bag processing station each year. Using this seed fungus, the plastic bag processing station processed a total of 2,400,000 plastic bags containing inoculated mycelia. They were sold to farmers at a price of 500 rupiahs per bag and earned US\$48,000 (360,000,000 rupiahs) net profit per year. The wood-ear mushrooms produced by the farmers each year amounted to 140,000 kg, which was sold at a price of 20,000 rupiahs per kilogram, with a net profit of US\$186,666 (1,400,000,000 rupiahs). The produced wood-ear mushrooms were collected by the farmers' organization and sold through trade companies. The company sold at a profit of 25–35% and earned a total net profit of US\$112,000,000 (840,000,000 rupiahs). The total net profit of the abovementioned four units amounts to US\$354,000 (2,655,000,000 rupiahs). This is a huge sum of money for farmers living in the remote mountains of Sleman County. More importantly, this project offered 2,500 job opportunities for the poor people in the area.

## Food and drinks 2: *Borassus flabellifer*

### Background

An influential recent study on the commercial values of NTFPs (Ruiz-Perez et al. 2004) called for caution against overoptimism in hoping that NTFPs could enable local people to escape the ‘poverty trap’. Ruiz-Perez et al. (2004) then classified particular forest products according to their role in household economic strategies, ranging from a subsistence (‘coping’) strategy through to households that had a specialised strategy. In her critique of this approach, Shackleton (2005) pointed out that it was crucial not to underestimate the role that NTFPs play as a buffer against rural poverty, but still considered that ‘different livelihood strategies tend to be represented by different products; for example, woodcraft is primarily a specialisation strategy, mat production a diversification strategy, marula beer selling a survival strategy, and broom production a coping or “necessity” strategy’. *Borassus flabellifer* (*lontar*) does not fit neatly into one household strategy or another. Instead, *lontar* use by households in ENT covers the full spectrum from specialisation to subsistence. In many respects, *B. flabellifer* is what Garibaldi and Turner (2004) termed a ‘cultural keystone species’, a term they chose to parallel the ecological concept of ‘keystone species’ that play an essential role in ecosystem structure and function. As Garibaldi and Turner (2004) explain:

Similarly, in human cultures everywhere, there are plants and animals that form the contextual underpinnings of a culture, as reflected in their fundamental roles in diet, as materials, or in medicine. In addition, these species often feature prominently in the language, ceremonies, and narratives of native peoples and can be considered cultural icons. Without these ‘cultural keystone species,’ the societies they support would be completely different.....Often prominent elements of local ecosystems, cultural keystone species may be used and harvested in large quantities and intensively managed for quality and productivity.

These roles of *B. flabellifer* were recognised in Fox’s (1977) seminal study on the *Borassus* palm economy of Rote and Savu, which masterfully expanded on

Ormeling’s (1956) point that swidden agriculture was being replaced by fire-resistant palms (both *Borassus* and *Corypha*). As Fox (1977, p. 52) pointed out:

On Sumba and Timor, palm economies directly confront swidden economies. In this situation a curious reversal seems to have occurred. It is reasonable to assume that the climatic conditions now generally felt throughout the outer arc had their effects on the small, low-lying, unprotected islands of Roti [Rote] and Savu. Abundant evidence in their own legends indicates that the Rotinese and Savunese once were swidden cultivators like the Timorese and Sumbanese. As their agriculture grew more precarious, it must have produced in its wake the palm savannah necessary for a new form of economy.

In Cambodia (Borin and Preston 1995), India (Davis and Johnson 1987), Thailand and Indonesia, *B. flabellifer* palms provide multiple products for households. These include low-cost housing (thatch and construction timber), food supplements from the fruits and sap, basketry for a wide range of purposes and pig food. It is *lontar* sap products that are commercially most important.

Loss of *B. flabellifer* palms would be a major disaster for local people, particularly on Rote, Savu and Raijua. In terms of commercial use, the main products from *B. flabellifer* are firstly from tapping the phloem sap, which is either sold fresh or converted into four main products: palm sugar, palm syrup, *laru* (palm wine) and *sopi* (distilled palm wine). Due to their wider commercial potential, palm sugar (Figure 28) and palm syrup (Figure 29) are a focus of this part of the report. Commercial basketry from the leaves is another important aspect, which is discussed in the ‘Cultural heritage and arts’ chapter.

### Palm sap tapping

Based on a review of palm-tapping technologies (Cunningham 1990) and field observation in tropical Africa and Asia, there is no doubt that the palm-tapping techniques used on Savu, Raijua and Rote are the most sophisticated and sustainable tapping



**Figure 28.** Production of palm sugar (*gula merah*) in West Timor: (A) a typical wood-fired stove for rendering down palm sap into palm sugar showing the places for six pots—when Fox (1977) did his study, clay pots rather than the aluminium pots shown here were used; (B) fresh palm sap (*tuak manis*) being poured into the pots; (C) *Borassus* petioles used as fuel to reduce the cost of buying firewood; (D) rings made from young *Borassus* leaves used as moulds; (E) laying out the leaf rings before pouring in the palm sugar to dry; (F) palm sugar in the form of *gula lempeng*, the most popular form in which palm sugar is sold in East Nusa Tenggara



**Figure 29.** Palm syrup production on Savu—a product with wider potential as a ‘tropical maple syrup’: (A) straining flowers out of the palm sap—these are fed to chickens; (B) getting sufficient firewood (mainly *Schleichera oleosa* and *Borassus* petioles in this case) is a major challenge; (C) a single-pot stove with palm petiole used as fuel; (D) the final product; (E) women from the main palm syrup production areas of Savu (Dimu and Liae) with jerry cans of palm syrup—mainly sold to people on Raijua, who have stopped tapping due to better returns from seaweed farming (in 2009, before the oil-spill affected seaweed production); (F) large containers (*aru merai*) for storing palm syrup as a household food store; (G) here today, gone tomorrow—*Borassus* palms felled for construction wood on Raijua

methods used anywhere (Figure 30). The methods are essentially unchanged from those described by Fox (1977). Palm sap tappers, all of them men who are local farmers, tap the palm flower stalks, collecting the sap that excretes from the wound. This is generally done twice a day, once in the morning and once in the afternoon. There are two seasons, one with low yields (late April – August) and the high-yield season (September – early November). Unlike cases where more destructive, year-round tapping of the apical meristems occurs (Cunningham 1990), timing of *Borassus* palm tapping depends on flowering (due to tapping of axillary meristems of the flower stalks). Male flowers tend to fall into the palm sap, so a strainer (*kaba kuu*) needs to be used. Two knives are generally used, one only for trimming the palm flower stalk (*dope tua*) and the other for trimming other things, such as for making a new string (*dope papaka*) for the palm leaf container (*haba tenae*) in which the sap collects. This small palm leaf container (1.5 L) is used to collect palm sap dripping from tapped flower stalks. This is tied to the flower stalks that are being tapped by a single twined string. The *haba tenae* is often placed inside a rectangular basket (*kebiha*) that has a lid which folds over the top of the *haba tenae* to reduce the number of insects or flowers falling into the palm sap.

### Importance of income from palm products

When we started this study, we had heard of case studies where families had been able to get out of poverty through income derived from *lontar* palm tapping being invested in children's education (see Box 2).

Income from sale of palm products (particularly palm sugar and syrup) is undoubtedly important to many households. In the Dimu area of Savu, sources of cash income in order of importance were: (1) palm sugar (*dona hu*); (2) peanut (*wo manila*); (3) maize (*terae jawa*); and (4) cashew (*wo aju holo*). In common with the case study from West Timor (Box 2), the income was used for school fees by households with children of school-going age. After the children finished school, the money was used for buying kerosene (which costs Rp17,500/L on Savu compared with Rp3,500/L in Kupang). On Savu (Table 7), two of the important *B. flabellifer* palm production areas are Dimu and Liae. Mehara is not a major producing area, but, even there, all but the wealthiest of the c. 650 households produce palm syrup. Based on interviews we conducted in May 2009, the minimum quantity for subsistence is c. 200 L of palm syrup. This is stored in large clay containers (such as *aru merai*; see Figure 29F).

### Box 2. *Borassus flabellifer* (*lontar*) income and social outcomes in Insana area, West Timor

In Insana (Kecamatan Letneo), West Timor, there is a significant number of families whose children have been educated through income generated by palm sugar (*gula merah*) and palm wine (*sopi*). This case study is one of several known to one of us (Willy Daos Kadati). In this case, the *lontar* palm farmer was able to educate his children through sale of products from *B. flabellifer*. Each of his five children attended and completed senior high school, and the oldest and youngest of his children attended university in Kupang, West Timor, and in Java. The oldest child studied social and political science in Java and, once graduated, became the Head of the local council district (*kecamatan*). He then went on to work as the Head of

the Treasury Department at state level (*kabupaten*). The youngest child studied law at university, also in Java, and went on to work within the government Forestry Department. A promotion saw him become Head of the Pemukiman dan Prasarana Wilayah Kabupaten T.T.U. The remainder of the farmer's children worked as teachers or government officials, with one of the three married to a teacher. Each of these professions is quite valued within Indonesian society. Through this process, the farmer was also able to fund his nephew's university studies in agricultural science, which were also undertaken in Java and which led him to return to West Timor and head the Agricultural Department in Alor.



**Figure 30.** *Borassus* palm tapping technology used on Savu: (A) crimping the male flower stalk; (B) using a wooden crimping tool along the whole flower stalk—tapping starts after the second squeezing; (C) the wooden device for ‘squeezing’ (*hengapi*) the flower stalks, carved from *kola* (possibly *Rhus*) wood—this tree species is also used to make the main posts of the traditional house (*rumah-adat*); (D) two types are sometimes used, one with ridging inside and (E) the other smooth—the ridged type is used to crush the older flower stalks when they get tough; (F) the ‘crimping’ process takes place three times: at first, before tapping starts and before the flower stalks are tied together bound in groups of four to five; (G) cut tip of the male flower stalk—the first palm sap is reddish and is ritually used in West Timor, offered to the church (by Christian Rotinese); (H) male flower; (I) freshly cut sliver of male flower to maintain phloem sap flow; (J) old surface, trimmed in the afternoon



**Table 7.** Summary of information from *Borassus flabellifer* palm tappers and traders on Savu, 2008

Process	April–August	September–October
Number of palms tapped	7–10	25–50
Number of flowers per palm	3–4	Up to 7
Yield ( <i>haba dawu</i> (container)/palm)	0.5 small, 9 L <i>haba dawu</i> (morning); 0.3 <i>haba dawu</i> (evening)	1 large, 11–12 L <i>haba dawu</i> (morning); 0.75 <i>haba dawu</i> (evening)
Link to agricultural cycle	Palm sap tapping is not the primary activity at this time, as people are harvesting (rice, sorghum, green mung bean).	Primary activity. In early November, people stop tapping, as it starts to rain, and they will have enough palm syrup accumulated at this stage.
Syrup production		Cook 6 times/day during peak season when tapping 30 trees. Yield is 15–18 L of syrup/day.
Sale price per jerry can (1 jerry can = 5–6 L, if filled to the top)	Rp50,000	Peak season, Rp25,000
Fuelwood use and costs	Collect own fuel, mainly palm petioles and leaf bases. <i>Schleichera oleosa</i> wood in more remote production areas where this prime-quality fuelwood is still available.	Go further and further afield to cut fuelwood. In the peak season, three truckloads (3 m <sup>3</sup> fuelwood per truck) are needed to cook the palm syrup. The trees are cut, then a vehicle is hired to collect the fuelwood (Rp150,000 Rp/load; three loads = Rp450,000). This is done early in the season (c. August) so that the wood dries.
Marketing	Women from Menia are marketing (Rp40,000–50,000/5–6 L). Some of them mix baking soda with the palm syrup to thicken it, but this affects quality and it does not last as long. However, less cooking is required, so yields are higher.	During the peak season, they go into Seba every time the boat arrives, 3–4 times/week, taking 6 × 20 L jerry cans per trip. Taxi costs Rp5,000/jerry can and Rp10,000/person. Usually only one person will go into Seba. The main markets for this syrup are Sumba (big jerry cans); Raijua (small jerry cans); and, to a lesser extent, Ende. The buyers from Sumba are middlemen.

### Sustainability issues

A potential problem is that sustainable use depends not only on the natural resource base, but also on customary knowledge and skills. If there is no incentive to pass these skills down to the next generation, those techniques and knowledge will be lost. This process of change is facing *B. flabellifer* (*lontar*) palm tapping on Raijua and possibly on Rote due to a ‘clash of economies’ (to use Fox’s (1977) terminology) between seaweed production and *lontar* sap tapping. For the past 2 years, people have been selling palm syrup to Raijua in large quantities. This is related to the seaweed business, which has developed on a large scale on Raijua since 2006. Although seaweed production started on Savu first, the seas off the

western part of Raijua are clean and better located in terms of currents and tides for seaweed production. Many people have therefore stopped tapping *lontar*, particularly near the port. This is obvious from the flowers of male palm trees, which are uncut. Seaweed harvesters are attracted by the opportunity for entering into the cash economy. As one tapper (c. 40 years old) said: ‘I have been tapping *lontar* since I was a teenager, but I never held money in my hand until I started farming seaweed.’

Until the late 1980s, areas such as Liae (on Savu) had high densities of *lontar* palms. *Lontar* palm gardens with enclosures (Figure 31E), such as those described by Fox (1977), are now in decline. In the 1970s, these *lontar* palm gardens within enclosures

(to demarcate tenure and stop browsing by livestock) were described to Fox (1977, p. 34) as a relatively recent development of *lontar* domestication:

...has occurred within living memory. They constitute a conscious attempt to increase the number of *lontar* and concentrate them for purposes of tapping. The fact that the fencing and planting of *lontar* palms has now begun suggests a potential new dimension for palm utilization in the islands. Under the pressure of an increasing population, a system of intensive gathering has begun to develop into an even more efficient system of gathering based on cultivation of the prime source of supply.

*Lontar* agroforestry systems are still being developed in some parts of Savu (Figure 31C), but there is little incentive to plant in other, less remote places. In moist sites, such as along roadsides where water accumulates, natural regeneration takes place (Figure 31D), but in dry sites (most of Savu), deliberate planting is required to maintain populations. Coupled with felling of adult palms for timber, poor recruitment and lack of maintenance of the *lontar* gardens may result in long-term decline of this agroforestry system. According to local people we interviewed, palm gardens were a lot more prevalent in the southern part of Savu, such as Liae and Mehara, in the 1970s and early 1980s than they are today.

### **Palm syrup and palm sugar production and trade**

Fresh palm sap is rendered down to palm sugar (*gula merah*) or palm syrup (*gula air*). According to the palm tapper we interviewed from a household producing palm syrup, he has a low season (late April) yield of 27 L in the morning and 18 L in the evening, based on measured volume of the *haba dawu* (a 9 L capacity palm leaf container) from eight *B. flabellifer* palms. In order to produce palm syrup, the sap is boiled until it becomes thick and syrupy. A spoon (c. 70 cm long) is used to scoop off the froth (*woro due*) during the boiling process. This is fed to pigs along with fresh palm sap (*tuak manis*). Sticks of *Lannea grandis* (*kehi*) are bound together, with two bundles placed across the container of boiling palm syrup to prevent it boiling over.

The colour of the palm syrup depends on the heat used in the cooking process. Some women in the Menia area of Savu add sodium bicarbonate before the palm syrup is reduced to its final stage, in order to thicken it more quickly. However, this practice

reduces its shelf life. Much of the palm syrup goes to Raijua or Sumba. If export of organically certified palm syrup develops, quality control will be needed at various stages of the supply chain (for reproducible quality, in sufficient quantity) through proper straining and use of stainless steel (not aluminium) pots. Jerry cans will have to be kept clean using organic soap.

To make palm sugar, more water is boiled off and the thick mixture is then placed in a coconut shell and pounded until thick and hard. For making *gula lempeng*, the palm syrup is poured into palm-leaf rings, where it hardens before transport and sale in local marketplaces (Figure 28). In Kupang market, West Timor, most of the palm sugar being sold comes from Rote (Figure 32). There is significant variation in the price of palm sugar (*gula merah*) between the wet and dry seasons (Figure 33).

### ***Borassus* palm product diversification**

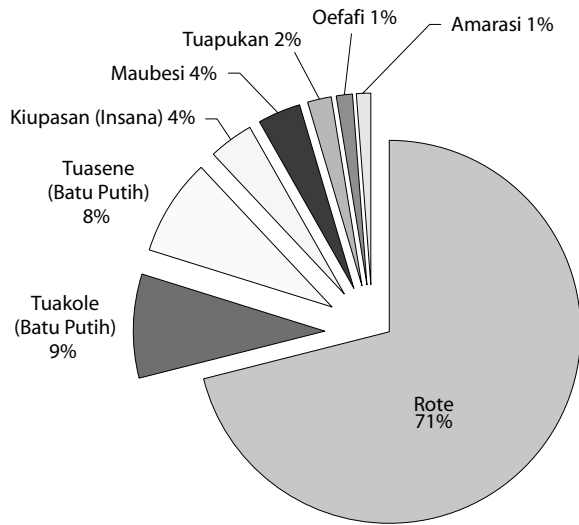
*Borassus flabellifer* (*lontar*) has the most diverse array of commercial products made by manufacturers based in ENT of any local agroforestry or forest product (Figure 34). In addition, there is a long history of attempts to add value to *lontar* products. In the 1970s, for example, the *Anak Rusak* ('baby deer') factory was started in Kefamenana (West Timor) to produce *lontar* palm alcohol, but this collapsed after a few years. Today, small-scale production of 'medicinal' palm wine (*sopi*) (e.g. with crocodile penis) persists, but is not considered viable on a larger scale.

