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Trade in Palm Products in North-Western South America

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Abstract More than 200 scientific publications and Internet sources dealing with trade in palm products in north-western South America are reviewed. We focus on value chains, trade volumes, prices, and recent developments for some of the most important raw materials derived from native palms. Trade in palm products takes place at local, regional, national, and international levels. For local communities and individual households palm products may play a key role as the most important or only source of cash income. Most of these palm products are inadequately or not at all captured in trade statistics at the local and regional economic levels. Only products such as vegetable ivory and palm heart are monitored statistically, mainly because they are exported. Most raw materials derived from palms are extracted from the wild, and mainly by destructive harvesting. Reduced availability and rising prices on local and regional markets reflect incipient resource depletion. Only in vegetable ivory more or less sustainable wild harvesting methods prevail. Palm heart is increasingly being harvested from orchards and non-sustainable exploitation of wild populations is loosing ground. The international market for native palm oils and pulp (esp. *Euterpe oleracea* or *açaí*) is currently served almost exclusively from Brazil. Due to low oil contents and high production costs palm oils are currently used mainly for cosmetics. Based on their content of protein, starch, tocols, and carotenoids palm fruits have high nutritional value and represent a considerable potential for the development of functional foods, food supplements and animal fodder. Palms could undoubtedly play a more important role in the socio-economic development of north-western South America. Sustainability and marketing potential of palm products are negatively affected by the low income obtained by primary producers which often represents no more than 0.01–3% of the retail value. Poor governance, insecurity of land tenure and unequal sharing of profits endanger a sustainable long-term development of these valuable resources.

Resumen Se revisan más de 200 publicaciones científicas y fuentes en Internet relacionadas con el comercio de productos de palmas en el noroeste de América del Sur. Nos enfocamos en las cadenas de valor, los volúmenes del comercio, los precios y el desarrollo reciente de algunas de las materias primas más importantes derivadas de las palmas. El comercio de productos de palmas se lleva a cabo a nivel local, regional, nacional e internacional. Para las comunidades locales y las familias individuales los productos de las palmas pueden desempeñar un papel clave como la fuente más importante o única de ingreso de dinero en efectivo, y esta importancia no se refleja adecuadamente en estadisticas oficiales. Los productos de las palmas se registran inadecuadamente en las estadísticas del comercio a nivel económico local y regional. Solamente los productos de palmas como el marfil vegetal y el meollo de palma son las que se monitorean estadísticamente debido principalmente a que son de exportación. La mayoría de las materias primas derivadas de las palmas se extraen de la naturaleza, principalmente por cosecha destructiva. La menor disponibilidad y el aumento de los precios en los mercados locales y regionales reflejan el agotamiento incipiente de los recursos. En el marfil vegetal prevalecen en mayor o menor medida técnicas de cosecha sostenible. Cada vez con mayor frecuencia el palmito se está cosechando de los huertos y la explotación no-sostenible de las poblaciones silvestres está perdiendo terreno. En la actualidad, el mercado internacional del aceite de palma nativa y la pulpa (especialmente *Euterpe oleracea* u *açaí*) está surtido casi exclusivamente por Brasil. Debido al contenido bajo de aceite y a los altos costos de producción, actualmente los aceites de palma se utilizan principalmente para cosméticos. Los frutos de las palmas tienen un alto valor nutricional (proteínas, almidón, tocols, carotenoides) y tienen un gran potencial para el desarrollo de alimentos funcionales, complementos alimenticios así como forraje para animales. Las palmas podrían desempeñar indudablemente un papel más importante en el desarrollo socio-económico del noroeste de América del Sur. La sostenibilidad y la comercialización potencial de los productos de las palmas son afectadas negativamente por los bajos ingresos obtenidos por los productores primarios de las materias primas (tipicamente 0.01 a 3% del precio de venta). La deficiente gestión gubernamental, la inseguridad de la tenencia de la tierra y la distribución desigual de los beneficios ponen en peligro el desarrollo sostentable a largo plazo de estos recursos valiosos.

Keywords Arecaceae · Value Chains · Vegetable Ivory · Palm Oil · Palm Heart

Palabras claves Arecaceae · Cadenas de Aumento de Precios · Marfil Vegetal · Aceite de Palmas · Palmito

Introduction

Conservation through use or through trade has been proposed as a key mechanism to provide incentives for the conservation of species and habitats by turning them into sources of income (Peters et al., 1989; Wild & Mutebi, 1996). Sustainable harvest and trade of Brazil nuts and rubber are examples of this. Reconciliation between conservation and rural development can also be achieved via trade of genetic resources under access-and-benefit sharing agreements ensuring back-flow of cash generated by the trade. The most direct approach to conservation through use is sustainable trade of natural resources such as medicinal and aromatic plants (MAPs), wild fruit and fibres. Palms provide both timber and a wide range of non-timber forest products (NTFPs). Many useful palm species occur in large, dense stands and have large regenerative potential. In this way they constitute ecologically and economically important natural resources that can be traded and may improve the livelihoods for rural populations.

Palms provide many useful products and literally thousands of individual palm uses have been reported in the scientific literature (see Balslev & Barfod, 1987; Bates, 1988; Balick & Beck 1990; Bernal, 1992; Henderson, 1995; Moraes-R. et al., 1995; Johnson & the IUCN/SSC Palm Specialist Group, 1996; Borchsenius et al., 1998; Macía, 2004; De la Torre et al., 2008; Soler-Alarcón & Luna-Peixoto, 2008; Galeano & Bernal, 2010; Macía et al., in press; see also Table 1). These uses vary greatly in overall economic importance and trade levels. Most species and many raw materials are used locally by ethnic groups and bartered outside the cash economy, if traded at all. Other products are traded on a minor scale locally or regionally, or on a wider, national scale. The most common use categories of traded palm products are food (fruit, palm heart, vegetable oil; see Fig. 1), construction material (timber, thatch; see Fig. 2), raw material for handicrafts (mainly fibres and seeds; see Fig. 3) and medicine (Borchsenius & Moraes-R., 2006; Sosnowska & Balslev, 2009).

A thorough understanding of value chains for palm products is crucial for the development of current and future markets. There is much literature on palm use in tropical America that provides insights into the socio-economic impact of palm products. Non-timber forest products, including many palm products, are accepted as important sources of income for rural dwellers, but quantitative information on the role that NTFPs play in local economies is virtually non-existent (Padoch, 1987; Pinedo-Vasquez et al., 1990). There are few studies on current trade volumes, the economic potential and the value chains.

The aim of this review is to provide an insight into the volume of palm trade in north-western South America, encompassing Colombia, Ecuador, Peru and Bolivia, and to assess its impact at different economic levels. We also wish to clarify how far current extraction of palm resources agrees with, or is amenable to the "conservation through use" principle. We will concentrate on the commercially most important and most intensively exploited native palms across the major use categories in Bolivia, Ecuador, Peru and Colombia. These are *Iriartea deltoidea* (timber), *Astrocaryum* spp. (fibre, fruit), *Euterpe* spp. (palm hearts, fruit; Fig. 1g–i), *Mauritia flexuosa* (fruit, oil; Fig. 1a, b), *Oenocarpus bataua* (fruit, oil; Fig. 3g), *Lepidocaryum tenue* (thatch; Fig. 2a, c, d, f–h), *Ceroxylon* spp. (religious ornaments), and *Phytelephas* spp. (vegetable ivory). Table 1 summarizes the most important species and uses of South American palms as treated in this review.

Table 1 Focus Species and their Primary Uses *as Treated in this Review*

Species	Primary use(-s)	Secondary uses	Trade level
Iriartea deltoidea (also *Socratea exorrhiza*)	timber (construction, furniture)	fruit (food, beverage & fodder), leaves (thatch), seed (handicraft)	local, regional, international
Astrocaryum chambira, A. malybo, A. standleyanum, A. murumuru, A. jauari	leaf fibre (handicraft)	fruit (oil, food, beverage & fodder), press cake (fodder)	local, regional, international
Mauritia flexuosa	fruit (food, beverage, oil)	fibre & seed (handicraft), timber (construction)	local, regional
Oenocarpus bataua	fruit (food, beverage, oil)	rhachis (construction, handicraft)	local, regional, international
Lepidocaryum tenue	leaves (thatch)	–	local, regional
Euterpe precatoria, E. oleracea	palm heart (food)	fruit (food, beverage), seed (handicraft)	local, regional, international
Ceroxylon spp.	leaves (ceremonial)	timber (construction)	local, regional
Phytelephas aequatorialis, *P. tenuicaulis, P. macrocarpa*	seed (handicraft)	leaves (thatch), fruit (food, beverage, fodder)	regional, international
Bactris gasipaes	palm heart & fruit (food, beverage)	–	local, regional

Fig. 1 Food from palms. **a**-**c** *Mauritia flexuosa*. **a**, habit (Iquitos region, Peru). **b**, sale of *aguaje* fruits at a fruit market in Lima (Peru). **c**, stem wound. **d**, *suri*, the edible larva of *Rhynchophorus palmarum*. **e**-**i**, *Euterpe* spp. products. **e**, preparation of *pepiado* near Isquandé (Colombia). **f**, *açaí* soft drink (Iquitos, Peru). **g**-**i**, *palmito*. **g**, worker collecting *palmito* (Colombia). **h**, river mole as *palmito* collecting point (Colombia). **i**, canned *palmito* in a Peruvian shop. (photographs: a—i, G. Brokamp; except e, g, h, N. Valderrama)

Materials and Methods

We reviewed more than 200 publications on tropical American palm uses and trade, and searched relevant websites (see literature list). Internet sites are the only up-to-

Fig. 2 Use of palm products in construction. **a**, *Lepidocaryum tenue* leaf piles (*cargas*) for *crisneja* production. **b**, *Socratea exorrhiza* stem splits (*ripas*) for *crisneja* production. **c**, *crisneja* plaiting. **d**, stockpiled *crisnejas*, sales unit *el ciento* (100). **e**, roof ridge made of fronds of *Attalea* spp. **f**, *crisneja* transport from producing community to Iquitos (Peru). **g**, shop for construction materials selling *crisnejas* in Iquitos. **h**, palm roof in an indigenous community near Iquitos. **i**, palm roof made from *Geonoma deversa* leaves, Parque Nacional de Carrasco (Ecuador). (photographs: **a**—**f**, G. Brokamp; **g**—**i**, M. Mittelbach)

date sources on many currently traded palm products and their prices and were therefore extensively consulted, in spite of their ephemeral nature and consequent disadvantages as sources. Special attention was paid to trade with palm products in

Fig. 3 Handicraft, pharmaceutical and cosmetical preparation from palms. **a**-**f**, handicraft. **a**, *Astrocaryum chambira* fibre extracted from young leaf shoot. **b**, freshly dyed fibre. **c**, cord of twisted fibre. **d**, bracelets made with *chambira* fiber, *Phytelephas* spp. endosperm or *Euterpe* spp. seeds. (Peru). **e**, vase woven from *Astrocaryum standleyanum* fibre (Colombia). **f**, mats made from *A. standleyanum*. **g**—**i**, cosmetics. **g**, *Oenocarpus bataua* mesocarp oil (*aceite de majo*, Bolivia) as hair tonic. **h**, *Attalea speciosa* (*cusi*) and *Acrocomia aculeata* (*motacú*) oils as hair tonic. **i**, soap produced from *Attalea speciosa* oil. (photographs: **a**—**i**, G. Brokamp; except **c**, **e**, **f**, N. Valderrama)

Bolivia, Colombia, Ecuador, and Peru. The referenced information was organized into a number of Excel®-spreadsheets. A core spreadsheet contained all product and species-specific information. Quantitative data were converted into the metric system. Values and prices were calculated in US$ (exchange rate as of November 2010). Scientific palm species names follow Govaerts & Dransfield (2005).

Results

Palm Timber

Many tropical American palms have woody stems with hard and durable timber that is used for floors, walls, roof beams, boards, furniture, fishing and hunting tools, fruit boxes, and fence posts (Fig. 2b, c, g–i).

Iriartea deltoidea, probably the most important palm species for timber in northwestern South America, is common throughout our study area (Henderson, 1995). It is mostly old palm trees that are cut since the quality of the timber increases with age, due to increasing amounts of sclerified tissues (Borgtoft Pedersen & Skov, 2001). *Iriartea* timber is extremely hard, durable and heavy, and mainly used for flooring and walls, and to a lesser extent for (fence) posts, roof beams and furniture (Borchsenius et al., 1998; Borgtoft Pedersen & Skov, 2001; Moraes-R., 2004; Balslev et al., 2008). It is also used to make tools for cultivation, hunting and fishing, banana props and fruit boxes (Barfod & Balslev 1988; Barfod & Kvist 1996; Anderson, 2004). *Iriartea* timber is increasingly used for handicrafts and furniture (Anderson, 1998) and is sold on local and national markets in Colombia (Galeano & Bernal, 1987) and exported to the United States, especially from Ecuador and Colombia.

In Ecuador a 10 m stem of *Iriartea* sold for 10 US$ in 1996 (Anderson & Putz, 2002; Anderson, 2004). A skilled worker is able to harvest 20 stems per day, so palm timber harvest represents a good daily income, compared to the average daily pay for unskilled labour, which is less than 10 US$ (Anderson, 2004). Little is known about retail prices of *Iriartea* timber and furniture in South America, but in the United States *Iriartea*-products are quite expensive. An office desk sells for ca. 1,000 US$ and kegs for 18 US$ each (Anderson & Putz, 2002). The price for raw materials makes up only 2–3% of the price of the finished product. Even when costs of transport, labour and additional materials are taken into consideration, the retail price is high. The primary producer receives only a modest share of the profits generated and the raw material trade is strongly influenced by local limitations in infrastructure. In Ecuador *Iriartea* has been depleted in several areas, not least since it requires an estimated 100 years to reach harvestable size and also because regeneration is poor in pastures and fallows, where it is typically harvested (Wollenberg & Inglés, 1998). Efficient policies for sustainable harvest and reforestation are not in place and the perspectives of *Iriartea* as a source of income for local and regional economies are bleak. A "fair trade" arrangement, by which the primary producers are guaranteed an adequate proportion of the final price, could accelerate the process of depletion. A maintenance and possible development of the national and international markets for *Iriartea* timber requires explicit and rigid harvest and reforestation strategies, based on reliable sustainability studies.