### **Supply chain analyses**

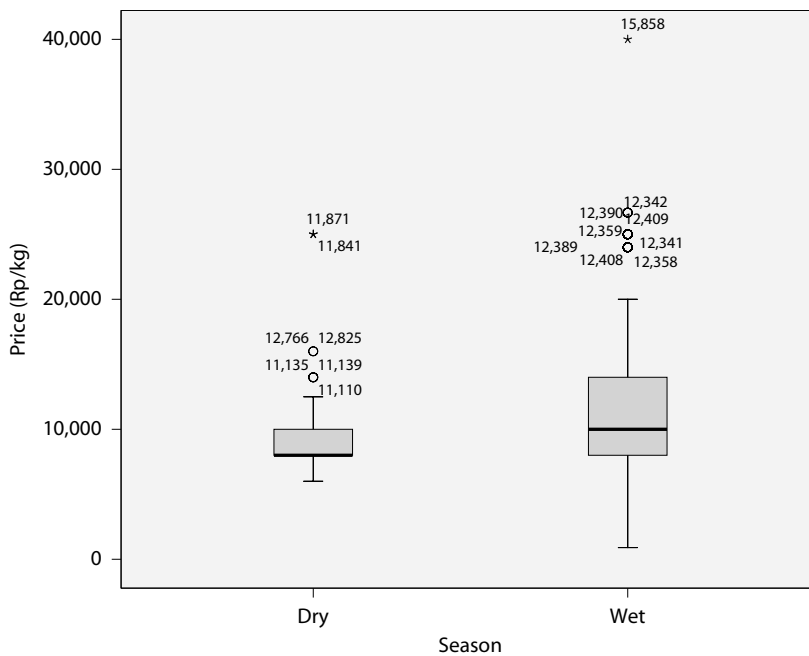
Over the past few years, an Australian who regularly visits West Timor has started exporting palm syrup to Darwin under the business name 'Skinny Pig'. Australia certainly offers the closest market to Indonesia for high-quality palm syrup. However, high insurance costs for shipping any products (including palm syrup) between Indonesia and Australia pose a challenging policy bottleneck that needs reform. In the short to medium term, the most realistic option is the export of palm syrup from Savu to the restaurant trade in Bali. Based on price information collected during this study, we assessed the costs and returns of initiating trade in high-quality palm syrup between Savu and Bali (Table 8).



**Figure 31.** *Borassus flabellifer* (*lontar*) agroforestry: intensive production of a keystone resource on Savu: (A) the Savu landscape showing *lontar* palm gardens; (B) fresh, ripe *lontar* fruits; (C) development of new *lontar* gardens—an increasingly rare activity today; (D) spontaneous recruitment from seed occurs in some places (moist sites where rainwater accumulates); (E) even-aged stands are typical of *lontar* gardens—in the long term, new recruitment is necessary to maintain populations in dry landscapes; (F) tethered pigs with *lontar* fruits as supplementary feed—part of the palm–pig production system described by Fox (1977)



**Figure 32.** Over 70% of the palm syrup (*gula air*) sold in markets in West Timor, shown here as a proportion of the total value (Rp3.3 million) of the stock sampled during this survey, was considered to come from Rote



**Figure 33.** Based on data collected during the marketplace surveys, there was much greater variation in the market price of palm sugar (*gula merah*) between the dry and wet seasons



**Figure 34.** Commercial products from *Borassus flabellifer* (*lontar*) produced and packed in East Nusa Tenggara for the local retail market: (A) *lontar* syrup, produced in Kupang; (B) *selai buah* (*lontar* fruit jam), produced in Kupang; (C) packed palm sugar using geographical origin branding, from Tuasene village, Kecamatan Molo Selatan, West Timor; (D) *gula semut* ('ant sugar'), a fine palm sugar from Keb. Rote Ndao; (E) popcorn sweetened with palm sugar, from Kupang; (F) *gula semut* from Tuasene village; (G) palm sugar (*gula lempeng*); (H) *dodol*, a toffee-like sweet made from *lontar*, from Kupang; (I) *dodol* mixed with peanuts, from Kupang; (J) locally packed, unlabelled *gula semut* from Kupang; (K) palm sugar in toffee-like form, from Oebobo, West Timor

**Table 8.** Costs and returns of the *Borassus flabellifer* (*lontar*) palm syrup supply chain between Savu and Bali compared with the retail price of palm syrup from Rote when it is sold in Darwin, Australia, by the Australian-owned business, ‘Skinny Pig’

Description	Price (Rp)
Cost of <i>lontar</i> syrup from producer in Savu	4,955/kg
Transport from Savu to Bali	6,710/kg
Bottling and labelling	33,740/kg
Product distribution in Bali	3,000/kg
Overheads and salaries	24,203/kg
Wholesalers’ profit	8,068/kg
Wholesale price in Bali	80,675/kg
Wholesale price in Bali per bottle	27,591/bottle (342 g)
Retail price in Bali (assuming 150% retail mark-up)	68,977/bottle
Retail price in Darwin of Skinny Pig <i>lontar</i> syrup (exchange rate Rp8,500 = A\$1)	102,000/bottle (= A\$12)
Dry coconut sugar in Bali	8,000/kg
Cost of making 5 kg of syrup from 1 kg dry sugar	2,000/5 kg
Coconut syrup in Bali (before bottling and distribution)	2,000/kg
Savu <i>lontar</i> syrup in Bali (before bottling and distribution)	11,665/kg

*Borassus flabellifer* palm sugar yields can be 18 t/ha/year (Khieu 1996) compared with coconut palm sugar production (19 t/ha/year) (Jeganathan 1974) and sugarcane sugar production (5–15 t/ha/year) (Dalibard 1999). At the start of this project, we considered that there was good potential for exporting organic certified palm sugar to Europe or North America. Since then, we have modified this view for three reasons. First, there is much competition with other palm sugars and palm sugar exporters. Palm sugar is not only produced from *B. flabellifer*, but also from *Arenga pinnata*, *Cocos nucifera* (coconut palm) and *Caryota urens*. Coconut palm sugar in markets in Europe and USA, imported from Cambodia, Thailand and India, is cheaper than *Borassus* palm sugar. Second, the costs of fuelwood are increasing, which includes felling of large, living *Schleichera oleosa* trees rather than use of deadwood. In addition to competing with local household fuelwood requirements, we suggest that the growth in the specialist smoked Timorese pork (*sei babi*) industry in West Timor and large-scale pollarding of *S. oleosa* trees on Rote and Sumba by lac producers have also affected stocks of this tree species (see the ‘Food and drinks 4: Cinderella fruits’ chapter for details). Third, the annual costs of certification are high. For example, certification through Ecocert would be US\$5,000–7,000/year.

### Proposed staged approach

We therefore suggest a three-stage process:

1. *Start with the palm syrup (rather than palm sugar) market in Bali, dealing with pricing issues identified in Table 8 and improving quality and traceability along the value chain.* This would have to include subsidies or low-interest loans for stainless steel (instead of aluminium) pots and quality control to stop the addition of sodium bicarbonate to the palm syrup (in the Menia area of Savu).
2. *Test appropriate technologies used for producing palm sugar and syrup that are either very fuel efficient or use solar technology.* In Cambodia, it is estimated that the 20,000 people producing palm sugar use 120,000–144,000 t of fuelwood per year (GERES 2009). In Cambodia and probably in ENT, this is the second highest usage after domestic cooking. The problem of fuelwood shortages facing palm sugar production is not a new one, and solutions have been implemented in various parts of South and South-East Asia over the past 60 years. In the 1950s in India, Khanna (1957) and Mathur and Khanna (1957) developed a solar cooker for palm sugar production. In Cambodia, the palm sugar exporter Eco-Biz has introduced Vattanak stoves to improve fuel efficiency of palm sugar production (Eco-Biz 2008; GERES 2009). These stoves, developed by Groupe Energies Renouvelables, Environnement et Solidarités (GERES) in Cambodia, reportedly use 30% less fuel. However, whether they are more efficient

than the multi-pot stoves locally developed in West Timor (Figure 28) needs to be tested.

3. *Conduct a cost-benefit analysis for organic certification only once the conventional market for palm syrup has developed.* Bali gets over 2 million tourists a year and has a thriving food culture and restaurant industry. Rather than try to surmount many practical and policy hurdles in getting palm syrup to Australian, European, Japanese and North American consumers, promotion of palm syrup ‘through the stomach’ offers an easier alternative. In Bali, coconut palm sugar products are already being sold as a specialty food. A good example is the Heritage Palm Sugars sold by Big Tree Farms. This is granulated coconut palm sugar sold in three flavours—turmeric, ginger and plain—at US\$8.99 for 241 g (8.5 oz) to their overseas market, and for roughly US\$4.00 for the same product in Bali.

### Initial focus on palm syrup

Traditionally, the most common use for palm syrup is in traditional Balinese cakes such as *klepon*, *gopel*, *tabagan*, *pasung*, *timus*, *kue lukis*, *mangkok*, *dadar*, *lalak* and *batun kluki*. These cakes are usually enjoyed by the Balinese at special holidays. Traditional Balinese drinks such as *daluman* (using the leaf of *Cyclea barbata*) and the famous, colourful *es cendol* also use palm syrup. Palm syrup is an essential seasoning used in almost all Balinese cooking.

Its modern application is pouring it over the banana pancakes that are popular with tourists or over ice-cream. Our recommendation to this project is that, by finding a good bottle with an easy-pour spout and attractive labelling, *B. flabellifer* palm syrup could be a definite winning product—‘the maple syrup of Asia’. Additionally, there could be local varieties sold, as different islands have different methods of cooking *Borassus* palm syrup, giving unique tastes from Rote, Savu and West Timor. This, in turn, may offer an opportunity for registration of different *lontar* palm syrups by their geographical origin, as occurs in Europe and as van de Kop et al. (2006) have described for various developing countries.

## Additional recommendations

In addition to the recommendations made above for marketing and to address the emerging fuelwood shortages (and rising fuelwood costs) that limit palm sugar production, we also suggest the following:

1. The introduction of the sugar date palm (*Phoenix sylvestris*) to ENT should be considered, mimicking the agroforestry systems of South Asia, which have coconut palms, sugar date palms and *lontar* growing together. As Dalibard (1999) points out, *P. sylvestris* is tapped during a different season to *B. flabellifer* and both grow very well together, enabling the option of year-round palm sugar production.
2. A study of the economics of pig production on Rote, Savu and West Timor should be carried out, similar to that conducted by Khieu et al. (1996) in Cambodia. In Cambodia, a focus on pig production (feeding palm sap to pigs) resulted in a profit of riels (KHR)150 per *Borassus* palm compared with just KHR11/palm for palm sugar production, mainly due to the high costs of fuel for producing palm sugar. The costs, species preferences and quantities of fuelwood used need to be studied, particularly in West Timor, where the booming *sei babi* (smoked pork) industry has grown rapidly over the past 5 years.

## Food and drinks 3: *Gnetum gnemon*

### Background

On a global scale, there are about c. 38 *Gnetum* species. Ten of these occur in South America, 1–2 in tropical West Africa and 20–25 in tropical Asia. Only two species are trees. These are: *G. gnemon*, which occurs from South Asia (Assam in north India) through South-East Asia to Fiji, but is intensively cultivated only in South-East Asia; and *G. costatum*, a tropical forest species in Papua New Guinea (Bougainville) and Solomon Islands. The remaining *Gnetum* species are lianas.

Worldwide, the largest trade in *Gnetum* products is in Indonesia (*G. gnemon* seeds, fruit skins and leaves) and tropical Africa (*G. africanum* and *G. bucholzianum* leaves). In South-East Asia, *G. gnemon* is widely cultivated, but is wild harvested in the Pacific. In Java, *G. gnemon* is intensively managed in agroforestry systems through transplanting, shoot grafting and bark grafting (described later in this chapter). In contrast, in tropical Africa, despite profitability and demonstration trials for over 15 years (Shiembo et al. 1996), there is a low level of adoption of *G. africanum* into agroforestry systems, with both African *Gnetum* species still harvested from the wild (Ndumbe et al. 2009). In Africa, 350–600 t of *Gnetum* are traded annually from south-western Cameroon to Nigeria (Ndumbe et al. 2009). Trade in *Gnetum* species in South America is not well studied, but appears to be only on a small scale (Vásquez and Gentry 1989).

*Gnetum gnemon*—*melinjo* (Bahasa Indonesia), *belinjo* (Javanese), *tangkal* or *sake* (Sundanese), *uwa sowa* (Seram)—occurs widely in Indonesia, where it is found on Ambon, Bali, Flores, Java, the Mentawai islands, Moluccas (Buru and Halmahera), Seram, Sumatra and Sumba. Three other *Gnetum* species also occur in Indonesia—*G. gnemonoides* (Ambon, Buru and Halmahera), *G. indicum* (Ambon) and *G. costatum* (West Papua). Two main commercial products are derived from *G. gnemon*. The first is *emping* (*krupuk melinjo*, *keceprek*), fried crackers that are widely eaten as a snack or side dish throughout

Indonesia, which are made from roasted and flattened seeds (Figure 35). The second is *sayur asam*, a vegetable soup in which key ingredients are the leaves, whole fruits and red skins of ripe *G. gnemon* fruits (Figure 35G).

### Potential for *G. gnemon* agroforestry production in ENT

At first sight, *G. gnemon* seems to be an anomaly in ENT. On one hand, in common with the rest of Indonesia, almost every small restaurant and shop (*toko*) sells ready-to-eat fried *emping*, and *sayur asam* is also popular. At the same time, *G. gnemon* occurs naturally in higher altitude forests (e.g. in Wangameti National Park, East Sumba) and in some home gardens close to sea level (e.g. in Ende). Despite the lucrative market for *emping*, none are produced within ENT. Instead, all *emping* are imported from Java, generally via Surabaya or Semarang. The central question this study addressed was: What lessons does *Gnetum* production and trade in Java hold for the possibility of *G. gnemon* agroforestry production and the *emping* trade in ENT? To answer this question, three steps were taken: (1) a thorough literature review; (2) a study of the *G. gnemon* value chain in West Java; and (3) discussions with farmers in West Java who are successfully growing *G. gnemon* in small-scale agroforestry systems.

Although extensive research has been conducted on *Gnetum*, almost all of the studies are either on evolutionary biology (Won and Renner 2003), anatomy (Tomlinson 2001), natural products chemistry (Iliya et al. 2003) or genetics (Carmichael and Friedman 1995). While the potential pharmaceutical applications of stilbene oligomers from *G. gnemon* may have commercial potential—for example, in treating colon cancer (Iliya et al. 2003)—very few studies have been conducted on agroforestry production. In their work for Plant Resources of South-East Asia (PROSEA), Verheij and Coronel (1992) recommended that better insights into *G. gnemon* yields were needed and that processing and marketing of *emping* could be





**Figure 35.** Labour-intensive processing of *Gnetum gnemon* fruits: (A) peeling and keeping the red peels aside for grading and sale; (B) roasting freshly peeled seeds in hot sand (West Java); (C) flattening freshly roasted seeds and combining them into one large cracker (*emping*); (D) lifting a raw *emping* before sun-drying; (E) sun-dried, uncooked *emping*; (F) processed and packed *G. gnemon* fruit peels; (G) *G. gnemon* fruits and leaves in *sayur asam* soup; (H) locally packaged sweet *emping* (Menes, West Java); (I) packets of fried *emping* for sale at one of the hundreds of thousands of small shops in Indonesia

improved, but few studies have been done to follow up on their suggestions. No peer-reviewed literature was available on *G. gnemon* marketing or value chains, although some reports were available through the internet. In Mejono village, Plemahan district, East Java, 780 people in 320 households reportedly produced 600 t of *emping* per year (Petra Christian University, Surabaya, website—details no longer online). These were marketed within Indonesia and internationally, including to Saudi Arabia through the company PT Delta Mitra Adiguna.

### Value chains in West Java

We studied value chains for *G. gnemon* products in the Kabupaten Pandeglang, Banten, West Java. Banten is well known as a producer of *emping*. Every year, according to our discussions with local traders, Pandeglang is able to supply nearly 20,000 t of *emping*. West Java also produces *sayur asam*, which is sold in the local market in a ready-mixed form, and many restaurants in Pandeglang serve it as one of their main dishes.

In this area, nearly all homesteads are planted with *G. gnemon*. Besides being a shady tree, the fruit can add to the family economy. From the time it is planted until the *G. gnemon* tree fruits takes between 3 and 5 years. Local farmers estimate that trees live for more than 50 years. The trees fruit three times a year, with mature trees producing up to 200 kg of fruit/year.

### Sayur asam: ready-mixed *Gnetum* soup

*Sayur asam* has a taste and aroma that is unique; that is, sour, spicy, sweet, salty, and with the aroma of *G. gnemon*. *Sayur asam* is made from young jackfruit, long beans, peanuts, chayote (*labu siam*), young corn, young papaya, green and red chillies, tamarind; and young leaves, ripe fruit skins and flowers from the *Gnetum* plant. As a ready-mixed soup, it is usually sold in a small plastic bag for Rp1,000/packet. As these ingredients are all locally available, it represents an excellent way for small-scale farmers to add value to local farm and agroforestry products. Cooking it is easy enough: wash all the ingredients, then boil and add salt and sugar as required.

The marketing chain for *sayur asam* in connection to the ingredients that come from *G. gnemon* is illustrated in Figure 36. Farmers are the primary suppliers of the basic ingredients, selling to the village collector, who goes from one village to another, for the price of Rp1,500/kg; however, if the farmer sells directly to a bigger collector/trader at the market, they can receive Rp1,700/kg. Market chains between the village collector and the larger traders differ. Large-scale traders supply *G. gnemon* products to other cities via a middleman trader at Rp1,800–2,000/kg for the young fruit and leaves. Travelling traders sell on to their destination area (e.g. Jakarta) at Rp2,200–2,500/kg.

The village collector himself sells young *G. gnemon* fruit and leaves to the vegetable trader at the Menes and Labuan markets at the price of Rp1,800/kg.