Ceroxylon timber is used for construction in Colombia (Albán et al., 2008; Galeano & Bernal, 2010), but is not yet subject of large-scale export even if it is highly appreciated regionally. The trade with *Ceroxylon* timber is becoming highly lucrative because over-exploitation is leading to rising prices. Where natural stands are almost depleted, a cultivated palm stem fetches up to 50 US$, as compared to 10 US$/stem in areas where natural populations are still abundant (Pintaud & Anthelme, 2008). In Colombia, the stems of *Ceroxylon quindiuense* were formerly exploited as an important source of wax, however, this practice is now rare (Madriñan & Schultes, 1995) and we have no information about trade volumes or prices for this activity.

Palm Thatch

All over tropical South America rural houses are thatched with palm leaves (Fig. 2) from *Euterpe precatoria, Geonoma deversa*, *G. orbignyana*, *G. macrostachys, Iriartea deltoidea*, *Oenocarpus bataua*, *Phytelephas macrocarpa, Attalea butyracea* and many more (Balslev & Barfod, 1987; Henderson, 1995; Borchsenius et al., 1998; Flores & Ashton, 2000; Moraes-R., 2004; Borchsenius & Moraes-R., 2006).

Lepidocaryum tenue (*irapay*) is probably the most important species used for palm thatch. It is a small, rhizomatous, clonal palm occurring in lowland forest on *terra firme*, or on periodically inundated flood plains (Henderson, 1995; Scariot, 2001). *Irapay* is of particular importance in the greater Iquitos region of Peru, where tens of thousands of houses are thatched with its leaves. Although *irapay* leaves for thatching are of moderate economic importance overall, they constitute the highest ranking NTFP in many communities in terms of percentage of total households marketing (31%) and contribute considerably to the local economy, sometimes representing the most important source of cash income (Pyhälä et al., 2006). Locally, it may be the *only* NTFP contributing to household cash incomes (Mejía, 1992). Due to its clonal reproduction it may occur at high densities and may even dominate terrace palm communities (Vormisto et al., 2004; Balslev et al., 2010). *Irapay* has distinct local and regional markets, but does not reach national and international markets. Shingles consisting of a slat with leaves attached to it are used thoughout the Amazon and are referred to as *crisnejas* (Fig. 2a–c; Mejía, 1983, 1988, 1992; Mejía & Kahn, 1996). Overall figures for the trade in *crisnejas* and its regional economic impact are not available so far, but it is evident that the local and regional socio-economic importance of *crisnejas* far surpasses its importance at a national level. For the roof of a 35 m^2 house 20,800 leaves are required. In Peru, *crisnejas* are produced for local trade and sold at ca. 26 US$/*el ciento* (100 *crisnejas*; Fig. 2d) or it is transported to major towns (Fig. 2f), e.g., Iquitos and sold for ca. 45 US$/*el ciento* (prices for *crisnejas* with a length of 3 m with 40–60 leaves each, Brokamp et al., 2010; 20 US$ for *crisnejas* of 2.2–2.5 m, Mejía & Kahn, 1996; see also Kahn & Mejía, 1987; Mejía, 1992; Fig. 2g). A detailed study by Warren (2008) reported slightly different figures: Primary producers in the Iquitos region manufactured an average of 20–30 *crisnejas* per day and used 90–130 leaves for each *crisneja*. They earned 9–70 US$/*el ciento* (= 1.80–21.00 US$ per day). Vendors in Iquitos sold an average of 2,955 *crisnejas*/month with a profit range of 5–32 US$/*el ciento* and the consumers paid 23–120 US$/*el ciento*. In December 2009, primary producers of the Iquitos region used only approximately half the number of leaves per 3 m-*crisneja* (40–60) for the *crisnejas* sold, but still used over 100 leaves on *crisnejas* for their own houses (Brokamp, personal observation). The number of leaves used per (commercialized) *crisneja* (of 3 m in length) dropped from an average of ca. 100 (Warren, 2008) to an average of 50 (Brokamp et al., 2010). With our limited data it is unclear if the lower number represents a drop in the quality of commercialized *irapay*-thatch in the last years in the Iquitos region. If there is a reduction in quality, this may be indicative of incipient resource depletion or go back to other market forces.

The harvest impact of *Lepidocaryum* leaves is considerable. Individual plants produce on average less than two new leaves/a, of which only one can be harvested without damaging the plant (Navarro, 2009; Navarro et al., 2011). Both sexual and clonal reproductive potentials of *irapay* are low, but population growth rates are greater than or not significantly different from 1.0, indicating populations maintained or increased in size in spite of the intensive harvest (Warren, 2008). Current levels of *irapay* harvest appear sustainable, but more detailed long-term studies would be required to test this assumption (Warren, 2008). The mid-term prospects for trade with this resource thus clearly depend strongly on the establishment and maintenance of sustainable harvest strategies.

Palm Leaves Used for Ceremonial Purposes

The yellow spear leaves or young unfolding leaves of several *Ceroxylon* species are harvested to produce traditional, religious ornaments for processions on Palm Sunday (Borchsenius et al., 1998; Moraes-R., 2004; Pintaud & Anthelme, 2008; Galeano & Bernal, 2010; Montúfar, 2010). Harvest, processing and sale of *Ceroxylon* leaves is an attractive, albeit highly seasonal, business. Individual leaves fetch ca. 0.5 US$ in the field and 24 US$ when processed into ornaments (Montúfar, 2010). Detailed data on the value chains or the extent of the trade in *Ceroxylon* leaves are not available.

Palm Fibre

Numerous palms provide strong and durable fibres that are used for many purposes such as fishing nets, brooms and brushes, hammocks, carpets, bags and baskets, jewelry cases, adornments, and hats (Fig. 3c–f). Fibre producing palms include *Leopoldinia piassaba, Aphandra natalia, Attalea colenda*, *Mauritia flexuosa* and several species of *Astrocaryum* (Balslev & Barfod, 1987; Henderson, 1995; Borchsenius et al., 1998; Kronborg et al., 2008; Guel & Penn, 2009; Isaza-A. et al., 2010). Historically, fibres of *Leopoldinia piassaba* were traded to Europe and were the economically most important source of palm fibres (Spruce, 1860). Nowadays, *Leopoldinia* fibres are of local importance only (Putz, 1979; Bernal, 1992; Lescure et al., 1992). In Europe palm fibres have been replaced by either plastic or, to a smaller extent, other natural fibres from annual crops such as hemp, linen and millet. The international trade in handicrafts, which includes mats and baskets made from palm fibres, exceeds 1 billion US$/a (www.intracen.org, accessed 20.11.2010). However, the product categories are rarely broken down and up-to-date export figures for palm-based handicrafts are not available for any of the countries in our study region.

Astrocaryum chambira is common and produces leaf fibres used in handicraft production in Amazonian Peru, Colombia and Ecuador (Borgtoft Pedersen, 1994; Holm Jensen & Balslev, 1995; Borgtoft Pederson & Skov, 2001; Gupta, 2006; Albán et al., 2008; Guel & Penn, 2009; Isaza-A. et al., 2010). *Astrocaryum malybo* and *A. standleyanum* are important sources of fibre in the Pacific lowlands of Colombia, Ecuador and Panamá (Borgtoft Pedersen, 1994; Velásquez-R., 2001; Linares et al., 2008; García et al., 2010). *Astrocaryum* fibres are mainly used as raw material in cottage industries for handicrafts contributing considerably to local and regional incomes. In Colombia the annual export of handicraft amounts to ca. 400,000 US$ and includes numerous palm products (www.intracen.org, accessed 20.11.2010). Ecuador had a considerable export of *Astrocaryum standleyanum* fibres and processed items made from these fibres in the 1980ies (1981–1991, mainly to Peru and Japan) reaching maximum volumes of 37 t/a (1987), corresponding to an export value of 80,000 US$/a (Borgtoft Pedersen, 1994).

In Colombia, handicrafts made primarily of fibres extracted from *A. malybo* and *A. standleyanum* are sold at local markets or at arts and craft fairs in the major cities (Torres-R., 2007; Barrera-Z. et al., 2008). Retail prices are two to three times higher than the producer's prices and these do not adequately reflect the artisans investment of time and raw material (Torres-R., 2007; García et al., 2010). In Ecuador, where *A. standleyanum* is commonly left as a shade tree in agroforestry systems, the potential annual harvest of young leaves ranged from 579 to 1158 kg/ha/a (with two leaves harvested/palm/a) and 1,158–4,060 kg/ha/a (with four leaves harvested/palm/a), corresponding to 82–289 US$/ha/a respectively 165–577 US$/ha/a (based on market prices in April 1992; Borgtoft Pedersen, 1994). Both raw material and manufactured fibre-products are commercialized: young leaflets, from which fibres are extracted, are sold at 1.26–1.48 US$/kg, large hammocks are commercialized for 15 US$/kg (at 3.7 kg equals ca. 4 US$/kg). It is reported that an entire family (two adults, four children), preparing fibres and making hats as their main occupation, earned as little as 18 US$ per week without deducting the expenses for production material. Conversely, the production costs of the landowner employing harvesters at the minimum wage, is only about 15% of the income he obtains from selling the fibres (Borgtoft Pedersen, 1994). In Colombia, there is a growing concern about the sustainability of fibre extraction from *Astrocaryum* species, which is an important source of income for households in the region. Several initiatives with the purpose of encouraging sustainable fibre harvest and enrichment planting are under way (Penn & Neise, 2004; Barrera-Z. et al., 2008; Guel & Penn, 2009; Torres-R. & Avendano-R., 2009).

In Ecuador and Peru, *Astrocaryum chambira* fibres are extracted from young leaves and processed manually. Harvest, fibre processing and handicraft production are often done by those who sell the finished products directly to the consumer. After separation of fibres they are bleached in hot water, washed and left in the sun for drying and further bleaching over 1–2 days (Fig. 3a) (Bianchi, 1982; Paymal & Sosa, 1993; Holm Jensen & Balslev, 1995; Coomes, 2004; Linares et al., 2008; Guel & Penn, 2009; Brokamp et al., 2010). Dying with natural or artificial dyes (Fig. 3b) and twisting of fibres into thread (Fig. 3c) requires an additional day. For a single hammock 1.8 kg fibre is required, which takes three, 8-hour working days to prepare. Lack of raw material and lack of time are the primary limiting factors for production of *chambira* based handicrafts. Therefore basic mechanization could undoubtly increase the volume and economical impact of the entire industry. In coastal Ecuador, for comparison, simple machinery has made processing of *A. standleyanum* fibre dramatically more efficient (Borgtoft Pedersen, 1994; Holm Jensen & Balslev, 1995).

The overall production time for a single *chambira* hammock is 5–8 days (Vormisto, 2002; Coomes, 2004) and it sells for 10–75 US$ in retail shops. The highest prices are fetched in towns with more tourist visitors (Holm Jensen & Balslev, 1995; Castaño et al., 2007), but most handicrafts are bartered to river traders or merchants in the towns in exchange for daily goods. The trade is poorly organized due to the remoteness of the processing sites, much to the disadvantage of the primary producers. In Peru, the producer obtains the highest price when handicrafts are sold directly to tourists (hammock 9.5–30 US$, bag 1–5 US$), much less when selling to an intermediary in Iquitos (hammock 7.6–9.5 US$, bag 0.8–3.0 US$), and least when selling or bartering to river traders (hammock 5.0–7.6 US$, bags 0.8–1.9 US$) who visit the producing communities (Vormisto, 2002; Coomes, 2004). The situation is similar in Ecuador, where retailers buy carrying bags for 1.5–5.0 US$ and sell them for 2.5–10 US$, and buy hammocks for 12.5–15.0 US$ and sell them for 20–50 US$ (Holm Jensen & Balslev, 1995). In some parts of Peru and Ecuador the sale of *chambira* products represents a monthly income of (0–)82(−275) US$/household or 300–400 US$/household/a (Coomes, 1996; Coomes & Barham, 1997; Brokamp et al., 2010), which constitutes a large proportion of the overall cash income (Coomes, 2004). The sale of *chambira* handicrafts is the most important source of cash income in many lowland communities in Colombia, Peru and Ecuador (Bennett et al., 1992; Borgtoft Pedersen & Balslev, 1992; Vormisto, 2002; Castaño et al., 2007). The local use and sale of hammocks from *Astrocaryum chambira*, however, is limited, and cotton hammocks are often preferred, even in communities that produce *chambira* hammocks (Vormisto, 2002).

Further development of the *Astrocaryum* fibre market depends on the availability of raw material. Traditionally, entire palms were cut down to harvest the fibres, which has led to a severe decrease in population density in many areas. The most heavily exploited species are becoming increasingly rare in some areas due to destructive harvesting practices (Velásquez-R., 2001; Coomes, 2004; Torres-R., 2007; García et al., 2010). Fortunately, there are also several reports of simple non-destructive harvest methods (e.g., Borgtoft Pedersen, 1994) in some regions (Holm Jensen & Balslev, 1995; Torres-R., 2007; García et al., 2010). It is increasingly being realized by local communities and public authorities that *Astrocaryum* fibres may be a finite resource, unless the species is sustainably managed. As a consequence, several initiatives have been started to resolve management issues and associated problems, such as land tenure (Guel & Penn, 2009). As in the case of *Lepidocaryum* thatch, the national economic importance of *Astrocaryum* fibres may be limited, but it still makes up one of the most important sources of cash income for many households in rural Colombia, Ecuador and Peru. The local and regional socio-economic importance of *Astrocaryum* palms is therefore considerable (Bodmer et al., 1997). In some areas, artwork and handicraft are driving local economies and the demand for *chambira* fibres is steadily growing (Guel & Penn, 2009). Furthermore, there is a growing market for *chambira* fibres abroad, especially in France and

Germany. Clothes are now made of a mixture of *alpaca* wool and *chambira* fibres (www.ponchisimo.com, 10.09.2010). The future prospects for this unique fabric and other novel application of *chambira* fibre are, at present, difficult to judge.