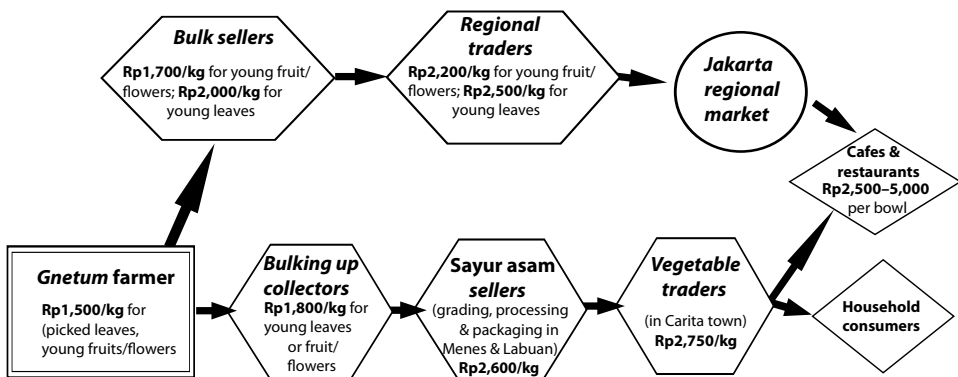


Figure 36. The value chain for *sayur asam* using *Gnetum gnemon* leaves, flowers and fruits produced in agroforestry systems in West Java

Traders at the market are those who will make and mix various types of vegetables to produce the *sayur asam* in a small packet which is sold for Rp2,500/4 packets, so approximately Rp650/packet. One packet of *sayur asam* weighs approximately 0.5 kg, which comprises more or less 5% *G. gnemon* product (25 g); hence, the *G. gnemon* product is sold for Rp2,600/kg. Packets of *sayur asam* are bought by traders from the Carita markets and then re-sold for Rp1,000/packet. One packet of *sayur asam* makes two servings. At the many *warung* (cafes) and restaurants, one bowl of *sayur asam* is sold for Rp2,500–5,000. Value-adding from parts of the *G. gnemon* as a chain is beneficial for farmer-entrepreneurs in Pandeglang area.

### Gnetum crackers (emping)

*Emping* (*krupuk melinjo, keceprek*) production continues to be done by hand and is very labour intensive, despite the remarkable dexterity and efficiency of the women who make them. A locally bought ‘hammer’ (costing Rp50,000) is the most expensive piece of equipment required. However, several implements are needed for household-level *emping* production. In West Java, a wok filled with sand (fine, from the beach or local river) is used for

dry roasting, whereas in Central Java, *Gnetum* seeds are boiled before they are dehulled and made into *emping*. The cost of seeds in the local Bangko market was Rp6,500/kg. Two kg of seeds (wet weight) make 1 kg of dry *emping*. In Bangko village, West Java, we were told that a group of 30 women are able to process 200 kg seeds/day, for which they get paid Rp2,000–3,000/kg. Different groups specialise in making different-sized *emping* (1-seed, 10-seed and 20-seed). In addition, *emping* processors buy seeds from the local market, as they do not produce enough from their own trees. Household income from *emping* production is low. The value chain for *G. gnemon* seeds and *emping* in West Java is shown in Figure 37. Figure 38 illustrates steps in the value chain for a variety of *G. gnemon* raw materials.

### Intensive management in Java: what lessons for ENT?

We investigated the intensive management of *G. gnemon* through discussions with small-scale farmers at Bangko village, near Pandeglang (Banten, West Java). Sophisticated grafting techniques are used as part of the intensive production process,

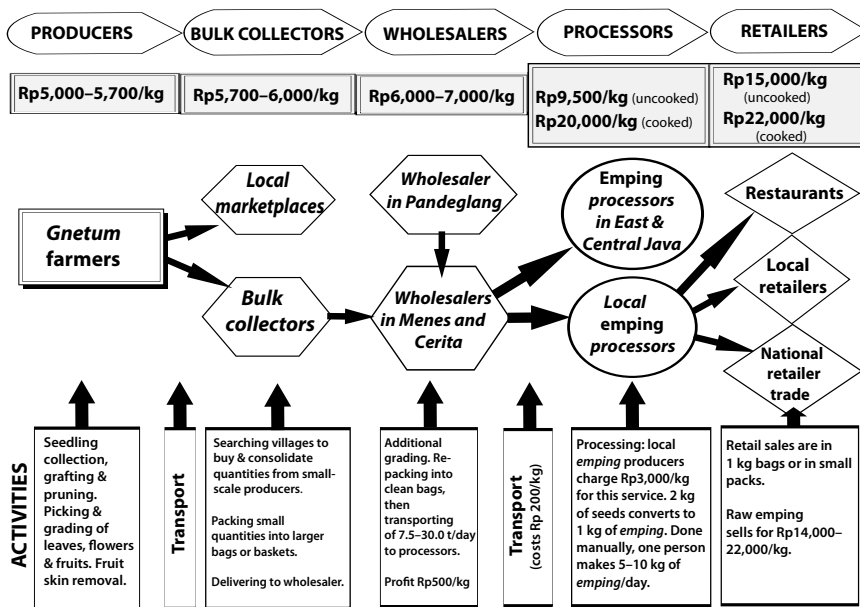


Figure 37. The value chain for *Gnetum gnemon* seeds produced in agroforestry systems in West Java and the trade in *emping*



**Figure 38.** Value chains for *Gnetum gnemon* in West Java: (A) edible peeled skins are sold, not discarded; (B) seeds are bought from farmers by middlemen, then resold to major traders; (C) leaves are sold through traders or directly in local markets; (D) weighing seeds in Carita, West Java, bought from intermediate-level traders; (E) drying and grading seeds in Carita; (F) repacking seeds at the warehouse of a major trader, who sells 30 t/seeds/day during the peak season; (G) repacked and graded seeds ready for transport to Semarang; (H) packing a 12-t load for transport at night from West Java to Semarang

with the ratio of male:female trees reduced from possibly 50:50 in a natural forest situation to 2:100 in agroforestry systems. According to a local farmer we interviewed (Pak Ridollah), the grafting methods were learned from his father and grandfather. Whether these grafting techniques are local or were learned (e.g. from the Dutch) is unknown at this stage. Two main grafting techniques are used:

- *kawinan pucuk* (*kawinan* = marriage, *pucuk* = young shoot), where a young shoot is grafted onto the apical shoot and bound together—this takes less than a week
- *kawinan kulit* (or *okulasi*), where a small rectangle of bark from a female tree that has already started to fruit is grafted onto a male tree of c. 10 cm diameter at breast height (dbh).

In the second technique, the bark rectangle is chosen from bark that has a potential bud (and not one where an axillary branch has been shed, as there is less potential for budding, plus visible scarring of the inner bark; see Figure 39). Once the graft has taken, the top of the male tree is cut off at an angle (to prevent rotting) and the new shoot(s) from the female tree are nurtured. Any male side shoots from lower down the trunk are pulled off. If more than one female shoot is produced from the grafted bark, these are encouraged, as multi-stemmed trees are easier to climb to harvest the fruits. In terms of other bark uses, the strength of the inner bark fibre from male trees is much stronger, so only male trees were traditionally used to make rope. However, today people buy nylon rope from the market.

## Opportunities for future research

The following are suggested as future research priorities:

- *Seed storage*: bulk sellers rely on storage of seed so that they can sell when the price is high. For example, when *G. gnemon* seed production is high in East Java and prices are consequently low in West Java, bulk sellers will buy from farmers but store the seeds until prices rise. Seed storage under current (cool, moist) conditions can be for up to 3 months. Extending this period would benefit bulk sellers. In addition, small-scale storage technology based on seed storage capacity would benefit farmers (or farmers' associations). Fortunately, *G. gnemon* does not appear to have a problem with insect seed pests.
- *Possible health issues in older consumers*: aching or swollen joints as a possible side effect of consuming large quantities of *emping* is well known among Javanese people who have a long history of eating *emping*. If this is a result of *emping* consumption, it would have a major influence on export markets as it may lead to refusal of novel foods registration (e.g. in Australia and the EU).
- *Quality standards*: in common with other food products, improved drying methods (e.g. to prevent faecal contamination by chickens) and product traceability systems would be useful in order to meet national food health and safety requirements.
- *Trademarking*: should be considered, perhaps using a similar system to geographical origin indicators used in the EU.
- *Mechanisation*: simple machines that can produce *emping* have been developed in Java. These are more efficient but, based on field observations, most production is still done manually. Semi-mechanisation of *emping* production was calculated to produce 1.7 kg of *emping*/hour (13.6 kg in an 8-hour day), compared with just 2.2–4.0 kg from 8 hours of manual labour (Hanafi et al. 1996). It would be useful to study why adoption levels are poor, so that changes in technology costs or production methods could be improved.

- *Seed germination studies*: planted seedlings grow very slowly compared with seedlings from natural regeneration (through bird dispersal). As the plants in the Order Gnetales (including *G. gnemon*) have mycorrhizal associations, this slowness is likely to be due to the need for inoculation with mycorrhizae when planting from seed. Solving this problem would greatly influence production.



**Figure 39.** Grafting technique used by local farmers in Pandeglang area, West Java, to increase the proportion of female *Gnetum gnemon* trees (which bear seeds used for *emping* production): (A) bark with latent buds is chosen; (B) the latent bud is visible from both the inner and outer bark; (C) the bark graft (from a female tree) is slipped under a bark flap of a male tree, then (D) bound into place; (E) successful bark graft from a female onto a male tree; (F) female branch shoots on a male stem, which has been lopped off to allow the female branches to form (3 months after grafting); (G) male flowers; (H) female flowers; (I) 5-month-old shoots; (J) graft after 10 years, forming a single stem onto the male tree (bearing 5 kg fruits/season, three seasons/year). At c. 50 years old (48.5 cm diameter at breast height, 5.9 m crown diameter, 21 m high), a large female tree produces 50 kg fruits/season (150 kg/year).

## Food and drinks 4: Cinderella fruits

In the mid 1990s, the term ‘Cinderella trees’ was used for useful tree species that had been overlooked and their economic potential left largely untapped (Leakey and Newton 1994). This section deals with the ‘Cinderella’ underutilised fruit species in ENT that are the ‘poor cousins’ of the better known and more economically developed fruits. South-East Asia has about 400 indigenous plant species that produce edible fruits (Verheij and Coronel 1992). The majority of these are wild species that have not yet been developed horticulturally. In addition, local home gardens include a range of introduced species whose commercial potential is recognised elsewhere but has yet to be realised in ENT (Figure 40). A good example of this is the star apple (*Chrysophyllum cainito*), which is native to the West Indies and is cultivated on a small scale on Flores (Figure 41).

Large-scale development agribusiness projects focus on a few mainstream commercial species, for example, the focal species of the SADI program (banana, cashew, citrus, mango, mangosteen). A broad diversity of fruit species are already widely cultivated in eastern Indonesia and sold in local markets in ENT to meet local demand. We suggest that it is also worth considering edible-fruit-bearing species that are wild harvested or cultivated, or managed in local production systems that have wider market potential in the medium to long term. In common with other parts of the world, local marketplaces are a good place to see which wild or ‘semi-cultivated’ edible fruit species appear for sale, as these represent a ‘short list’ of the most popular species in any particular region—probably less than 1% of the total number of wild edible fruit species in ENT. Our observations have resulted in a short list of six species. These are discussed in the sections that follow.

### *Antidesma bunius*

*Antidesma bunius* (Eurphorbiaceae), or bignay, is locally known as *kitikata* in Bahasa Kupang, *buni*, *katakuti* or *kutikata* (Bahasa Indonesia), *huni* (Sundanese) and *wuni* (Javanese and Madurese). It is indigenous to

South-East Asia and common along river valleys in ENT. The fruits (Figure 40B) are a popular children’s snack food that are sold in local marketplaces during the fruiting season (March–April). As such, they are a useful dietary supplement for nutrient-deficient starchy staple diets (Table 9). They also form the basis of the local wine industry in Thailand.

In the 1900s, the United States Department of Agriculture started *A. bunius* production in the USA, based on seeds collected in the Philippines (in 1905, 1913 and 1918). *Antidesma bunius* trees are also grown on experimental stations in Cuba, Puerto Rico, Honduras and Hawaii. Although wild trees are established from seed, horticultural production can be based on cuttings, grafting or air-layering, with air-layered trees reportedly bearing 3 years after they have been transplanted. As *A. bunius* has separate male and female trees, one male tree needs to be planted for every 10–12 females for effective cross-pollination. There are few studies on fruit production, but Morton (1987a) reported that an old, well-established tree in Florida produced 273 L of juice in one season.

### Potential for wine production in ENT

Used in some cooked fish recipes and in cooking rice, *A. bunius* fruits also have a wider market. Small-scale commercial production of the red-coloured fruit jelly started in southern Florida, but was only viable for a few years. Although low labour costs in Indonesia may offer an opportunity for *A. bunius* fruit jelly production, a better option may be the tropical wine and brandy market.

This market niche has been developed best in Thailand (maoberry wine) and the Philippines, where ‘organically grown’ wine from *A. bunius* fruits is produced by several wineries, including Federico’s Island Wine and Goyena’s Tropical Fruit Winery. Federico’s Island Wine also produces a ‘tropical wine’ from *Syzygium cuminii*. Given the high cost of imported wines and spirits in Indonesia and the interest in boutique wines in the tourist market, we suggest that a feasibility study be carried out on *A. bunius* wine production. Based on the experience



**Figure 40.** ‘Cinderella’ fruits in East Nusa Tenggara that have wider potential for commercial harvest and horticulture: (A) *Uvaria rufa*, showing the wide variation in fruit size (roadside market near Camplong, West Timor); (B) *Antidesma bunius* (Oeba market, West Timor); (C) *Schleicheria oleosa* (*kesambi*), which produces an oilseed and a nutrient-rich pulp (Soe market, West Timor)

of this wine industry in the Philippines, a product development strategy would need:

- a ‘bulking up’ centre that buys fruits during the season from local middlemen
- studies on fruit yields and an inventory of stocks
- varietal selection
- development of standards and proper procedures for high-quality *A. bunius* wine production to reach the relatively high-end tourist market in Bali
- a smart marketing strategy that emphasises organic production and health benefits (such as antioxidant and nutritional properties) of the product
- good presentation and packaging (e.g. see Negrosanon 2010).

**Table 9.** Nutritional value of *Antidesma bunius* (bignay) per 100 g edible portion<sup>a</sup> (Morton 1987a)

Component	Amount/100 g
Moisture	91.11–94.80 g
Protein	0.75 g
Ash	0.57–0.78 g
Calcium	0.12 mg
Phosphorus	0.04 mg
Iron	0.001 mg
Thiamine	0.031 mg
Riboflavin	0.072 mg
Niacin	0.53 mg

<sup>a</sup> According to analyses made in Florida and the Philippines

### *Chrysophyllum cainito*

The fruits of *C. cainito* (Sapotaceae) are variously known as star apples, *cainito*, *pomme du lait*, milk fruit, ‘star appel’ (Bahasa Indonesia) or *kanitu* (Madurese). This species was introduced to Indonesia from the West Indies and is cultivated in Flores. *Chrysophyllum cainito* trees grow to 8–30 m tall, bear fruits prolifically and are generally produced from seeds that remain viable for several months and germinate easily. Seedlings bear fruits in 5–10 years, but this is sped up through vegetatively propagating trees from cuttings, graftings or air-layered plants. Mature trees produce 60 kg of fruits per season (Morton 1987b). Ripe fruits (Figure 41) have a shelf life of 3 weeks.

Aside from the fresh fruits, star apple has wider commercial potential, as in other parts of the world, as a component of desserts, fruit juices and ice-cream. Iced fruit drinks are popular at hotels and tourist resorts throughout Indonesia. In the West Indies, ‘Jamaica fruit salad ice’ is a popular combination of star apple fruit pulp with mango, citrus, pineapple and frozen coconut water. Another Jamaican combination is a dessert that combines star apple, orange juice, sugar, grated nutmeg and sherry. Star apple pulp is also used as flavouring for ice-cream. In short, star apples are as delicious as they are nutritious (Table 10).





**Figure 41.** *Chrysophyllum cainito* (star apple): (A) ripe fruit, showing the attractive edible pulp; (B) fruits for sale at a village market on Flores

**Table 10.** Nutritional value of *Chrysophyllum cainito* (star apple) fruits per 100 g edible portion<sup>a</sup> (Morton 1987b)

Component	Amount/100 g
Energy	281.4 kJ (67.2 cal)
Moisture	78.4–85.7 g
Protein	0.72–2.33 g
Carbohydrates	14.65 g
Fibre	0.55–3.30 g
Ash	0.35–0.72 g
Calcium	7.4–17.3 mg
Phosphorus	15.9–22.0 mg
Iron	0.30–0.68 mg
Carotene	0.004–0.039 mg
Thiamine	0.018–0.080 mg
Riboflavin	0.013–0.040 mg
Niacin	0.935–1.340 mg
Ascorbic acid	3.0–15.2 mg
Amino acids:	
tryptophan	4 mg
methionine	2 mg
lysine	22 mg

<sup>a</sup> Analyses made in Cuba and Central America

## *Schleichera oleosa*

### Multiple uses from one species

The fruits of *S. oleosa* (Sapindaceae) are widely known as *kusambi* (Bahasa Indonesia), *kesambi* or *kahembi*, and their flavour is a reminder that they are related to other popular South-East Asian fruits, such as *Dimocarpus longan* (longan), *Litchi chinensis* (lychee, lichi) and *Nephelium lappaceum* (rambutan). As one of the most widespread trees in the dry woodlands and deciduous forests of eastern Indonesia, *S. oleosa* also produces edible leaves and an oilseed. The fruits (Figures 40C and 42A) and edible leaves are sold in local marketplaces and are an important seasonal snack food for children, particularly on dry islands such as Sumba, Savu and Rote where crop failure is common. The leaves are also fed to livestock in South and South-East Asia. These multiple uses have undoubtedly made a major contribution to food security—an issue of increasing importance in terms of local adaptation to climate change. In addition, *S. oleosa* is the source of ‘lac’, a naturally occurring resin that can be collected directly from the tree. However, more commonly, the trees are inoculated with the sap-sucking insect, *Laccifer lacca*, then lac is obtained from their resinous secretions. Lac is used in a variety of ways, including plastics and lacquer, including shellac (FAO 2010). Unfortunately, the introduction of *L. lacca* and a push for a commercial lac industry since 1992 have resulted in a serious decline

in *S. oleosa* fruit and leaf production. This has eroded local food security on a scale that can only be inferred from the extent of lac trade data from ENT (Figures 43 and 44). This is just one aspect of the decline of *S. oleosa* populations. In many ways, *S. oleosa* is a tree species that is ‘too useful for its own good’.

### Consequences of overexploitation

As a result, *S. oleosa* is under siege on four fronts. First, trees are subjected to severe pollarding in an effort to control the parasitoids that affect the introduced lac insect populations. Second, there is commercial-scale felling of the trees for fuelwood used by two types of enterprise: for producing palm syrup and palm sugar; and for the smoked pig (*sei babi*) industry. As a recent ACIAR report pointed out (Locke 2009), there are 1.5 million pigs in ENT and, in West Timor in particular, the *sei babi* industry is

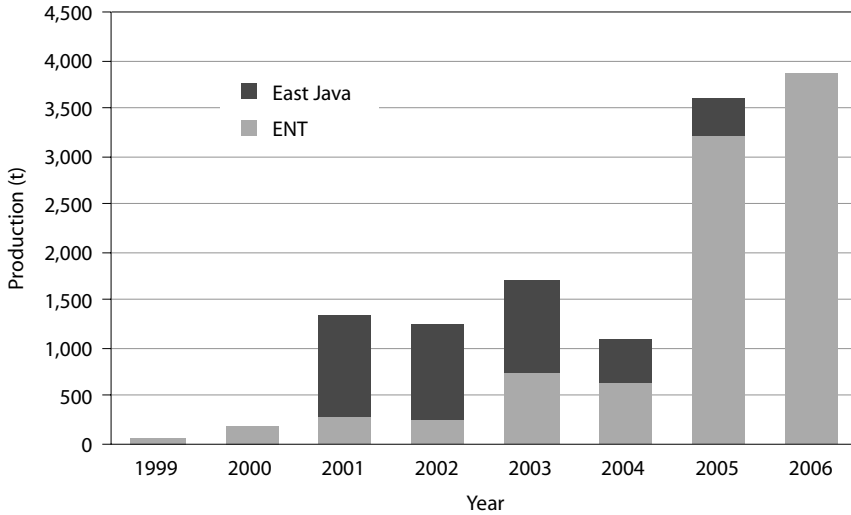
booming. Some commercial breeders have 100 sows, producing up to 1,000 piglets a year. That’s not only a lot of piglets but a lot of fuelwood to smoke them to produce *sei babi*—with *S. oleosa* wood preferred for this purpose. Deadwood is preferred, but this fuelwood demand is increasingly met by commercial suppliers who fell live trees and sell them by the truckload to *sei babi* producers (e.g. in Soe and Kefa, West Timor) or palm syrup producers (Savu, Rote and West Timor). Third, although no growth-rate data are available, we suggest that the sugary exudate from lac insects, which covers a high proportion of annual leaf production, reduces leaf photosynthetic efficiency and therefore tree growth. Finally, in some areas of ENT, such as near Doromeli (Flores), *S. oleosa* was already depleted by the 1960s due to exploitation of the bark, which was used as a colourant in lime-wash for buildings.



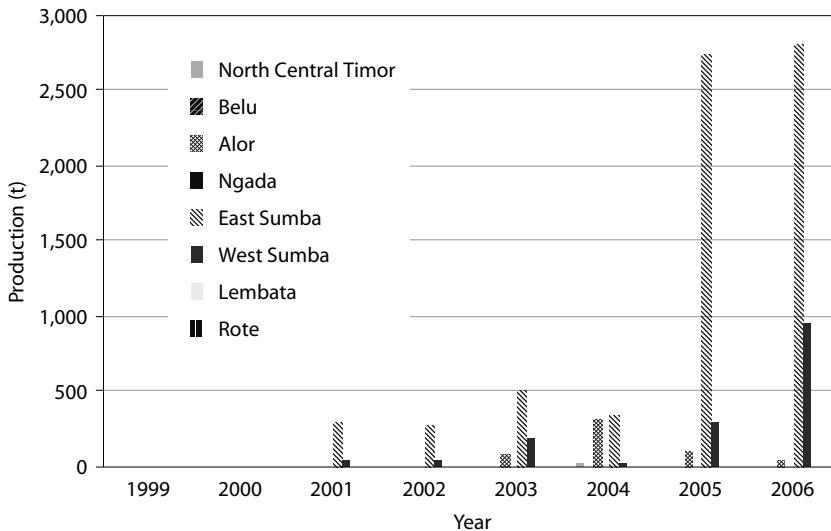
**Figure 42.** Clash of values—insect sap suckers versus people’s food security: (A) *Schleicheria oleosa* fruits, showing their size; (B) lac stored at a household in Rindi, East Sumba, before sale; (C) *S. oleosa* and custard apples for sale in Soe market, West Timor; (D) a natural stand of *S. oleosa* ‘privatised’ by a local entrepreneur, with trees under guard at night to prevent others taking lac from the infected trees. Since this photo was taken in 2005, severe pollarding of trees has resulted in a ban by traditional authorities in the Rindi area and reportedly on Rote due to local concerns about destruction of *S. oleosa* trees.

Over 54,000 ha of woodland are under lac production in ENT (Kudeng Sallata and Widyana 2005). The collision between local food security and commercial lac production, as described above, is probably worst on Sumba. As a dry limestone island, Sumba is particularly vulnerable to drought. As a result, local people have historically relied on deep-rooted,

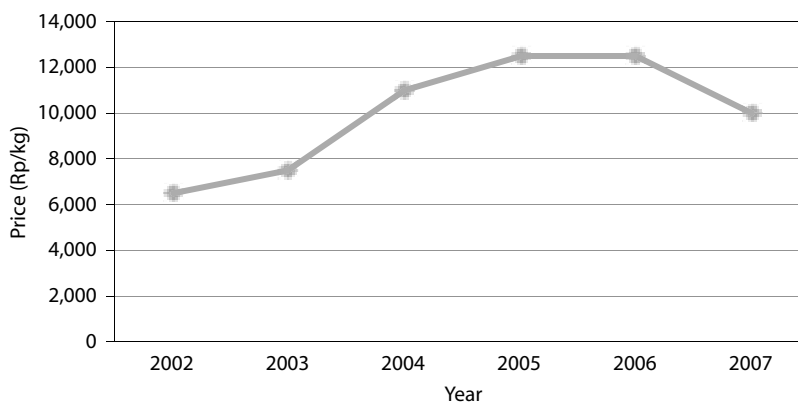
drought-resistant trees such as *S. oleosa*. It is telling, therefore, that traditional leadership in the Rindi area of East Sumba as well as on Rote was reported to have banned lac production in their areas due to the destructive effects this has had on *S. oleosa* populations. At the same time, the price of lac has declined from its peak in 2005–06 (Figure 45).



**Figure 43.** Lac export data, 1996–2006, showing the increase in production from East Nusa Tenggara (ENT) and the decline in production in others parts of Indonesia



**Figure 44.** Lac production within East Nusa Tenggara, showing the importance of East Sumba as a production area, followed by West Sumba



**Figure 45.** The trend in the price of lac in East Sumba, 2002–07

On a global scale, although India produces 50–60% of total world lac production (about 20,000 t/year), Indonesia and Thailand are also significant exporters. In India, methods have been suggested for better management of the lac insect host trees (Sequeira and Bezkorowajnyj 1998). In eastern Indonesia, tenure over the *S. oleosa* trees is weak, particularly in remaining forest patches and the mountains and river valleys away from the coast. In India, a mature tree yields 21–28 kg de-pulped seed per year. Fruit and seed yields in Indonesia are unknown at this stage. The seed oil content varies in the range 59–72%, producing a yellowish-brown, semi-solid oil and consists of oleic acid (52%), arachidic acid (20%), stearic acid (10%) and gadoleic acid (9%). After oil extraction, the pressed cake is fed to livestock or chickens. Per 100 g, it contains protein (22 g), fat (49 g) and carbohydrates (14 g).

These food and seed oil values are not possible under current tree management for lac, which results in slower tree growth and low (or no) fruit and seed production, due to the impacts of lac insects on the host tree. Combined with lopping of all leaf growth and associated smaller branches from host trees every 2 years in an effort to control lac parasites and predators, this reduces the growth rates of trees and often halts fruit production.

### Recommendation

An integrated economic value assessment of all *S. oleosa* products is therefore important in order to develop sustainable management plans that benefit local people in the long term, particularly as this species grows in marginal lands and produces a range

of forest products. A research study that assesses the current and potential uses and values of, and harvest impacts on, *S. oleosa* on Sumba was suggested to ACIAR in 2008 as a John Allwright Fellowship study (through a Charles Darwin University submission to ACIAR), but funding was not available. Research on this topic is still a priority.

### *Tamarindus indica*

In common with the other edible fruits in this section, the commercial values and potential of tamarind need to be considered alongside their nutritional values at the household level. In West Timor, for example, food is often scarce and people are hungry at the end of the hot wet season. This period of seasonal hunger is often exacerbated by crop losses due to drought or floods, especially loss of maize production. This time of the year, a lean season extending over 2 months, is known in West Timor as *musim asam* or ‘sour season’, a name is derived from the fruiting of *T. indica* (Leguminosae). At this time, tamarind fruits are collected and processed for their pulp for *gaji tambahan* (an income supplement) (Figure 46). This local sale or barter in tamarind pulp sustains tens of thousands of poorer families at this time of the year. Local people’s diets also benefit from the nutritious edible pulp and leaves (Table 11). An advantage of tamarind pulp is its long shelf life. This allows local farmers to store substantial quantities of the product before traders (predominantly Chinese-Indonesians) arrive, often travelling to remote and isolated places to purchase the product. Payment is always upfront. The long shelf life of this product also allows the

traders to stockpile large amounts of the produce in strategic towns or areas before transporting it to port towns/areas where the product will ultimately be sold to Java. This is resold nationally and some is exported. In common with 95% of world production, Indonesia produces sour tamarind rather than the sweet variety.

In terms of export markets, Indonesia competes with several other producing countries, particularly India, the world's largest sour tamarind producer with an annual production of about 300,000 t. Thailand is the second-largest producer in Asia and has diversified production through encouraging cultivation of sweet varieties. Thirty per cent of tamarind exports from Thailand are the sweet type, which is of growing importance as a small-scale plantation crop. Most of the fruit-pulp processing and trade is through informal-sector markets. Despite its value as an export product from Indonesia and a 'safety net' for poor people throughout ENT, there is a need for additional applied research on tamarind on a range on issues:

- Diversification through introduction of sweet tamarind varieties into agroforestry systems in ENT would be a good idea, as most production at the moment is from unimproved sour varieties from pre-colonial introductions of this species to Indonesia.

- Diversification in the market (e.g. through buying the seeds for industrial use—as discussed in the 'Oils and oilseeds' chapter) and improvement of production quality would give farmers the incentive to use more of the surplus fruit production (much of which goes to waste when fallen fruits and fruits from trees in more remote areas are not collected).
- Appropriate tamarind fruit and seed processing equipment developed in India should be investigated for application in Indonesia.
- Organic certification of higher quality tamarind pulp production should be considered for the Australian market, through direct marketing from Kupang to Darwin.

### *Uvaria rufa*

Locally called *lelak* (Bahasa Kupang) or *kok naba* (Dawan), *U. rufa* (Annonaceae) produces russet-coloured, 'banana'-like fruits with a flavour that is a cross between soursop and passionfruit. The plant occurs through South Asia into South-East Asia and is a scandent climber in coastal and upland thickets of ENT. The fruits are sold seasonally in Oeba market, Kupang, and in Camplong Dua area on the road to Soe, for Rp4,000–5,000/kg (Figure 47). In Camplong Dua, the women who sell *U. rufa* fruits are



**Figure 46.** *Tamarindus indica* (tamarind) fruit preparation: (A) peeling fruits and removing the seeds to get the pulp ready for sale in a local market (on Lembata); (B) tamarind pulp (still around the seeds), packed in a woven *lontar* basket during the period of seasonal hunger known as *musim asam* or 'sour season'

**Table 11.** Nutritional value of *Tamarindus indica* (tamarind) pulp, leaves and flowers per 100 g of edible portion

Component	Amount/100 g		
	Pulp (ripe) <sup>a</sup>	Leaves (young)	Flowers
Energy	481 kJ (115 cal)		
Moisture	28.2–52.0 g	70.5 g	80.0 g
Protein	3.10 g	5.80 g	0.45 g
Fat	0.10 g	2.10 g	1.54 g
Fibre	5.6 g	1.9 g	1.5 g
Carbohydrates	67.4 g	18.2 g	
Invert sugars (70% glucose, 30% fructose)	30–41 g		
Ash	2.90 g	1.50 g	0.72 g
Calcium	35–170 mg	101 mg	36 mg
Magnesium		71 mg	
Phosphorus	54–110 mg	140 mg	46 mg
Iron	1.3–10.9 mg	5.2 mg	1.5 mg
Copper		2.09 mg	
Chlorine		94 mg	
Sulfur		63 mg	
Sodium	24 mg		
Potassium	375 mg		
Vitamin A	15 IU	250 mcg	0.31 mg
Thiamine	0.16 mg	0.24 mg	0.08 mg
Riboflavin	0.07 mg	0.17 mg	0.15 mg
Niacin	0.60–0.70 mg	4.10 mg	1.14 mg
Ascorbic acid	0.7–3.0 mg	3.0 mg	13.8 mg
Oxalic acid		196 mg	
Tartaric acid	8.0–23.8 mg		
Oxalic acid	trace only		

<sup>a</sup> The pulp is considered a promising source of tartaric acid, alcohol (12% yield) and pectin (2.5% yield). The red pulp of some types contains the pigment chrysanthemins.

from poorer households, and also sell firewood, raw peanuts and *Annona* (custard apple) fruits.

There is a big variation in the size of the fruits, suggesting potential for domestication through selecting large-fruited genotypes for planting. Although developing *U. rufa* fruits is a longer term proposition, we suggest that, like the Chinese gooseberry (kiwifruit), this would be a good idea. There is potential for *U. rufa* in markets for attractive new tropical fruits: first, in specialty markets and in ice-cream, as an alternative to passionfruit, initially in local hotels; and second, the fresh juice market in Australia, just 500 km by sea from Kupang. To make better use of the existing wild resource, what is needed is:

- collection of different varietal types across the geographical range of this species for comparative testing
- genetic selection
- horticultural development.

### *Zizyphus jujuba*

*Zizyphus jujuba* (Rhamnaceae)—Chinese date or jujube (known in Bahasa Indonesia as *bidara*, *widara* (Sundanese), *rangga* (Sumbanese), *kok* in Timor)—occurs through ENT as a thorny wild shrub whose small, round, fairly tasteless fruits are eaten by children. In addition, the shrubs are grown (or the branches cut) as a fence to protect crops. Why suggest it as a potential ‘winning’ species?

There are two reasons for this. First, the current stocks of this species are widespread in ENT and extremely tough and resistant to drought. Many trees are close to households, where stronger tenure over the trees is possible if there is sufficient incentive. Second, there is a long history of grafting superior selections onto the rootstock of wild types. This was first done in the 19th century in India (near Bombay in about 1835). This technique was kept secret until 1904, after which it was widely adopted. These



**Figure 47.** *Uvaria rufa*: (A, B) leaf characteristics; (C) pulp and seed colour; (D) variation in fruit size and number per bunch; (E) typical plant, a scandent climber; (F) seasonal trade at a roadside market in West Timor; (G) fruit for sale in Kupang market

grafted plants have several advantages, including large, sweet fruits, high yields and fewer thorns. Returns from grafting can be rapid (Chovatia et al. 1993). In India, wild trees grafted with preferred cultivars in June were producing fruit a year later. At an early stage, this process was used in rural development. For example, the Punjab Department of Agriculture top-worked 50,000 trees between 1935 and 1938 without cost to local farmers. In the Sahel in Africa, superior cultivars of *Z. mauritiana* (particularly ‘Gola’) have been grafted to wild trees (Danthu et al. 2004). A similar extension effort is possible in ENT through trained local farmers or extension staff.

Over 90 cultivars of *Z. mauritiana* are known from India, many of which can be easily grafted onto *Z. jujuba*. These vary according to tree form, leaf

shape, fruit shape and size, colour, flavour, shelf life and fruiting season. Examples of cultivars are:

- ‘Umran’, a late-ripening variety with large golden-yellow fruits that turn chocolate-brown when ripe. Average fruit weight is 30–89 g (about 10 times larger than the fruits on trees in ENT), with a fruit yield of 150–200 kg/tree.
- ‘Gola’, which has been widely used in grafting in West Africa, Israel and India. The fruit are medium to large (average, 14–17 g), with a good flavour and a fruit yield of 80–100 kg/tree.

What are the advantages of a grafting program? We suggest three benefits. First, it would diversify farmers’ income through production of fruits for the local market, in common with India, where the large *Z. mauritiana* (*ber*) (Figure 48) are popular as a fresh fruit. Second, the surplus would provide a

nutritional dietary supplement to local families; and third, there is a potential national, and even export, market for the fruits, either dried and sugared as a confectionary (very popular in Asia) or as a yoghurt flavour (Figure 49).



**Figure 48.** Large *Zizyphus mauritiana* fruits of a superior cultivar for sale in an informal-sector market in Kolkata, India (in bags in the foreground)—this cultivar is easily grafted onto *Z. jujuba* in East Nusa Tenggara



**Figure 49.** The *Zizyphus*-flavoured yoghurt market is huge in China and could also be popular in Indonesia: (A) twin-packs of *Zizyphus* yoghurt; (B) low-cost, ‘ready to drink on the go’ *Zizyphus* yoghurt



## Food and drinks 5: honey

### Current honey production and trade

In world terms, Indonesia's honey production is dwarfed by that from China (298,000 t/year; 21.5% of global production), with other leading producers—Turkey (5.9%), Argentina (5.8%), USA (5.7%), Ukraine (5.1%), Russia (3.8%) and Mexico (3.6%)—having easier access to markets in Europe or North America. Most honey and beeswax in world production is from the honey bee (*Apis mellifera*). By contrast, most honey sold in the project study area (Figure 50) is from the giant honey bee (*Apis dorsata*). In addition, a small amount of honey is obtained from other bee species, including several species of stingless bees (Trigonidae).