Palm Heart

Palm heart, palm cabbage or *palmito* is a specialty vegetable, obtained from several palms (Fig. 1g–i). It is extracted from the crownshaft, formed by the overlapping, tubular leaf sheaths, and consists of the immature, etiolated leaves. The nutritional value of palm heart is low, but it is a good source of dietary fibre (Mora-Urpí et al., 1997). Palm heart is one of the economically most important non-timber forest products exported from north-western South America and the single most important edible palm product from native palms in this region. The volume of the world trade in *palmito* was 132.6 Mio US$ in 2008, with annual growth rates of 16% during 2004–2008 (Anonymous, 2009). Originally, single-stemmed *Euterpe edulis* from Brazil was the most important species delivering *palmito*, probably followed by *Prestoea acuminata* and *Euterpe oleracea* from Ecuador. *Euterpe edulis* is now rare and commercially extinct due to overharvesting (Kahn & Henderson, 1999; Backes & Irgang, 2004) and *Prestoea acuminata* has also suffered severely (Borgtoft Pedersen & Balslev, 1990, 1993). *Palmito* currently entering international markets is harvested from wild populations of *Euterpe precatoria* (mainly in Peru and Bolivia) and *E. oleracea* (mainly in Colombia and Brazil). The market share of palm heart extracted from plantation grown *Bactris gasipaes* is, however, growing and mainly so in Ecuador and Costa Rica. Already in the second year of production, *B. gasipaes* orchards yield ca. 1.35 t/ha/a *palmito* (Mora-Urpí et al., 1997). Palm heart is traded at all economic levels. France is the main port of entry into Europe. *Euterpe precatoria* has been considered as one of the economically most important native species in Peru due to the high sales prices fetched for palm heart (Stagegaard et al., 2002).

Until recently, the bulk of traded palm heart was obtained by destruction of wild palm stands. After the depletion of *E. edulis* in Brazil, *E. precatoria*, another single-stemmed species, largely replaced it in trade. Multi-stemmed *E. oleracea* is also exploited, but to a smaller extent. Since *E. oleracea* is able to regenerate after cutting, it is theoretically amenable to the development of sustainable management techniques (Vallejo et al., 2010, 2011). Recently, *palmito* from cultivated *Bactris gasipaes* is replacing palm heart from *Euterpe* species harvested from the wild. This has happened both on the domestic markets in Colombia and the export markets, where Ecuador and Costa Rica are the main players. Palm heart production based on wild *Euterpe oleracea* is still considerable in Colombia, mainly for export.

Because of its economic importance, palm heart is probably the best understood palm resource in South America, although some studies fail to distinguish between palm heart obtained from the different species. In both Bolivia and Peru a massive industry was built up in the 1990ies for canning palm hearts that were extracted mostly from the native *E. precatoria* (Mejía, 1992; Stoian, 2004; Vormisto, 2002). In 1991, Peru exported 677 tonnes of canned palm hearts (Fig. 1i) valued at over 1.5 Mio US$ (Anonymous, 2000). At this era palm heart was considered a product of great national importance (Pyhälä et al., 2006). Based on data obtained from a single canning factory in Iquitos (interview by C. A. Grandez R.) trade peaked during the years 1996–2000, with a production of ca. 1,000 t/a and a value of up to 3.8 Mio US $/a. Subsequently, the annual production of palm heart decreased to 142 t/a in 2002 with a value below 300,000 US$/a. Since then there have been signs of slow recovery. If we assume the average weight of the individual palm hearts to be 500 g, the production figures of a single canning company in a peak year corresponded to 2 Mio felled palms/a.

In Colombia, export of palm heart is essentially based on *Euterpe oleracea*, which is harvested from the wild, whereas palm heart for domestic consumption is either extracted from cultivated *Bactris gasipaes* (Janer, 2002a, 2002b) or imported from Ecuador. Exact trade figures are not available, but export volumes for *E. oleracea* apparently peaked in the 1980ies, when nine canning factories processed 80,000 stems per day, which corresponds to nearly 30 Mio palms/a at a value of >4 Mio US $. Production dropped dramatically in the 1990ies (Vallejo et al., 2010). Between 2000 and 2009 exports ranged from less than 3 t/a at a value of <7,000 US$ (2003) to more than 500 t/a at a value of nearly 1.5 Mio US$ (2007; www.proexport.com.co, accessed 20.11.2010). This corresponds to a total of ca. 5 Mio felled palms/a based on an estimated average weight of 100 g per *E. oleracea* palm heart. Since *E. oleracea* is a multistemmed palm it produces new suckers from the base, unlike *E. precatoria*, which is single-stemmed and does not recover from the harvest. Detailed studies of the value chain in Colombia are not available. In Colombia the average harvest rate per person is 150 stems/day, and the price fetched by the harvester is 0.1 US$/stem, and the average monthly income for a harvester working 3–4 days a week is 122–162 US$, corresponding to approx. half the minimum wage of 262 US$/month (Vallejo et al., 2010). Primary producers thus earn little from harvesting palm heart in Colombia, a situation that will persist as long as there are no alternative sources of income for the population groups concerned.

Palm heart trade is particularly well studied in Bolivia (Anonymous, 2010a). Until 1993 extraction rates were moderate (500,000 palm hearts/a), but increased dramatically to 7.3 million palm hearts/a in 1997 (Stoian, 2000) and subsequently dropped to less than 1.5 million palm hearts/a in 2004 (Stoian, 2004). Export of palm heart from Bolivia reached a maximum of 12 Mio US$ in 1997 and 1998 (Anonymous, 1999), making it the second most important non-timber forest product after Brazil nuts. In 2008, Bolivia exported a total of 3,580 tonnes of palm heart worth 9.4 Mio US$ (Anonymous, 2010a). Most Bolivian palm heart was harvested from wild stands of *Euterpe precatoria*. In any given area typically 90% of the mature trees were felled during the harvest period (Zuidema & Boot, 2000; Stoian, 2004). The minimum age of the trees felled for palm heart was estimated at 70 years and the average age at 90 years (Peña-Claros, 1996; Zuidema, 2000). Recovery of natural stands is slow. Under favourable conditions full population recovery is achieved in 75–80 years (Zuidema & Boot, 2000). Cultivated stands of *E. precatoria* are ready for harvest after 5–6 years (Villachica, 1997) or 12 years (Kahn & de Granville, 1992; Stoian, 2000b), which puts the destruction of wild populations into perspective as particularly irresponsible. Uncontrolled harvest will inevitably lead to depletion of natural stands (Kvist & Nebel, 2001). Palm heart extraction for trade in Bolivia is highly lucrative for local communities, in spite of the fact that the collector receives only 2–6% and intermediaries 3.4% of the retail price of the final product

(Stoian, 2004). The break-down of the income derived from the export of canned palm heart from Bolivia to Brazil is as follows: retailers (40–52%), wholesalers (13–36%), exporters (14–21%), and canning plants (8.3–16.9%; Stoian, 2004). Nevertheless, 21% of the benefits generated by export of palm heart are returned to rural areas in northern Bolivia (Kahn, 1988). Destructive harvest of palm heart from *Euterpe precatoria* has led to large-scale destruction of the natural stands in Bolivia and Peru (Peña-Claros, 1996; Moraes-R., 1998), and probably also in Ecuador and Colombia. The collapse of the Bolivian canning industry was, however, largely due to poor sanitary conditions in the canning plants and external economical factors such as currency crises in importing countries (Stoian, 2004).