Stingless bees occur across the tropics and neotropics. In northern Australia, they are distributed across

the monsoonal tropics, where they are known as 'sugar-bag' bees by Aboriginal people, who place a high value on the honey (Brand Miller et al. 1993). In ENT, in common with most other parts of the tropics, stingless bees are used extensively for subsistence, usually through opportunistic exploitation of wild colonies, which yield small amounts of strongly flavoured honey as well as a black wax. In northern Australia, several projects have tried to introduce nesting boxes to Aboriginal communities interested in keeping stingless bees (J. Gorman, pers. comm. 2008). This is already taking place in West Timor, where some villagers keep stingless bees in bamboo hives (Figure 51A). Stingless bees produce a range of commercial products, such as honey, wax used for art and musical instruments, and pollen used as a natural health product (Roubik 1989; this study). At present, however, the sale of stingless bee products in ENT



**Figure 50.** Map showing the location of areas where wild-harvested honey from the giant honey bee (*Apis dorsata*) is sold from roadside stalls in the study area, and of a recent development project using Langstroth hives with *Apis mellifera*

is insignificant and honey yields from domesticated stingless bee hives are small (less than 500 mL/year). By comparison, *A. dorsata* hives produce relatively large volumes of honey per hive, which is in the form of large combs hanging from tree branches (Figure 51G). Due to this higher scale of production, there is more commercial potential for *A. dorsata* honey than stingless bee honey. However, the pollination services of stingless bees to farm production (Heard 1999) and in tropical forests (Momose et al. 1998) should not be ignored.

Much more is known about *A. dorsata* honey production and ecology than honey production from stingless bees, as is evident from the recent bibliography on stingless bee research (Hepburn and Hepburn 2007). At the moment, most of the *A. dorsata* honey produced in West Timor and on Flores is sold to passing motorists or to retail outlets in nearby towns. In West Timor, honey from the Looneke area is sold in Atambua, honey from Sainiup is sold in Beboki, and honey from Amfoan and Polen is sold in Kupang. Honey from the *A. mellifera* beekeeping project near Kapan is sold locally through a development non-government organisation (NGO).

Official trade data for the honey trade from ENT are patchy and may not be particularly reliable, but give some indication of the destinations (Figure 52) and volumes sold per year (Figure 53). If these trade data are even vaguely correct, the quantity of honey produced (over 3,000 L/year exported from Kupang in some years) is on a large-enough scale to warrant investment in quality control, labelling and ‘*Apis dorsata*’ honey branding to improve returns to honey-hunters. This has been implemented on Sumbawa under similar circumstances.

## Recommendations and challenge

### Marketing and certification

At the moment, honey quality is good but variable, with no branding or niche marketing. Honey is sold at the roadside in second-hand bottles (Figure 51C). We recommend that a similar approach to that followed by the Sumbawa Forest Honey Network (*Jaringan Madu Hutan Sumbawa*; JMHS) is used, which was assisted by the Indonesian Forest Honey Network (*Jaringan Madu Hutan Indonesia*). Through training and better marketing, including development of an *Apis dorsata* honey brand and label, honey-hunters on Sumba have improved their honey-processing methods from squeezing to filtering to improve honey quality.

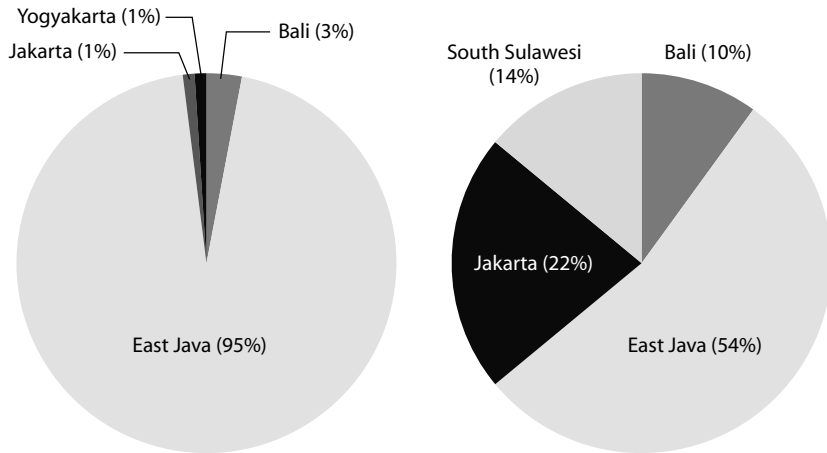
Whether organic certification would pay off or not is uncertain. There have been steps to have *A. dorsata* honey from Riak Bumi in West Kalimantan certified by BIOCert, an organic certifying body based in Bogor (BIOCert 2008). In a recent assessment of natural products (including honey) sold to certified versus conventional markets in Africa, for example, we found that, where beekeepers live closer to urban markets or are able to access regional trade, conventional trade brings better returns. In remote Mwinilunga district, however, NGO interventions, certification and high numbers of producers have enabled beekeepers to access the international market for certified honey, despite the fact they are paid lower prices for their honey (M. Husselman, pers. comm., 2010).

### Reversing declining production

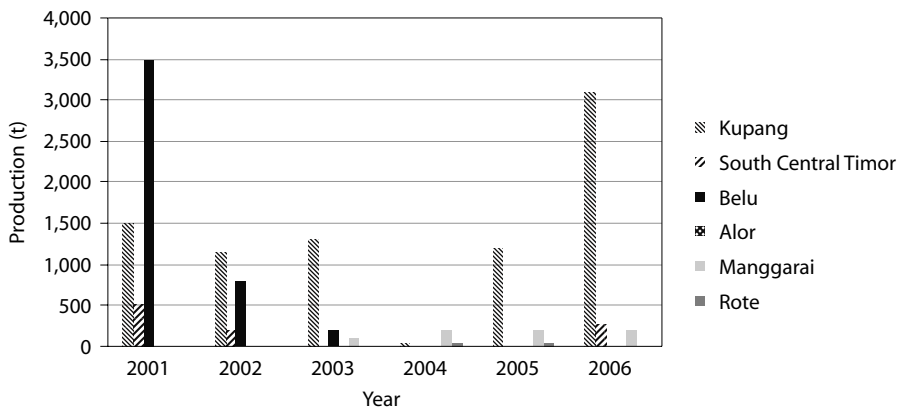
A major challenge to the honey industry in ENT is declining production of *A. dorsata* honey due to loss of forest habitat and favoured nesting trees. In common with many other parts of South-East Asia, *A. dorsata* colonies in West Timor and on Flores are high in the trees (usually 15–25 m above the ground). In contrast with tropical forests in Thailand, where *A. dorsata* combs are in trees of the Dipterocarpaceae family, tall trees in the Bombacaceae, Datisceae (such as *binong*—*Tetrameles nudiflora*) or Sterculiaceae are favoured in ENT. It is likely that these provide the safest nesting sites, not only because they are very tall trees, but also due to their smooth bark and trunks that have few (or no) branches in the first 5–8 m from the ground. These features provide protection from predators (as well as making honey collection dangerous for local people). Despite this, a common concern across Asia is that the *A. dorsata* populations are declining, due to forest loss, pesticide use in farmlands and destructive honey exploitation practices. The biggest challenge in ENT is probably loss of habitats preferred by *A. dorsata*. This is reversible through two processes: first, by planting fast-growing Bombacaceae or Sterculiaceae from wildings (the wild seedlings that grow from seeds dispersed naturally in the forest) in the honey production areas; and second, by improved management and protection of the remaining forests used by *A. dorsata*. We also recommend an independent assessment of the JMHS project (described above) in order to learn appropriate lessons relevant to *A. dorsata* honey marketing in West Timor and Flores.



**Figure 51.** Honey production in East Nusa Tenggara from stingless bees (*Trigonidae*) and *Apis dorsata* (*Apidae*): (A) a bamboo hive used for keeping stingless bees at the village level (West Timor); (B) stingless bee hive hanging under the eaves of a house (West Timor); (C) *A. dorsata* honey for sale at a roadside stall (Polen, West Timor); (D) stingless bee honey (West Timor); (E) stingless bees (West Timor); (F) beeswax from *A. dorsata* for sale at Maumere market, Flores; (G) *A. dorsata* nests in secondary forest at the main honey production area of Polen, West Timor



**Figure 52.** The destination of honey exported from East Nusa Tenggara in 2001 (left) and 2002 (right), showing Java as the major destination



**Figure 53.** Honey trade from East Nusa Tenggara, based on official trade data collated by the Forestry Research and Development Agency (FORDA) during this study

# Stimulant plants

## *Areca catechu*

### Background

*Areca catechu* (*pinang*, betel nut) has the advantage in that it is a multi-use species that is grown not only for its fruits. The termite-resistant wood is widely used as rafters in the construction of Austronesian houses and even as water-piping in more remote villages. In Bali, the spathes are used in cooking a special duck recipe. In addition, the cultural importance of the ‘*pinang*, lime and *sirih*’ chewing (see below), combined with the cultural diversity and skills of ENT’s people, has generated a rich material culture of baskets and lime containers. These currently bring a small cash income to rural men (making lime containers) and women (weaving betel nut baskets) for sale in local markets. In the future, we predict that export trade in the diverse range of high-quality baskets associated with *pinang-sirih* will increase as international awareness of these finely made products grows (see the ‘Cultural heritage and arts’ chapter).

### International trade

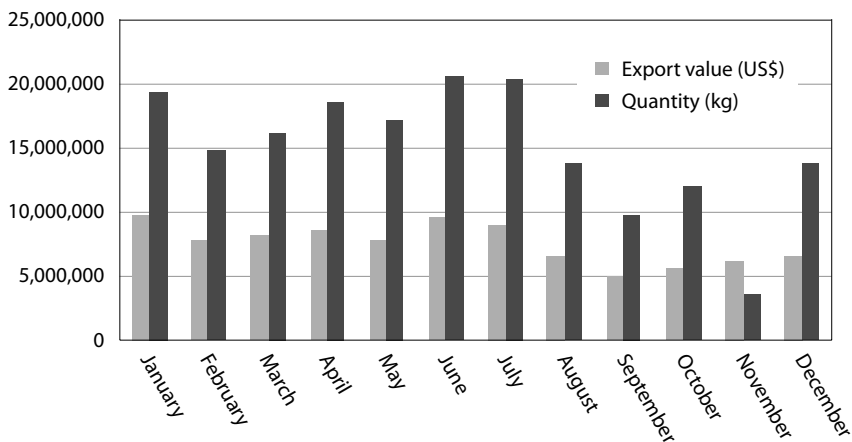
On a global scale, the fresh, dried or processed fruits of *A. catechu* are chewed by about 10% of the world’s population, or 600 million people (Gupta and Warnakulasuriya 2002), making it a more popular product than chewing gum. Chewing *A. catechu*, generally with lime (*kapur*) and the leaves or fruits of *Piper betle* (*sirih*) has a very long history in South-East Asia. Characteristically stained teeth from prolonged chewing of *A. catechu* from an archaeological site in Vietnam have been dated to 2,000–2,400 years ago (Oxenham et al. 2002). Cultural preferences in different parts of the Asia–Pacific region account for regional variation in *A. catechu* fruit use. Fermented fruits are chewed in Sri Lanka and north-eastern India, unripe fruits are preferred in Guam and Taiwan, and *A. catechu* flowers are chewed in Papua New Guinea (Gupta and Warnakulasuriya 2002). Although use is declining in some parts of Asia, such as Thailand, it is increasing in others, such

as India, which is the world’s largest producer and consumer of *A. catechu* fruits (Figure 54). Processed, packaged *pan masala*; *gutka* (which also has tobacco added); or the more traditional dried *Areca*, lime and *P. betle* combination are popular in both rural and urban areas of India. Despite improved varietal selections and more intensive production methods, large Indian companies producing *pan masala* also import *Areca* fruits from Bangladesh, Indonesia, Burma (Myanmar), Sri Lanka and Thailand.

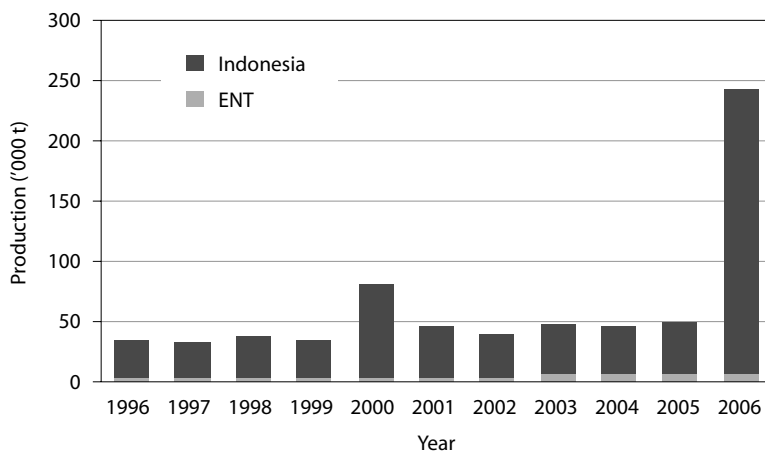
Indonesia is a major exporter of *A. catechu* fruits, exporting 116,779 t, worth US\$41.6 million, followed by Thailand (56,703 t, US\$19.97 million) and Malaysia (2,025 t, US\$736,000) in 2004 (FAO 2004). In 2005, 50,000 t of *A. catechu* fruits were reported as being imported into India, resulting in the call for a ban on imports from Indian producers (Anon. 2005). This is not reflected in FAO (2004) trade data, however, which shows Bangladesh at the main importer (53,321 t, worth US\$12.8 million), followed by Thailand (2,545 t, US\$4.2 million) (FAO 2004). Between 1996 and 2005, Indonesia produced between c. 40,000 and 50,000 t/year of *Areca* fruits. In 2010, *A. catechu* exports from Indonesia totalled almost 180,000 t, which were worth nearly US\$90 million (Figure 54).

### National trade and trade within ENT

According to official statistics, the production of *A. catechu* fruits in ENT averaged 12.1% of total national production (1996–2005) (Figure 55). Within ENT, West Sumba dominates production, representing 63–72% of total production between 1996 and 2006, followed by East Sumba (Figure 56). *Areca catechu* fruit production from West Sumba increased to just under 5,000 t in 2006. Although official trade data indicate that Kupang district is the third most important source of *A. catechu* fruits, this may include shipments of fruits that come from Flores. While official trade data indicate general trends in production, analysis of informal-sector trade during this survey certainly shows a more complex picture (see ‘Future steps’, below).



**Figure 54.** *Areca catechu* (fruits, fresh or dried) exports from Indonesia in 2010, showing monthly export values and volumes. Source: based on data from the Statistics Indonesia database, available at <<http://dds.bps.go.id/eng/exim.php>>.



**Figure 55.** Production of *Areca catechu* in East Nusa Tenggara (ENT) as a proportion of total national production between 1996 and 2005, based on official statistics analysed by the Forest Research and Development Agency (FORDA)

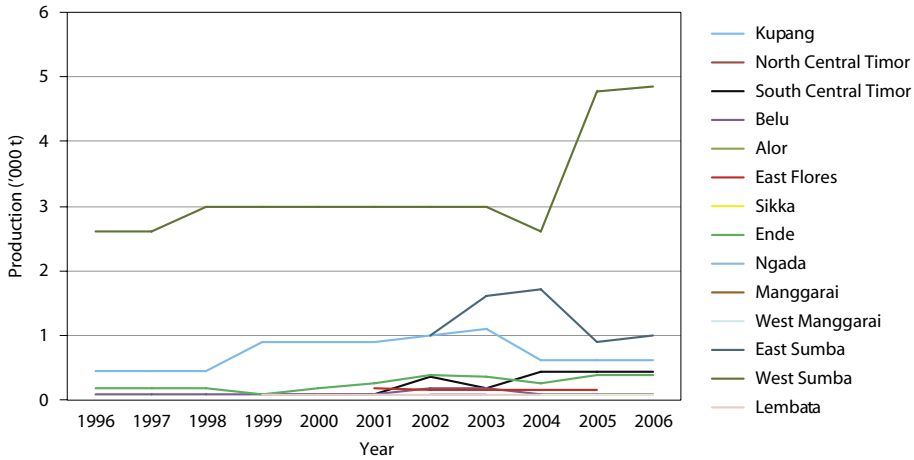
### Inter-island and local trade

The popularity of chewing betel nut (*A. catechu*) and the importance of *pinang* and *sirih* as a ritual gift creates a significant local demand that was evident in our local marketplace surveys in ENT (Figure 57). With a relatively high price per volume and a long shelf life, sliced, dried *A. catechu* fruits (*pinang kering*) are transported long distances to meet local demand. As production is lower on drier islands, there is extensive intra- and inter-island

trade from places with higher rainfall. In Kapan weekly market (West Timor), for example, fresh *pinang* was produced locally, but most dried *pinang* was imported into from Flores. On Sumba, betel nut and betel vine (*P. betle*) were the dominant agroforestry products in the Waitubala market, yet both commodities came from Wajewa and south-west Sumba. Similarly, the source of *A. catechu* fruits in the Atambua market was farmers in upland West Timor (Kefamenanu).