Ecuador used to export large quantities of wild harvested palm heart from *P. acuminata* and *E. oleracea* (ca. 900 tonnes in 1991) at a commercial value of 1.5 Mio US$. Today, wild harvested palm heart only plays a minor role (Borchsenius & Moraes-R., 2006) and Ecuador's palm heart trade is mainly based on cultivated *Bactris gasipaes* (Anonymous, 2000, 2009; Anonymous, 2010a). The volume of the palm heart trade in Ecuador has increased steadily since 1997 at which time it was worth 12 Mio US$/a (Anonymous, 2000). In 2008, the export alone reached a value of 72.7 Mio US$/a. Ecuador is now the largest exporter providing 55% of the canned palm heart in international trade, followed by Costa Rica with 20% (Anonymous, 2009). Palm heart harvested from the wild is loosing importance on international markets. In Colombia wild harvested palm heart provided <1% of the internationally traded palm heart in 2008. The corresponding figures for Peru and Bolivia are less than 3.5% and 7.5%, (Anonymous, 2010a). Unsustainable wild harvest of palm heart may soon lose its socio-economic importance.

Palm Fruits

Several palm fruits are part of the staple diet of rural populations in north-western South America. Palm fruits are rich in starch, high-quality protein and oil, but low in acids and sugar and have high nutritional value (Balick & Gershoff, 1981; Balick, 1985, 1986, 1992; Bora et al., 2001; Miranda et al., 2008; Jacobo et al., 2009; Oboh, 2009). They are consumed unprocessed, boiled, blended with water, or used as fodder for domestic animals. Palm fruits are traded locally, regionally and, to a lesser extent, nationally.

Bactris gasipaes (peach palm). The most important palm fruit in tropical America, *B. gasip*aes, is widely cultivated and doubtfully known from the wild (Clement & Arkcoll, 1985; Clement & Mora-Urpí, 1987; Blanco-Metzler et al., 1992; Mora-Urpí et al., 1997; Borgtoft Pedersen & Skov, 2001; Couvreur et al., 2007; Balslev et al., 2008). The yield may reach 20–30 t/ha/a in well managed stands (Mora-Urpí, 1979). Numerous land races differ in fibre, oil, and carotene contents, and fruit size (Henderson, 2000; Clement et al., 2004; Jatunov et al., 2010). *Bactris* fruits have a high content of carbohydrates (60–80% dry weight; Mora-Urpí et al., 1997) and the starchy fruits are boiled and consumed directly in large quantities (Borchsenius & Moraes-R., 2006). Numerous attempts have been made to process the fruits further into products such as flour and fodder due to their high carbohydrate content. Some of these products have already entered the market (Mora-Urpí et al., 1997; De

Oliveira et al., 2006). However, in spite of domestication and intensified research on *Bactris gasipaes*, the market has developed little in the past decades (Clement et al., 2004).

Mauritia flexuosa. Wild populations of *M. flexuosa* (*aguaje* or *buriti*) are an important source of edible palm fruit in north-western South America, next only to cultivated *Bactris gasipaes* (Peters et al., 1989; Penn, 2008). *Mauritia flexuosa* has a wide distribution in north-western South America and is also very common in Brazil. It often forms extensive, monodominant stands, called *aguajales,* in periodically inundated areas. The total area of *aguajales* in Peru alone is estimated at 5.3 million ha of which five million are in the Department of Loreto. In natural habitats the trees reach the fruiting stage in about 8 years and maintain a high productivity for 30–40 years, after which productivity declines. A mature female tree produces ca. 290 kg of fruit/a (Anonymous, 2005). In Roca Fuerte, Peru, the annual harvest of *aguaje* fruits is 1 t/ha (Macuyama-R., 2008) and the productivity of wild *aguajales* in Colombia may be 9.1 t/ha/a and that of plantations 19 t/ha/a (Castaño et al., 2007). Fruiting of *Mauritia flexuosa* (Fig. 1a) is aseasonal, with a peak that differs among localities (Navarro, 2006). *Aguaje* forms part of the staple diet in lowland Peru and Brazil with large turn-overs of fruits at local and regional markets, whereas the markets in Bolivia, Ecuador and Colombia are comparatively small (Castaño et al., 2007; Holm et al., 2008). The export market is negligible constituting less than 1% of the production in Peru. Traditionally, *aguaje* fruits form an important part of the diet of Amerindian groups (Delgado et al., 2007). The trade has recently expanded to markets of major towns and *aguaje* is increasingly being sold in the capital Lima. The main market is in Iquitos, however, where fruits are sold in various degrees of processing: crude, cooked, as *aguaje* soft drink called *aguajina*, or in fermented form, ice creams, popsicles (*chupetes*), or frozen in plastic bags (Kahn, 1991; Mejía, 1992; Del Castillo et al., 2006; Navarro, 2006; Delgado et al., 2007). *Aguaje* flavoured ice cream is a major product, mainly sold in the Iquitos region, but also in Pucallpa and Lima (Rojas-R. et al., 2001). Harvesting of *aguaje* fruits represented the third most important economic activity for households in Roca Fuerte, Peru, in 2002, accounting for 31% of the cash income and involving 75% of the households (Manzi & Coomes, 2009).

Aguaje fruits (Fig. 1b) are sold in Iquitos in bags of 35–40 kg. Several fruit varieties are recognized on the market. *Aguaje shambo* with a thick, red mesocarp is the superior quality. Another variety is *ponguete*, with a more yellowish pulp. Varieties with particularly thick mesocarp are collectively referred to as *aguaje carnoso* (Ruiz-M., 1991). Additional descriptive terms such as *aguaje de color* and *posheco* are also used. Prices vary according to season. During peak harvest time (July–October) they are sold for 0.06–0.07 US$/kg and in the low season for 1.5–1.7 US$/kg (Anonymous, 2005). This price difference is partially reflected in retail prices for the *masa de aguaje* (pulp), which is used for ice cream. The price/bag (600–700 g) varies between 0.5 and 1.2 US$/kg (Rojas-R. et al., 2001; Anonymous, 2005) over one season, depending on the supply and demand. These prices are similar to those reported from Colombia (ca. 0.5 US$/kg; Castaño et al., 2007) and Bolivia (0.28 US$/kg, personal observation G. Brokamp and M. Mittelbach). Prices also depend on fruit maturity and fruit quality.

Harvesters typically sell *aguaje* fruits to riverboat traders in their home villages, or wholesalers in Iquitos (Macuyama-R., 2008) and in Peru there is a complex market pattern for both processed pulp and unprocessed *aguaje* fruits (Anonymous, 2005). For each type of finished product the value chain included both primary collectors, several levels of intermediaries, wholesalers, street vendors and retailers. Intermediaries (*mayoristas*) in Iquitos may subcontract *patrones* in local communties, who in turn subcontract collectors. The harvest is sent by boat from the collection sites to markets in the vicinity of the Iquitos river ports. There are also intermediaries in Iquitos (*rematistas*) buying *aguaje* directly off the boats and barges. Sometimes they even use speedboats to meet the *aguaje* boats before they reach Iquitos and purchase the fruit with cash. The amounts bought typically range between 10 and 30 bags per person and the sellers are typically independent collectors without a business network in Iquitos. The *aguaje* is resold, either to other intermediaries, or directly to the consumer, usually through family members. A number of small enterprises have specialized in selling fruits, *masa de aguaje* (i.e., pulp), or processed products such as ice cream. A major part of the fruit entering the markets are cooked in street kitchens and sold as a snack (Del Castillo et al., 2006).