Based on our surveys of local marketplaces, the main production areas of fresh *A. catechu* for sale in local marketplaces in West Timor were, in order of importance, Aimere, Eban, Burain and Kapan (Figure

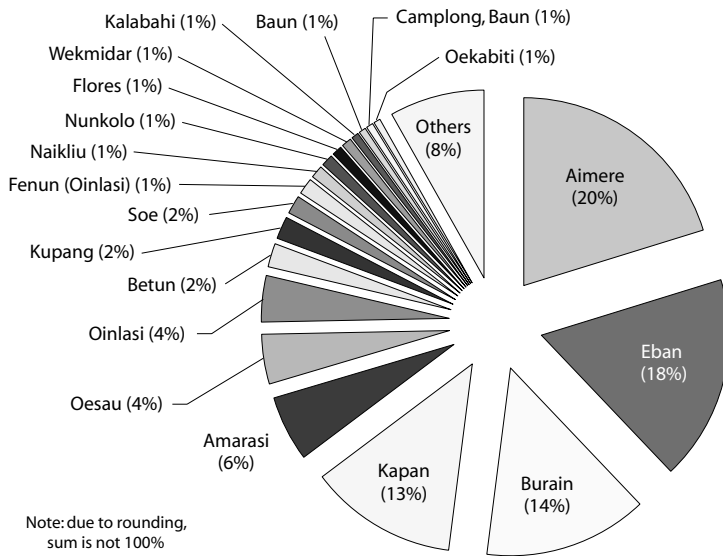
58). On Flores, the main production areas for the marketplaces we surveyed were Mauponngo, Mataloko, Ndona and Watublapi (Figure 59); while on Sumba, Wajewa was the dominant source (Figure 60).



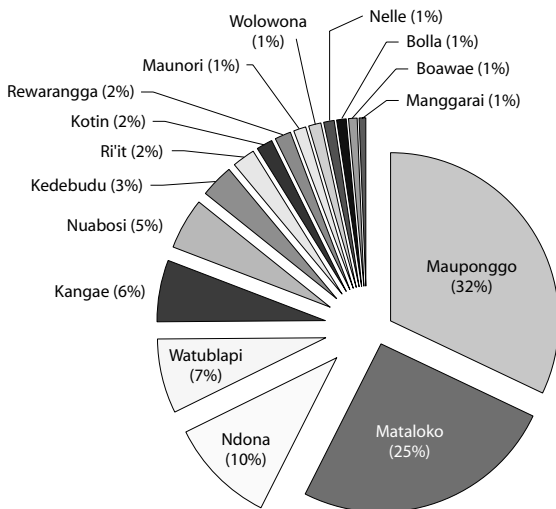
**Figure 56.** Production of *Areca catechu* in East Nusa Tenggara by district, 1996–2006, based on official statistics analysed by the Forestry Research and Development Agency (FORDA)



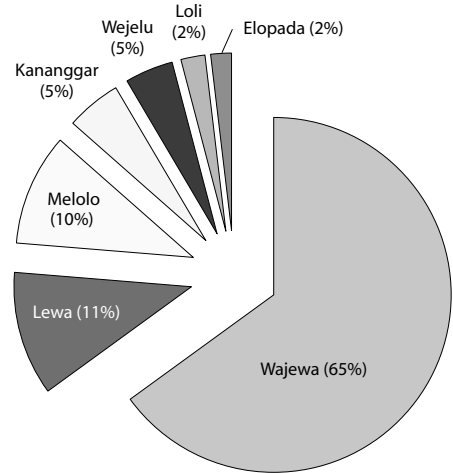
**Figure 57.** Niche marketing of stimulants: informal-sector sellers of dried and fresh betel nut (*Areca catechu* fruits) typically also sell betel vine (*Piper betle*) fruits (lower left), lime and tobacco



**Figure 58.** Sources of fresh *Areca catechu* fruits sold in local marketplaces in West Timor, represented by percentage of stock value held by sellers—the main sources were Aimere (on Flores) (Rp3,533,000), followed by Eban (Rp3,088,000), Burain (Rp2,465,000) and Kapan (Rp2,223,000)



**Figure 59.** Sources of fresh *Areca catechu* fruit sold in local marketplaces in Flores, represented by percentage of stock value held by sellers—the main sources were from Mauponggo (Rp702,000), Mataloko (Rp556,000), Ndonga (Rp225,000) and Watublapi (Rp157,000)



**Figure 60.** Sources of fresh *Areca catechu* fruit sold in local marketplaces on Sumba, represented by percentage of stock value held by sellers—the main source was from Wajewa (Rp414,000)

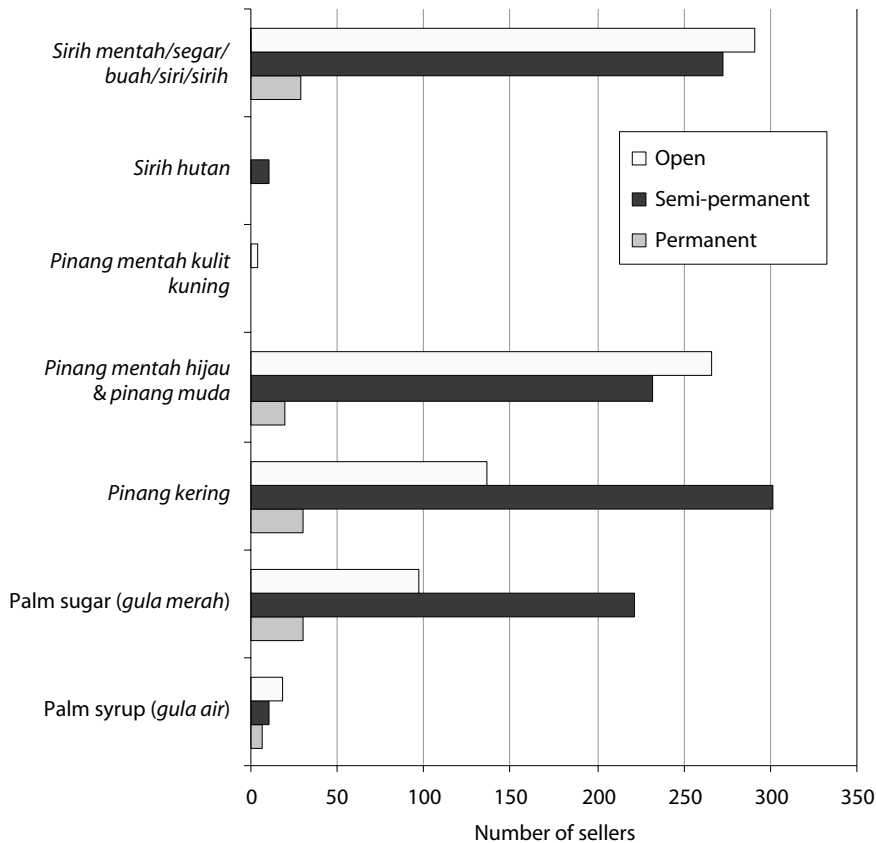


On Savu, the traders we surveyed said that they obtained most (99%) of their dried *pinang* from Sumba, with just a fraction from Kupang (1%).

**Future steps: *pinang* production and trade in other products**

*Areca catechu* for *pinang* (betel nut) as a cash crop instead of other commercial crops has been criticised (Staples and Bevacqua 2006) due to public health concerns about betel nut use (Gupta and Warnakulasuriya 2002). However, thousands of people in ENT are self-employed selling *sirih* and *pinang*, which are more important agroforestry products in the informal sector than palm sugar (Figure 61). We therefore suggest that the following steps are taken:

- *Diversify commercial production.* All parts of *A. catechu* are useful. In addition to the commercially valuable fruits discussed above, the stems are valued locally as a termite-resistant construction timber, and the spathes (Figure 62) are used as ‘disposable containers’ and, in Bali, for baking ducks. Elsewhere in Asia, *A. catechu* is a component of particle board useful in furniture manufacture, based on old *Areca* palms felled at the end of the production cycle (Cheng et al. 2008).
- *Use the results from provenance trials to select improved varieties.* Provenance trials have been conducted in Indonesia for six different *A. catechu* varieties at Gorontalo, Sulawesi. In India, 16 varieties were assessed at the Central Plantation Crops



**Figure 61.** The number of informal-sector sellers in the market surveys subdivided by stall type of those selling *Piper betle* (*sirih*) products, wild *Piper* (*sirih hutan*), fresh yellow-skinned *Areca catechu* fruit (*pinang mentah kulit kuning*), fresh green *A. catechu* fruit (*pinang mentah hijau*) and dried *Areca* fruit (*pinang kering*) compared with the number selling palm sugar and palm syrup



**Figure 62.** (A) *Areca* spathes, a discarded by-product through much of East Nusa Tenggara, are marketable in Bali; (B) unshed spathe on *A. catechu*, millions of which are shed each year

Institute in Vittal, based on germplasm from Sri Lanka, China, Thailand, Malaysia, Singapore, Indonesia, the Philippines, Fiji, Solomon Islands and Mauritius (Staples and Bevacqua 2006). It would also be useful to make a provenance collection of *A. catechu* in ENT that links to local folk taxonomy of these palms.

### *Piper betle*

#### **Background**

The economics of *Piper betle* (*sirih*, betel vine) have been best studied in India, where the main crop is the fresh leaves, which are chewed by 15–20 million people a year. In India, *P. betle* is a smallholder crop worth Indian rupee 9,000 million/year (c. A\$263.3 million) from a production area of 50,000 ha, mainly in West Bengal (Guha 2006).

Several *Piper* species are sold in local marketplaces in eastern Indonesia. The two most important of these are components of agroforestry systems, namely *Piper nigrum* (black pepper), used worldwide as a spice, and *P. betle* and *Piper retrofractum* (long pepper), which are chewed with slivers of *A. catechu* seeds. In addition, several wild species of *sirih utan* fruits (possibly from *Piper caducibracteum*) are sold on a small scale for medicinal purposes in most local marketplaces in ENT.

In contrast to India, where *P. betle* leaves are most commonly chewed with lime and *A. catechu* seeds, it is *P. betle* fruits rather than leaves that are most commonly chewed in eastern Indonesia (Figure 63). *Piper betle* leaves are also used, but are less common in local marketplaces.

*Piper betle* is widely sold in local marketplaces (Figure 64) and the supply chains are complex, varying from market to market and across the different islands (Figures 65 to 68).

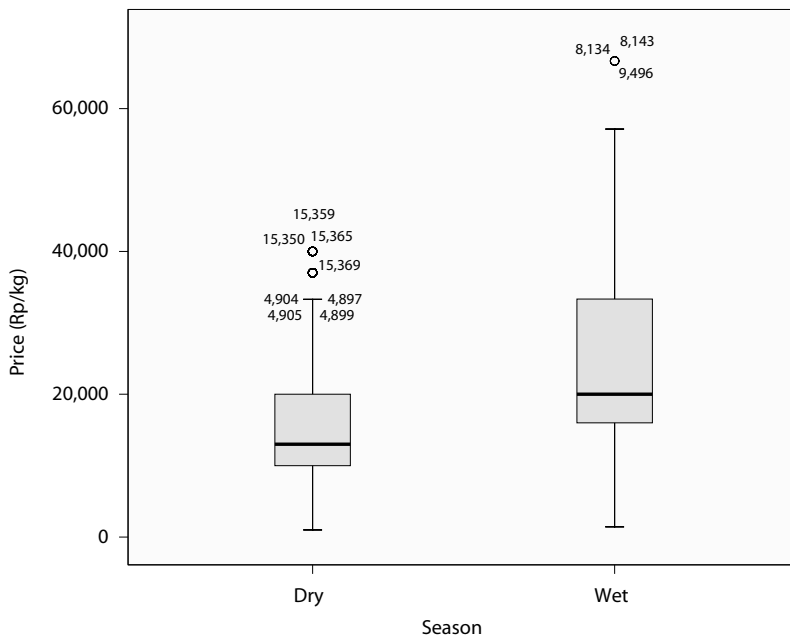
### Wild betel vine (*sirih hutan*)

Wild harvested fruits of a *Piper* species (possibly *P. caducibracteum*) are also sold in most local

marketplaces in ENT. Locally known as *sirih hutan*, the fruits are much smaller than those of *P. betle* (Figure 69) and are sold in small quantities. The main sources of supply are Amarasi, Batu Putih, Tesbatan and Betun in West Timor (Figure 70), and Detusoko and Kloangpopot on Flores (Figure 71).

### Recommendations

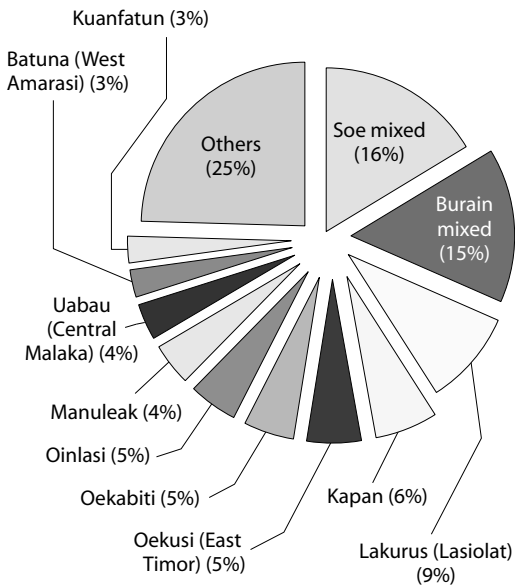
Two suggestions for *P. betle* production are: first, that assessment is done based on the wider range of cultivars available in India to test for varieties that may also be suited to ENT; and second, investigation is made into the opportunity for an essential oil industry based on betel leaf oils. Due to relatively limited supplies in ENT, this may be more appropriate to other parts of Indonesia. However, the oil has potential use in production of chewable mouth fresheners and incense sticks. It also has insecticidal properties (Gragasin et al. 2006). The Indian experience of this process (Guha 2008) may therefore be worth considering.



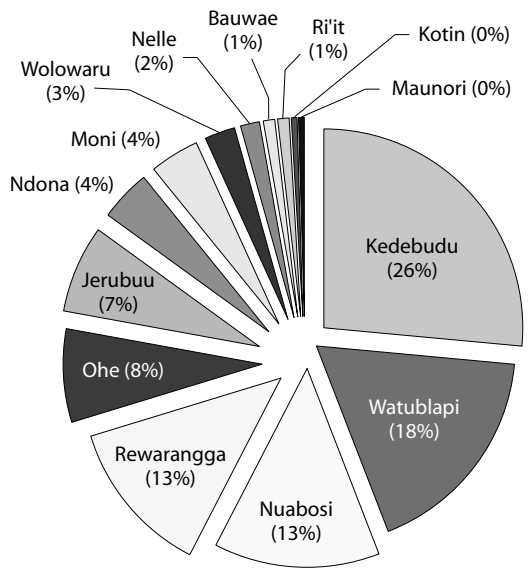
**Figure 63.** The market price per kilogram for fresh *Piper betle* fruits, showing the difference in price between the dry season ( $n = 185$  traders) and wet season ( $n = 260$  traders).



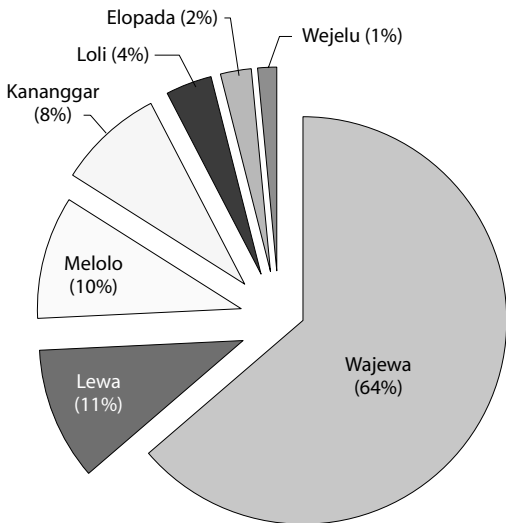
**Figure 64.** *Piper betle* production and sale: (A) multi-cropping, in which *P. betle* climbing up trees as trellises makes efficient use of space (Savu); (B) rolls of *P. betle* leaves, wrapped in banana leaves to keep them fresh, for sale in Kefamenanu market, West Timor; (C) a typical betel chewer's basket with fresh leaves (Bote, West Timor); (D) possibly due to their longer shelf life and because they are more easily transported, *P. betle* flowers are more commonly traded than leaves, where they are usually sold with dried *Areca catechu* seeds; (E) *P. betle* with fresh *A. catechu* fruits



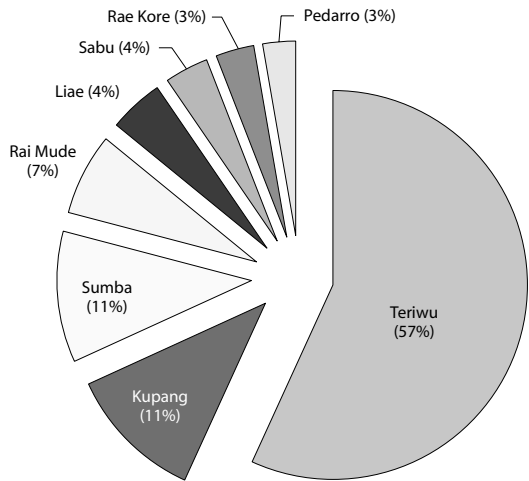
**Figure 65.** Supply areas for fresh *Piper betle* sold in West Timor based on ‘snapshot’ surveys of local marketplaces, showing that Soe (Rp2,886,000) and Burain (Rp2,696,000) are major supply areas



**Figure 66.** Supply areas for fresh *Piper betle* sold in Flores based on ‘snapshot’ surveys of local marketplaces, showing that, for the marketplaces we surveyed (Bajawa, Maumere and Ende), the main supply areas were Kedebudu (Rp342,000) and Watublapi (Rp228,000)



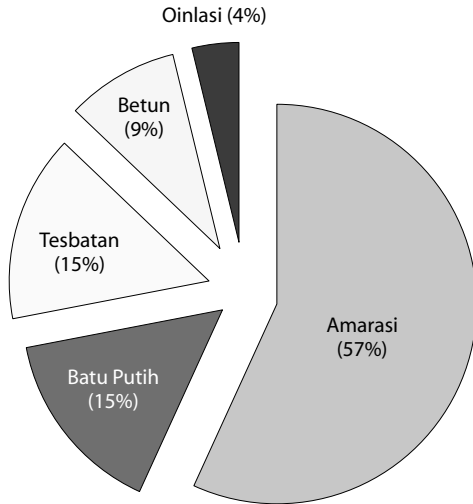
**Figure 67.** Supply areas for fresh *Piper betle* sold on Sumba based on ‘snapshot’ surveys of local marketplaces, showing that the main production area was Wajewa (Rp338,500)



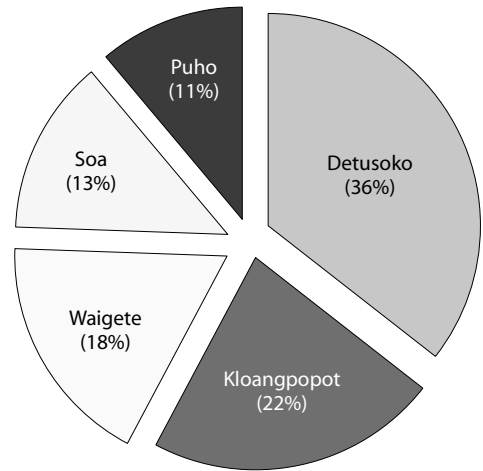
**Figure 68.** Supply areas for fresh *Piper betle* sold on Savu based on ‘snapshot’ surveys of local marketplaces, showing that the main production area was Teriwu (57%)



**Figure 69.** Fruits of *sirih hutan* (possibly *Piper caducibracteum*)



**Figure 70.** Supply areas for *sirih hutan* sold in West Timor based on ‘snapshot’ surveys of local marketplaces, showing that the main forest harvest areas were near Amarasi (57%).



**Figure 71.** Supply areas for *sirih hutan* sold on Flores based on ‘snapshot’ surveys of local marketplaces, showing that the main *sirih hutan* harvest areas were Detusoko (36%) and Kloangpopot (22%).

# Cultural heritage and arts

## Introduction

East Nusa Tenggara, with all its cultural diversity, has a rich and overlooked resource: intangible cultural heritage. This is defined by the United Nations Educational, Scientific and Cultural Organization (UNESCO 2003) as:

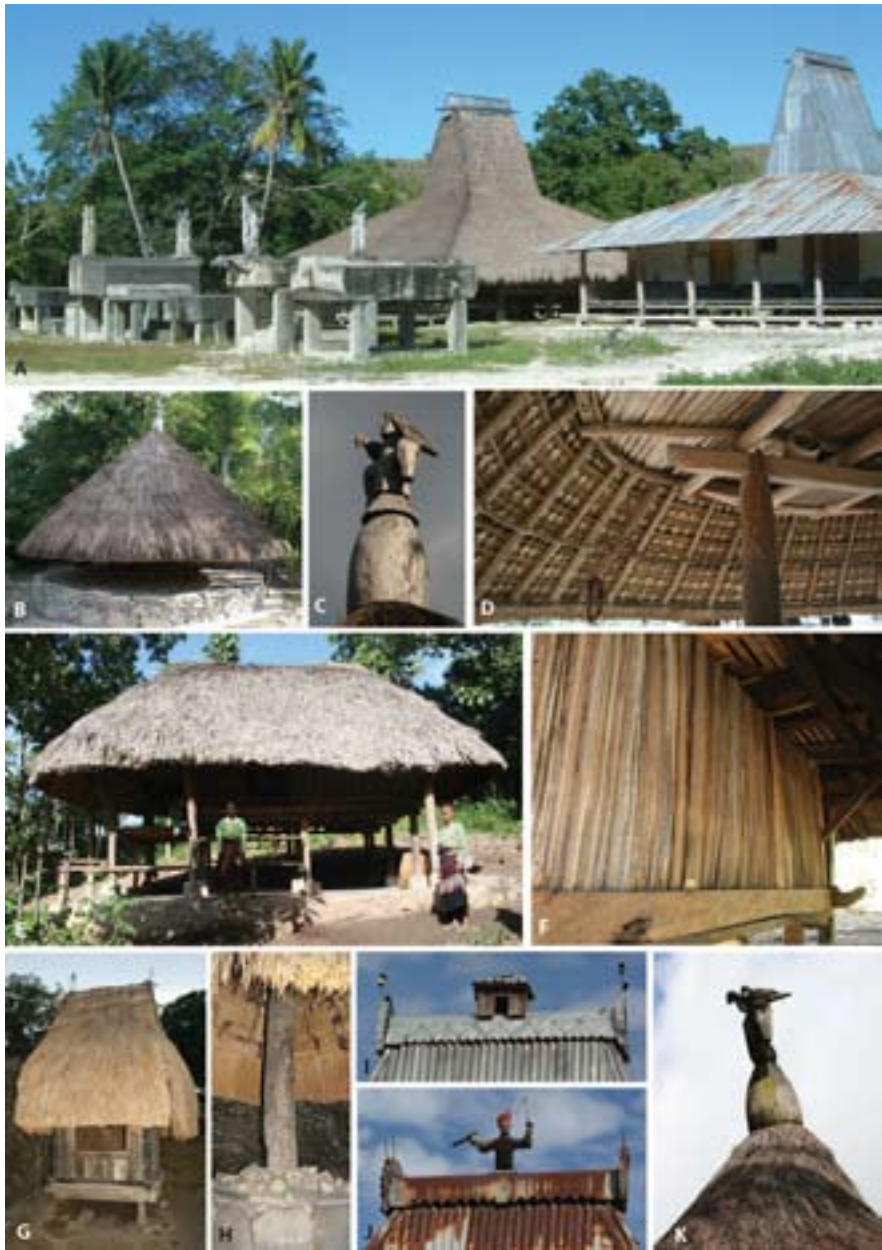
the practices, representations, expressions, knowledge, skills—as well as the instruments, objects, artefacts and cultural spaces associated therewith—that communities, groups and, in some cases, individuals recognize as part of their cultural heritage. This intangible cultural heritage, transmitted from generation to generation, is constantly recreated by communities and groups in response to their environment, their interaction with nature and their history, and provides them with a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity. For the purposes of this Convention, consideration will be given solely to such intangible cultural heritage as is compatible with existing international human rights instruments, as well as with the requirements of mutual respect among communities, groups and individuals, and of sustainable development.

Hardcore foresters may wonder what this has to do with a research report on NTFPs from forests and agroforestry systems. The fact is that it is through the region's living heritage that value is added to many natural resources to produce the textiles, basketry and carvings that are not only in daily use, but which also bring income through their sale in local, regional and international markets. As the UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage (2003) points out, living heritage 'is the mainspring of humanity's cultural diversity and its maintenance a guarantee for continuing creativity'.

In ENT, the region's biological diversity links with the people's diverse lifestyles, languages and cultural skills. This is clearly seen in the diversity of architectural styles (Figure 72), with their strong reliance on forest and agroforestry products, from thatch, to walls and doors to construction timber. It

is not the purpose of this report to describe traditional architecture in any detail—this has been covered elsewhere by Cunningham (1964), Fox (1993) and Keane (1995). The point is that the links between natural resources, cultural diversity and creativity are strong. Selection of tree species for construction or carving is not random or opportunistic. Choice of species depends on the type of product made, and few species have all the varied qualities required. Particular tree species, such as *Cassia fistula*, are considered ritually essential for centre posts of buildings (Figure 72G, H): a combination of termite resistance (due to wood chemistry) and the symbolic red colour of the wood. *Pterocarpus indicus* is more than just a commercially valuable timber. It is also an essential wood favoured for musical instruments such as *feku* whistles (Figure 73) or carvings on the roof apices of houses (Figure 72B, C). The choice of *Pterocarpus* is deliberate, due to its resinous wood that is incredibly stable, with a radial shrinkage of only 0.5% and tangential shrinkage of 2.5%, even if dried under full sun—conditions that would cause most timber to crack. Wood for carving masks needs to be light, smooth and splinterless—so *Alstonia scholaris* wood is ideal. Wood for carving drums, on the other hand, needs to be resonant to produce an excellent tone. Acoustic properties of wood are influenced by wood structure, including width and density of annual rings, tracheid length, microfibril angle and extent of microscopic crystals in the wood (Bucur 1995), leading to choice of a different range of tree species (Cunningham 2005).

There are two ongoing problems, however—one related to forest management and the other to management of cultural heritage. First, as forests disappear or particular tree or rattan populations are overexploited, so cultural traditions consequently erode away. Second, the 'mining' of finite cultural heritage, such as the heirloom textiles and ancestral carvings that have been acquired (or sometimes even stolen) for resale to meet an international demand for antiquities, means a loss of items of important cultural significance from their place of origin.



**Figure 72.** Architectural diversity, creativity and strong links to forest resources and the cosmos: (A) traditional houses in East Sumba, where four tree species are essential for the centre posts of the house; (B) thatched shelter with *Pterocarpus indicus* woodcarving at the apex; (C) detail of carving; (D) detail of inner roof, showing fine *Borassus* palm fibre work (all in Belu, West Timor); (E) *Corypha utan* thatch on ‘traditional’ house, Belu, West Timor; (F) detail of wall and timber supports, all of *C. utan*; (G) ritual house near Bajawa, with *Cassia fistula* support poles; (H) *C. fistula* support pole, ritual shelter, Bajawa; (I) change in materials but not in ritual links or creativity; (J) roof ridge figure bound in *Arenga pinnata* fibre rope, which has ritual significance, Bajawa area; (K) *P. indicus* carving of birds, Belu, West Timor





**Figure 73.** Forest and agroforestry products, cultural heritage and commercial opportunities: (A) an acoustic *sessando*, the traditional Rotinese musical instrument with a *Borassus (lontar)* leaf resonator, made by a small business in West Timor that also produces non-acoustic *sessando*, plus miniature *sessando* placed at wedding tables as a sign of Rotinese identity; (B) a *feku* whistle, carved from *Pterocarpus indicus (kayu merah)*—traditional musical instruments like these have a niche market to which value can be added through marketing of traditional music on CD

There is a better way, however: traditional skills can add value to fibre, wood, dye and mordant plants so that local people earn an income. This is what Threads of Life (2009) have been doing for many years. Under the right circumstances, art and craft production can link skills and encourage their transmission to younger people. At the same time, this can build self-esteem and confidence in product quality. In many ways, this link to natural resources and culture builds on people's strengths and not their weaknesses. Through this process, living cultural traditions become an important economic asset. The sheer size of the indigenous arts and crafts industry around the world indicates its role in income diversification and as an economic 'safety net' for those unable to find employment elsewhere because of

their lack of formal education. The Watublapi group outside Maumere on Flores is a good example, where rich cultural traditions and good organisation bring the group an income from tourism (such as cruise ships), performance of traditional dances, sale of a music CD and sale of traditional textiles.

## Basketry

### Palm basketry (*Borassus flabellifer* and *Corypha utan*)

In terms of innovation, quality and diversity, eastern Indonesian basketry can compete with any other part of the world (Figure 74). However, unlike the southwestern USA, which is a thriving centre for Pueblo and Navajo Indian baskets, or southern Africa, there



**Figure 74.** Creativity and culture—products produced and sold in East Nusa Tenggara that have wider market potential, showing betel-nut-related arts as an example: (A) sculptural woven cover (*Corypha utan*) for a carved bowl (*Alstonia scholaris*) used for rice and known as *ndabi uhu* (*uhu* = rice), East Sumba; (B) similar design, a *Corypha* basket (*ndabi wai*) over carved coconut shell container; (C) finely silversmithed container for lime—one of the many products for which Ndao is famous; (D) betel nut presentation basket (*oko mama*), West Timor; (E) basket with *Piper betle* (*sirih*) leaves (*oko tuke*), West Timor; (F) baskets for *sirih-pinang* (both *oko mama* and *oko tuke*) for sale at Oinlasi market, West Timor—some partly completed; (G) carving a bamboo lime container (*kal ao*), West Timor

is very little awareness of eastern Indonesian baskets. However, this is changing. During the course of this project, Threads of Life—the fair trade partners in this study—diversified from handwoven textiles and started marketing baskets. The rapid increase in sales of baskets from Flores, Lembata, Sumba and West Timor (Figure 75), and the increasing proportion of income from baskets as a proportion of total sales (Figure 76), are good indications of the export potential of high-quality baskets from ENT.

At the moment, however, most baskets are sold or bartered locally. Nevertheless, basket-making enables people across ENT to use local plant materials and basketry skills to earn a cash income without large financial outlay. Most basket-makers use palm fibre (from either *B. flabellifer* or *C. utan*) collected from agroforestry systems or sometimes bought in local marketplaces.

Income from baskets is usually low, but does compare to income from alternative employment available to craft workers. For most basket-makers, the money they earn is used to buy food, clothing and basic household goods such as salt or soap. On Flores, the tough stems of the fern *Lygodium circinnatum* (known locally as *nidho*) are collected and bought by traders who send the bundles to Bali, as local stocks of this species have been overexploited.

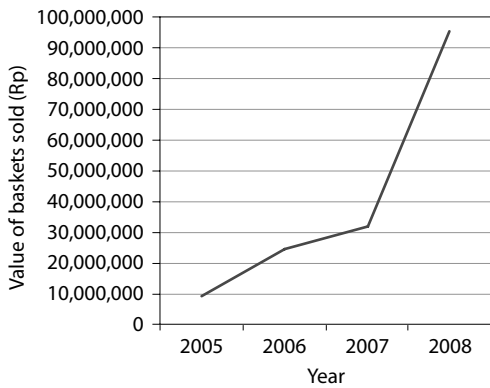
Basket-making and other crafts can help to keep the culture alive. Because these activities work

with local materials, techniques and designs, crafts can strengthen local cultural traditions rather than disrupt them. The presence of these material objects can help to maintain cultural skills, and to educate others about people’s lives. Collecting craft objects and displaying them in museums and galleries are aspects of the craft sector that help in this important education process.

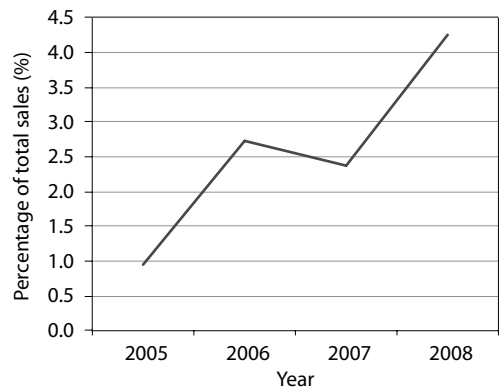
***Lygodium circinnatum***

*Lygodium* climbing ferns (Schizaeaceae) are a genus of about 40 species traditionally used for fish traps, mats and basketry (Mabberley 1997). The flexible stems of *L. circinnatum*, known as *ata* in Bali, are used to produce baskets that are sold to tourists on a large scale in Bali (Figure 77). The best quality *ata* baskets are made in Bali in the village of Tenganan, where weaving skills originally developed when this fern was woven into shields used in the ritual *Perang Padang* battles between men from Tenganan. Tenganan, an old traditional village, has been a popular tourist destination since the late 1970s.

In the 1970s, new designs using basket-making techniques were introduced to produce large urns and platters, placemats and coasters. At that time, there was not much competition from other villages in Bali, so Tenganan was the major production area for these baskets. Local basket craftsman Pak Kedap feels his market has enormously declined as there



**Figure 75.** Marketing of eastern Indonesian baskets by Threads of Life, showing that the baskets have potential to improve income to local women beyond higher volume, low-price sales in local marketplaces



**Figure 76.** Percentage of sales by Threads of Life (ToL), showing that diversifying into basketry (after focusing primarily on handwoven textiles until 2005) has increased income to more women in East Nusa Tenggara and increased the proportion that basketry sales represent in ToL’s turnover

is much more competition from small craftspeople who produce and sell their own *Lygodium* products on Bali. In 1999, many of the craftspeople making the baskets to be sold in Tenganan were from the tenant village of Gumung, 1 km up the mountain from Tenganan.

Today, most of the *Lygodium* products are made by craftspeople in the dry hills of east and west Seraya, a 1-hour drive from Tenganan, where the labour is cheaper. There are 50 dealers and over a 1,000 producers. Their biggest market is taking baskets to Tenganan. According to Pak Jadug, a middleman interviewed in Seraya, he was taking 100–150 pieces to Tenganan every day in 2003, but he was only selling

one-third of that number by 2008. For example, a Seraya craftsperson sells a handbag for Rp45,000 to a dealer like Pak Jadug. Pak Jadug makes about Rp10,000/handbag, selling on to a Tenganan dealer for Rp55,000. In Tenganan, it costs Rp5,000 Rp to smoke (probably a pest-control treatment) a single handbag. The handbags are then re-sold in Ubud, Denpasar or Nusa Dua.

*Market survey in Bali*

During this study, YPBB undertook a survey of *L. circinnatum* basket sellers in Ubud, Bali, during November and December 2008. Of the 43 *Lygodium* retail outlets selling in Ubud, 18% were interviewed



**Figure 77.** *Lygodium circinnatum*—a climbing fern with potential for enrichment planting: (A) Pak Kedap, from Tenganan (Bali), with a high-quality basket that sold for US\$200 in the late 1990s when the US\$1 was worth Rp2,500. This basket would be worth more than four times that amount today. However, the cheap handbags in the background have become his main source of income; (B) one of 43 retail outlets in Ubud, Bali, that sell *Lygodium* baskets and mats; (C) *L. circinnatum* in montane forest, Ende regency, Flores; (D) *Lygodium* is used locally on Flores, but in small quantities compared with the millions of stems used annually in Bali.

and assessed. Fifty per cent of these were market stallholders, 38% had open-fronted shops, and 13% had closed-fronted shops. Eighty-eight per cent of these were retailers and all bought their products directly from producers. The market stallholders had been in the business considerably longer (the mean start-up year was 1998) than the open-fronted shops (2002) and the closed-fronted shops (2004). Sixty-nine per cent of retailers rated the importance of *Lygodium* basket sales to their overall business as low or medium. Closed-fronted shops all reported the importance as low; opinion among open-fronted shopkeepers was evenly split between low, medium and high importance; and 38% of market stallholders said the importance was high or very high. When accounting for *Lygodium* baskets as a percentage of a shop's visible inventory, 63% were in the first three quintiles. For market stallholders, 38% were in the upper two quintiles. In open-fronted shops, inventory was evenly spread across the first, second and fourth quintiles. For closed-fronted shops, half were in the third and half in the fifth quintile.