Detailed data for sale and consumption are not available and estimates vary, since informal street vending makes up a major proportion of the *aguaje* commerce. It has been suggested that approximately 30 tonnes of *aguaje* are consumed daily in Iquitos, roughly equivalent to the fruit obtained from just over 100 trees. This translates into a per-capita consumption of 2.14 kg/month (Anonymous, 2005) and an estimated annual overall consumption of 10,000 tonnes corresponding to the annual yield from ca. 38,000 trees. Other estimates suggest a consumption of 150–660 tonnes per month (5–22 tonnes per day; García & Pinto, 2002; Delgado et al., 2007) and an annual trade for all of Peru of 10,000 tonnes, of which only a tiny fraction is exported (<1 t/a; Santa Natura, www.aguajeperuano.blogspot.com, accessed 05.09.2010). Seasonal fluctuations in prices, differences in *aguaje* varieties as well as details of the value chain leading to the finished product are not fully understood. A conservative estimate indicates that the raw *aguaje* trade in Iquitos alone is worth around 550,000 US$/a (based on lowest price of 2 US$ and an average weight of 37.5 kg/bag). However, it may be several times higher - reaching 2.5 Mio US$/a under the assumption of an average price of 9.5 US$/bag and an average weight of 37.5 kg/bag. The overall economic impact including processing, transport and retail will likely be several times higher and may reach several million US$/a.

Destructive, large-scale harvesting is depleting this seemingly inexhaustable natural resource. Every year 24,000–200,000 palms are cut down with the sole purpose of harvesting the fruits. *Mauritia* is dioecious and since only the mature, female trees are cut down for their fruit, the proportion of male and juvenile trees is steadily increasing in the accessible *aguajales*. The market is contracting in many regions of Peru because readily accessible *aguajales* have largely disappeared and only a small number of productive female plants remain for fruit extraction (Guel & Penn, 2009). Prices in Iquitos are rising due to an increasing demand in combination with a reduced supply. Fruit quality is highly variable and the best varieties such as *shambo* are cut down first (Manzi & Coomes, 2009) and they are becoming increasingly rare in the wild and on the market. Furthermore, the natural *aguaje* stands are genetically impoverished since only trees producing low-grade fruits are left to reproduce. Large-scale degradation of *aguajales* and concomitant genetic erosion pose immediate threats to future attempts to commercially develop this promising resource. Non-destructive harvesting techniques must be introduced to stop this direct and indirect resource depletion. Considering the popularity of *aguaje* fruits, semi-domestication, domestication and cultivation in agroforestry systems (Penn & Neise, 2004) will probably be the only options for meeting the current and future demand. *Aguaje* orchards would not compete with other crops, since *Mauritia* grows on marginal lands, such as swamps, that have little agricultural potential.

Euterpe spp. Açaí, the fruits of *E. precatoria* and *E. oleracea*, has developed from a minor local product into an international commodity in the past 10 years. In southwestern Colombia, fruits of these *Euterpe* species are highly appreciated and sold for ca. 0.36 US$/kg in March 2010 (Vallejo et al., 2010). The market potential for *Euterpe precatoria* fruits is promising. This species produces 13–20 kg fruits/plant/a (Bovi & de Castro, 1993), which represents a commercial value several times higher than that of its palm heart. The fruits of *Euterpe precatoria* are traded locally in Amazonian Colombia at a price of 0.54 US$/kg (Castaño et al., 2007). In Bolivia fruits for oil extraction are sold by street vendors for 0.36 US$/kg. The corresponding price on the retail market is 0.57 US$/kg. For local collectors this is a lucrative business, since they are able to harvest 50 kg in 3 h (Madre Tierra de Amazonia/IPHAE, pers. comm.), corresponding to an income of ca. 6 US$/h. Individual palms of *E. oleracea* may produce nearly 27 kg fruit/a. This is equivalent to a market value of 9.8 US$/palm/a (on the local market), which is considerably more lucrative than the once-only income of 0.1 US$/stem obtained by felling the tree to obtain the palm heart (Vallejo et al., 2010). When *palmito* production based on *Euterpe oleracea* was at its peak in Colombia in the 1990'ies, a single year's palm heart harvest removed fruits corresponding to an approximate market value of 290 Mio US$. Although this amount of fruit likely would have exceeded the local market capacity at the time, they could have formed the basis for an export business. In Brazil, the *açaí* export became important over a decade ago and individual companies now produce up to 1,000 t/a (www.acai-mania.com, accessed 20.11.2010) and *açaí* fruits constitute the single most important food item (by weight) in certain communities in Brazil (Murrieta et al., 1999). Fruit harvest is, however, seasonal and can not provide a continuous income to rural populations, in contrast to the aseasonal harvest of palm heart. In pulp production only about 30% of the *Euterpe* fruit is retrieved. The pulp is sold both locally and regionally, for example to *açaí* ice cream factories at about 2 US$/kg in Bolivia (Madre Tierra de Amazonia/IPHAE, pers. comm.).

Recently, *açaí* pulp was introduced to the Asian, European, and US markets, as an ingredient in "energy drinks" (www.calidris28.com, accessed 12.11.2010), fruit juices and yogurt (Coïsson et al., 2005; Sabbe et al. 2009a, 2009b). It is widely traded in the US and gaining market shares in Europe (e.g., in Germany) with considerable market potential (Sabbe et al., 2009a, 2009b). Managing *açaí* is highly profitable in Brazil (Muñiz-Miret et al., 1996). For one hectare of orchard the profit ranged from 896 to 1,814 US$/a, after deducting leasing expenses. The *açaí* market is currently dominated by *E. oleracea* from Brazil (Vallejo et al., 2010) with an estimated production of at least 480,000 t/a (Rogez, 2000; Brondízio, 2008). The estimated volume of the international market of *açaí* pulp was approx. 30,000 metric tons in 2007 (www.biocomerciosostenible.com/Boletin2.html, accessed 17.10.2010), and rising fast. One website (www.alibaba.com, accessed 20.11.2010) lists 38 wholesalers of *açaí* pulp, of which 24 are based in Brazil and five in India. Wholesale prices vary from 6 to 270 US$/kg and individual companies can deliver up to 2,000 t/a. Retail prices for fruit powder in Europe and North America vary from 70 US$/kg for large orders to 100–340 US$/kg for smaller orders. Promotion of *açaí* products is boosted by alleged high contents of phenolic compounds with beneficial "antioxidant" properties (Schauss et al., 2006; Pacheco-Palencia et al., 2008), although health authorities such as EFSA (Anonymous, 2010b) regard these claims with considerable scepticism and recent studies revealed that various *açaí* drinks are only slightly higher in antioxidants than, e.g., apple juice, and considerably lower than other and cheaper fruit juices (Seeram et al., 2008). The current boom may therefore be short-lived, but it is difficult to predict how the overall *açaí* market will develop in a longer time perspective.