Other than for the closed-fronted shops (of which only two were sampled), there is a close correlation between stated importance and observable inventory. We conclude that *Lygodium* baskets are relatively more important for smaller sellers. For all sellers, medium-sized baskets (length of 10–50 cm) represent the majority (40–80%) of inventory. In the overall inventory, up to 40% were decorated with black *Lygodium* rhizome bark. Size and decorative accents appear significant for determining saleability.

The market survey done by YPBB in 2008 on *Lygodium* baskets sold in the markets in Ubud indicates that the price today compared to 5 years ago is actually declining in many cases. The variety of basket types seems to have declined as well. Architectural or designer pieces are not found as they were 10 years ago. In 1998, Threads of Life worked with a client to fill a container for resale in the USA, and Tenganan baskets were a significant portion of the cargo. At that time, one could find large architectural basketry, but it is difficult to find such pieces today. It is unclear if this is the result of a change in market taste, or if other islands are producing comparable basketry from other resources for less money than the Tenganan baskets.

There is potential for getting better prices in new markets. One example is a designer on Bali who is working with weavers in Tenganan to produce large sculptural pieces that are exported to California, USA. Like other products sold by Threads of Life,

if the product is of high quality and has a 'story' that adds value to the product, it is highly likely that there is a market for it. Given that the traditional shield of Tenganan is not interesting as art, it may require working with designers to find interesting product designs. Baskets made from sustainably harvested *Lygodium* can be part of that story.

#### *Sustainable harvest and enhancing production*

One of the problems that producers in Bali are facing is the scarcity and rising cost of the raw materials. *Lygodium* grows in forests on Bali but not in large-enough quantities to meet the market demand. Much of the *Lygodium* today used by craftspeople in Tenganan comes from Flores, Java and Sulawesi. Ten years ago, in response to the decline of local *Lygodium* supplies on Bali, a study was undertaken by Astuti et al. (2001) that showed that craftspeople from Tenganan were using 72–270 million stems of *Lygodium* each year to meet their production needs. Due to limited local stocks in Bali, supplies of *Lygodium* stems were coming from as far away as Flores, Kalimantan and Sulawesi. This situation continues today and, during fieldwork for this project, it was apparent that one of the supply sources of *L. circinnatum* was forests in Ende regency, Flores.

We suggest that there is good potential for sustainable harvest of *L. circinnatum*, and Threads of Life and YPBB are currently working on a community-based forest management project in Ende regency that includes *L. circinnatum* resource management. An advantage in terms of resilience of harvest is that *Lygodium* species spread through windblown spores. Studies of *L. microphyllum*, an invasive fern species in Florida, USA, have shown that spores can be produced year round, with a single fertile leaflet producing up to 28,600 spores, each of which is potentially capable of starting a new population (Lott et al. 2003; Volin et al. 2004). Although spore reproductive success of *L. circinnatum* in its native habitat may differ, we suggest that *Lygodium* could potentially be harvested sustainably from forest areas, and has potential for enrichment planting in agroforestry systems. Given the reproductive output of *Lygodium*, it is amazing that stocks in Bali have been depleted, but this is probably due to four main factors: high commercial demand; uprooting of the mature climbing ferns in order to get the dark root base that is woven into *Lygodium* baskets for decorative purposes; lack of tenure over wild stocks in montane forests; and presence of insects that eat *Lygodium*.

## Textile dyes and mordants

Despite the availability of synthetic dyes and significant religious, social and economic change, textile weavers in more remote areas of Indonesia continue naturally dyed textile production as a living tradition. Within ENT, where much of our fieldwork was conducted, 130,000 women (10.2% of those aged 15–70 years) and 45.8% of all villages continue to practice weaving arts (Anon. 2004). In recent years, the global market for Indonesian traditional textiles using natural dyes has grown considerably. The market was worth at least A\$1,485,000 in 2008 for the Lesser Sunda Islands. Over the past 6 years, Threads of Life, one of the main dealers of contemporary traditional naturally dyed textiles from the region, has increased purchases from weavers 10-fold—an annualised increase of 67% (Figure 78).

Traditional textile dye processes demonstrate local people's sophisticated knowledge of natural-product chemistry. Every traditional textile is the result of this local knowledge, combined with the skills required for tying, mordanting and dyeing cotton before weaving. Plants used for dyes and tannins have been relatively well documented in South-East Asia (Lemmens and Wulijarni-Soetjipto 1992; Burkill 2002), but, until recently (Cunningham et al., in press), mordant plants had been neglected in ethnobotanical research. To

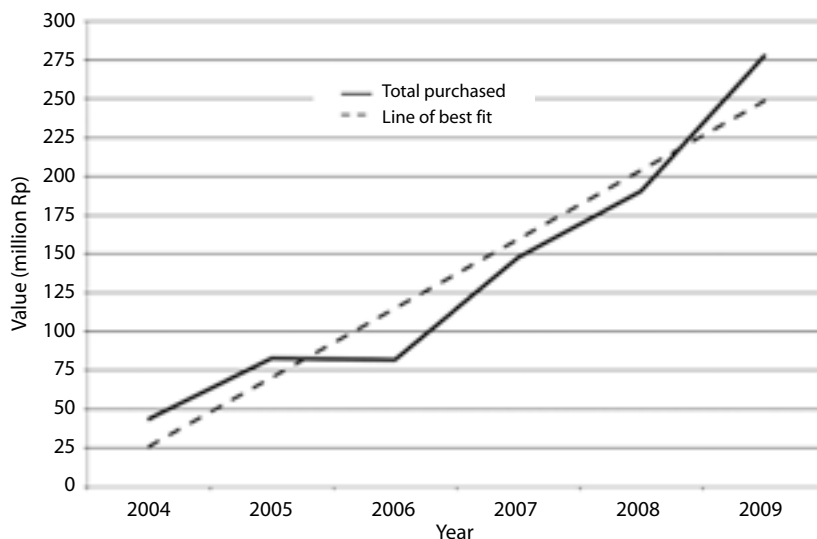
produce a single naturally dyed textile can take a year. This is due to seasonal differences in the wet-season availability of indigo (from *Indigofera suffruticosa* and *I. tinctoria*), while the red dye processes are done during the dry season when moisture levels in *Morinda citrifolia* root-bark are low and, presumably, anthraquinone levels are high.

A premium is paid for naturally dyed textiles, such that returns to labour can be 370% higher than using synthetic dyes. This section focuses on two tree genera, both crucial to the production of textiles that have red-dyed threads. The first are trees in the genus *Symplocos*, which are the source of a mordant essential to fix the red colour. The second genus, *Morinda*, is the source of the red dye.

Continued supplies of both genera are required to sustain handwoven, naturally dyed textile production. In the sections that follow, we review the situation and steps that have been taken, and suggest those that need to be implemented in the future.

### *Symplocos*

Centuries before the development of modern analytical chemistry, textile dyers in South and South-East Asia were selecting plants that hyperaccumulate aluminium (Al) for use as mordants (substances used to fix dyes). Aluminium hyperaccumulation is now known to be a primitive trait limited to particular



**Figure 78.** The value of textile purchases from weavers in East Nusa Tenggara by Threads of Life, 2004–09

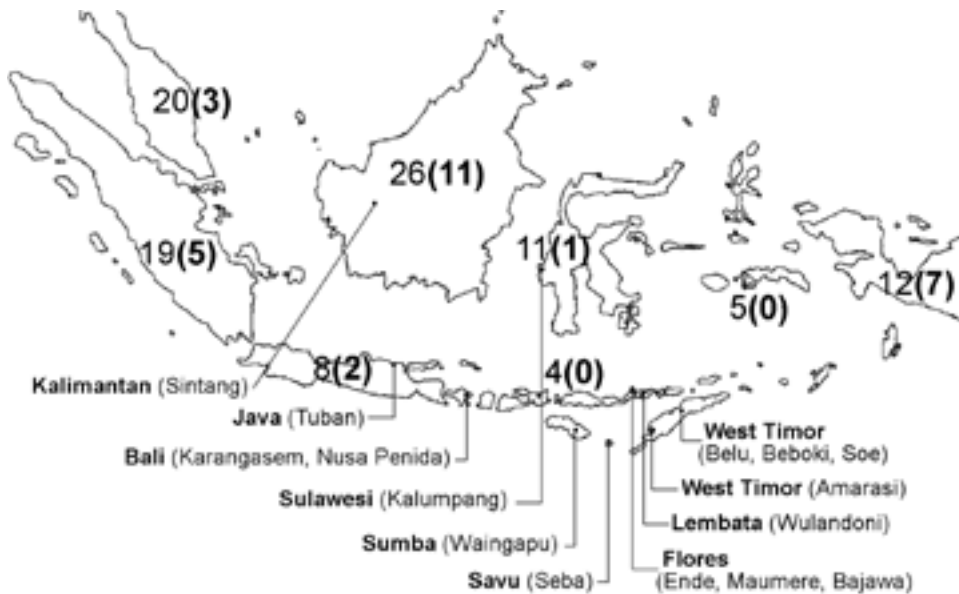
plant families, genera and species (Jansen et al. 2002, 2004). Over 260 years ago, Rumphius (1743) recorded local ethnobotanical knowledge of what he termed the ‘alum tree’ (*aluy boom* or *arbor aluminosa*, later identified as *Symplocos*) used by Indonesian textile producers. This drew the attention of European scientists to Al-hyperaccumulation in plants for the first time. Despite early Dutch studies in Ambon (Rumphius 1743), and more recent extensive academic work on Indonesian textiles (Maxwell 1990; Hamilton 1994), plants used as mordants in Indonesia have not been thoroughly documented. A wide variety of *Symplocos* species are present across Indonesia (Figure 79).

The leaf or bark matter from *Symplocos* trees (Symplocaceae) is critical to the mordant process that prepares cotton threads for a complex red dye made using the roots of species of the genus *Morinda* (Rubiaceae) (see below). At the moment, an estimated 15,000 weavers rely on a supply of dye materials from the forest of the Lesser Sunda Islands. The network of weavers with whom Threads of Life works, known as the Nusantara Weavers’ Network, uses an estimated 930 kg of *Symplocos* leaves per year.

Over the past decade, however, supplies of *Symplocos* have dramatically declined. There are two

main reasons for this. First, there has been extensive clearing of montane forests in ENT (Figure 80), some of which have provided supplies of *Symplocos* and products such as *Canarium* kernels and rattan for centuries. Second, although dead *Symplocos* leaves (Figure 81) are high in the Al compounds valued as mordants, and can be collected in a completely sustainable way, commercial harvesters, particularly on Sumba, commonly debark *Symplocos* trees as well, wrapping the bark around the leaves (Figure 81A) as a form of ‘guarantee branding’ for the real *Symplocos (loba)*, rather than using an inferior substitute material. Unfortunately, taking the bark usually kills the tree.

Over the past 5 years, the market price of *Symplocos* leaves has risen 335%. This brings the long-term future of natural-dye weaving into serious doubt. In contrast to industrial dye processes, where synthetic metallic salts of chromium, aluminum, tin, copper and iron are the main mordants, traditional dye processes depend on Al-mordants from plants or, in mud-cloth, metallic salts of iron. It is no surprise that use of Al-hyperaccumulating plants as mordants is widespread in Indonesia. First, plants in the Symplocaceae have the highest recorded Al levels. Second, mud dyes produce duller colors than



**Figure 79.** Map of Indonesia showing study sites and the number of species of the major mordant plant genus, *Symplocos*, in each island or island group, with the number of endemic species shown in brackets (modified from Nootenboom (1975) in Cunningham et al., in press)



**Figure 80.** Habitat loss, mainly due to clearing for agriculture and the establishment of coffee and *Aleurites moluccana* production, has decimated the montane forests over 700 m above sea level on Flores, where *Symplocos* is found



**Figure 81.** Uses of *Symplocos* species: (A) bundles of *S. cochinchinensis* leaves enwrapped in bark for sale in Waingapu market, Sumba; (B) *Symplocos* fruits; (C) powdered *Symplocos* leaves for sale to textile weavers (Ende market, Flores); (D) dead *Symplocos* leaves: a completely sustainable harvest; (E) surplus dead leaves harvested for an export trial to the international natural-dye market



Al mordants. Third, mordanting cotton threads in mud in any quantity requires dyers to take the cotton threads away from the household to an area with iron-rich muddy swamps, where they need to be left for two nights. Mordanting at home using *Symplocos* rather than mud is more convenient and secure, and avoids the ritual potency of swamps. A final reason for using Al mordants may be because, as Kajitani (1979) points out, iron-mordanted cotton threads start to break down and are weakened due to the catalytic effect of iron oxidation.

In theory, cultivation could meet local needs for *Symplocos* leaves. Cultivated *Symplocos* leaves certainly have the same mordant properties as those from wild populations. However, cultivating *Symplocos* has proven to be problematic. Preliminary research has achieved only 5% establishment. In order to have feasible, sustainable cultivation of *Symplocos*, a propagation method is needed with a higher success rate. Over the past 4 years, the high value of dried fallen *Symplocos* leaves that are crushed and packaged for sale (Figure 81E) has provided an entry point for our work with a local community in Ende regency. We are undertaking a community-based

forest conservation initiative in the largest—and one of the last—remaining forests on Flores. The fact that this forest is rich in *S. cochinchinensis* and other useful plants is providing a key incentive for community forest management (YPBB 2008) (Figure 82). This initiative is making good progress, with a good chance of support under Indonesia's forest decentralisation policy.

### *Morinda*

*Morinda citrifolia* root-bark, as well as bark from possibly a range of chemotypes considered distinctive under local folk taxonomy (which may be other *Morinda* species), is used in much larger quantity than *Symplocos* leaves (Table 12). Across the Nusantara Weavers' Network, an estimated 268 t are required per year. Unlike *Symplocos* trees, *M. citrifolia* (and possibly other *Morinda* species) is widely cultivated in local agroforestry systems in ENT (Figure 83) and through the Asia-Pacific region. Depending on the dyer's preference, a single textile may need to be dyed up to 20 times before the required colour is achieved. We estimate that this can take up to 120 kg of roots per textile.



**Figure 82.** Participatory planning has been a key to developing management plans for *Symplocos* and other non-timber resources in the largest patch of montane forest in Ende regency: an island in a sea of rural farmland, coffee and *Aleurites moluccana* production

In 2009, a survey of perceptions of *Morinda* (*mengkudu*) availability among 196 natural-dye weavers from 11 *kelompok* (weavers' cooperatives) across the Lesser Sunda Islands revealed a growing problem with the supply of *Morinda* roots for the red dye process. When asked, 'How do I view my supply of *Morinda* roots at the moment?' on a scale of 1 to 5,

where 1 was 'There is much more than I need' and 5 was 'There is much less than I need', the average answer was 3.26, between 'There is enough' and 'There is a shortage'. For 67% of respondents and 80% of cooperatives (where more than half of a cooperative's members held the same opinion), *Morinda* supplies were said to have changed over the year before the

**Table 12.** Estimated quantities of *Symplocos* and *Morinda* used by four weavers' cooperatives (*kelompok*) producing high-quality, handwoven, naturally dyed textiles on Flores, extrapolated to the quantities required by the whole Nusantara Weavers' Network

Cooperative	Location	<i>Symplocos</i> (kg/year)	<i>Morinda</i> (kg/year)	No. of members
Kelompok Bou Sama Sama	Ende	77.8	5,795.0	23
Sanggar Bliran Sina	Maumere	12.0	16,800.0	50
Ebi Rie	Bajawa	5.6	560.0	13
Kelompok Kapo Kale	Ende	2.9	5,184.0	10
Total		98.3	28,339.0	96
Nusantara Weavers' Network	Estimate	930.8	268,334.9	909



**Figure 83.** *Morinda* production and use: (A) a large *Morinda* tree in an agroforestry system in West Timor; (B) methods of root harvest vary from place to place—in some places, fine roots are preferred, in others, the main root system is taken; (C) unless a drying process is developed similar to that used in India, fresh root-bark has to be used

survey. More than half the members of three cooperatives felt that their supplies had improved, while three others felt they had declined, showing the regional nature of this problem. The principal cause for supply decline was cited as overharvesting to meet increasing demand for textiles.

Addressing this issue requires cultivation of *Morinda* in weaving communities using non-natural dyes, where a lack of alternative opportunities still makes *Morinda* root harvesting attractive. A reliable *Morinda* root-bark drying method will also be needed, as most users currently use fresh root-bark. Research into this is currently underway.

## Horticultural plants

Through many parts of Indonesia, people are keen gardeners. As a result, informal-sector nurseries thrive next to highways of major cities or on the outskirts of small towns. Plants that have spectacular flowers (such as *Adenia*) are popular, with the added advantage that these shrubs are able to withstand tough conditions. Among the diversity of plants sold—most of which are grown from cuttings or seed—one species stands out: *Pemphis acidula* (*santigi*).

### *Pemphis acidula*

*Pemphis acidula* (Lythraceae), known as *sentigi* (Javanese) and more widely as *santigi*, is a coastal tree that is widespread across the Indo-Pacific region. In Bali and Java, the wood of *P. acidula* is believed

to have magical properties and is much prized. This has led to destruction of many trees in ENT (Figure 84A), including trees on Raijua (an island off Savu) that under local customary law (*adat*) was strictly protected, in the belief that it kept the island afloat. This area needs to be protected as a valuable genetic resource and out of respect for local customary law.

*Pemphis acidula* is also internationally and locally valued as an excellent tree for bonsai. In Kupang, wild-harvested trees can sell for Rp30 million (Figure 84B). What is needed is stricter control over remaining populations. This could be achieved through community-based conservation. Innovative mechanisms for buying seedlings or viable seed through, and support for, a growers' association may be a useful way to improve on the current situation.



**Figure 84.** The need to conserve wild habitat and seed stocks: (A) a small *Pemphis acidula* (*santigi*) forest formerly strictly protected under local law that has been chopped down by outsiders in order to get the valuable wood; (B) a wild-harvested *P. acidula* for sale at the Kupang show in 2008—pruned into a bonsai form, the asking price is Rp30 million (c. US\$3,300)

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