The largest and most accessible stands of *E. precatoria* and *E. oleracea* have been mostly destroyed for *palmito* harvest. The palms are also still commonly cut down for fruit harvest in rural areas throughout north-western South America. This practice terminally precludes ecologically and economically sustainable development of this valuable resource (Velarde & Moraes-R., 2008). A sustainable development of markets for wild harvested *açaí* depends on the introduction of sustainable harvest policies. Also, the perishable fruit needs speedy transport to processing plants, and overall a considerable degree of technical sophistication and development will be required to establish a major *açaí* industry in the Andean countries.

The prospects for palm fruits as a commodity in the food industry depend on a variety of factors such as availability of raw materials, formation of prices, harvest practices, and sustainability of resource management. The high tocol and carotenoid levels may also provide an opening to the lucrative health food and functional food markets on the international level.

Palm Oil from Native Species

There is much interest in oil from palm pulp and kernels (Pesce, 1985; Lleras & Coradin, 1988; Bereau et al., 2001, 2003; Jacobo et al., 2009; Montúfar et al., 2010). Although oil contents are often low, palm oil production per area is potentially high for native palms, reaching 0.5 t/ha (Lleras & Coradin, 1988). Most native palm oils have a fairly conventional fatty acid composition, with chain lengths of (6–)16–18 (−24) of mainly saturated fatty acids. Many palm kernel oils are rich in lauric acid (C_{12}), and, based on their fatty acid composition, most fall within the lauric and myristic acid subclass and the palmitic acid subclass, which are primarily of interest as texture agents added to cosmetics and food (Dubois et al., 2007). The fatty acid composition of most tropical American palm oils is similar to many known and widely used oils, but some palm oils are very high in tocols and carotenoids. Due to these particular properties, palm oils may be subject to further market development, provided that they are critically evaluated for negative side effects and that technologies for

Table 2 Current Prices and Availability of Some Native Palm Oils as Raw Materials for the Cosmetics Market (Researched on the Websites Indicated, 10.11.2010)

Palm kernel oil (*Elais guineensis*)	–	–	–	3.7–6.6[d]
Palm oil, bulk (*Elais guineensis*)	–	–	–	3.7–6.6[d]
Coconut oil fractionated (*Cocos nucifera*)	–	–	–	7.5–13.1[d]
Babassu/*Babaçú* oil (*Attalea speciosa* as *Orbignya oleifera*)	–	–	166[c]	8.0–17.4[d]
Tucuma seed butter/oil (*Astrocaryum aculeatum* as *A. tucuma*)	7.50–9.00[a]	200/20,000[b]	85[c]	29.7–48.5[d]
Açaí butter/oil (*Euterpe oleracea*)	80.00–120.00[a]	50/50,000[b]	400[3]	34.9–52.0[d]
Murumuru butter (*Astrocaryum murumuru*)	12.95–16.69[a]	200/50,000[b]	85[c]	45.7–83.8[d]
Buriti Oil (*Mauritia flexuosa*)	21.88–23.75[a]	200/50,000[b]	166[c]	–

[a] www.100amazonia.com (FOB, wholesale, US$/kg) BRAZIL

[b] www.100amazonia.com (minimum order/- supply limit/year), BRAZIL

[c] www.oca-brazil.com (retail, US$/kg), BRAZIL

[d] www.camdengrey.com/ (wholesale and retail, US$/kg), US

extraction and processing are refined. The market potential of native palm oils is currently severely limited by their generally high price (Table 2).

Attalea phalerata, *A. speciosa, A. maripa,* and *A. butyracea* are locally exploited in Bolivia to produce oils that are primarily used in cosmetic preparations at small and medium scale, but they could also be used in human consumption (Borchsenius & Moraes-R., 2006). In Bolivia, fruits of *Attalea speciosa* (*cusi*) for commercial processing are currently sold at 0.05 US$/kg and the oil is sold for about 30 US$/kg in bulk sale and 29 US$/liter in retail sale. *Cusi* oil is primarily used in soap, cosmetics and shampoo (www.indelcusi.com, accessed 20.11.2010; Fig. 3h, i). The oil is marketed professionally as hair care product (www.oleunsbeauty.com, accessed 20.11.2010). Due to a particularly high percentage of lauric acid the demand for these oils for the use in cosmetics may increase in the future.

Mauritia mesocarp oil has high β-carotene, α-tocopherol, and oleic acid contents and resists oxidation, which is highly appreciated by the food and cosmetic industries (Lleras & Coradin, 1988; Santos, 2005; Vásquez-Ocmín et al., 2010). Oil from the seed has a high concentration of ώ6 (linoleic acid), which is known to prevent negative effects of oxidation (Vásquez-Ocmín et al., 2010). In Bolivia, an experimental plant for palm oil extraction uses 30 kg of *Mauritia flexuosa* fruits to produce 1 l of *buriti* oil (Madre Tierra de Amazonia/IPHAE, pers. com.). Prices are high due to these meagre yields. In Brazil, 1 l of *buriti* oil is currently sold for 23–26 US$/kg in wholesale and for 130–210 US$/kg on the European retail market (www.regenwaldladen.de, accessed 20.11.2010; www.seasonsskin.com, accessed 20.11.2010). Due to the high prices *buriti* oil is imported into the US and Europe mainly for use in skin and hair care products (www.thebodyshop.co.uk, accessed 20.10.2010; www.oleunsbeauty.com, accessed 20.11.2010).

Oenocarpus bataua is widespread in north-western South America and represents a major natural resource (Balick, 1985; Kahn, 1991; Moraes-R. et al., 1995; Miller, 2002; Montúfar & Pintaud, 2006; Castaño et al., 2007; Orihuela-Ardaya, 2009).

Fruits are harvested from the wild, often by felling the trees (Vasquez & Gentry, 1989; Borgtoft Pederson & Skov, 2001; Miller, 2002; Stagegaard et al., 2002). A large proportion of the fruit is consumed locally (ca. 40% in Bolivia, Departments of Beni & Pando), the remaining part is processed industrially for oil (Fig. 3g) or ice cream (Orihuela-Ardaya, 2009). Near densely populated areas the abundance of *Oenocarpus bataua* is rapidly decreasing. As a consequence fruits are rare on local markets and prices are rising (Vasquez & Gentry, 1989; Miller, 2002; Gupta, 2006). The fruiting cycle of *Oenocarpus bataua* is biennial and fruit set is relatively low. The yields in natural *Oenocarpus* stands in Peru and Ecuador range from 0.7 to 1.3 t/ha/a, which corresponds to ca. 50–100 kg of oil/ha (Kahn, 1991; Miller, 2002). On the Pacific coast of Colombia fruit yields were ca. 0.23 t/ha/a (Castaño et al., 2007). In Amazonian Colombia there is a considerable market for fresh fruits, which are sold at 0.54–1.6 US$/kg (Castaño et al., 2007). The fruits are sometimes preserved and used for jams, ice creams and soft drinks (Vasquez & Gentry, 1989; Borgtoft Pederson & Skov, 2001; Albán et al., 2008; Balslev et al., 2008). A valuable oil is extracted from the mesocarp with a yield of 6.5–12% of the fruit fresh weight. It is reminiscent of olive oil in fatty acid composition and contains high levels of tocopherols (Montúfar et al., 2010). *Oenocarpus* oil is consumed by humans and used in cosmetic preparations (Gupta, 2006).

The use of *Oenocarpus* oil is not new. A considerable export market existed in the early 20th century, when 100–200 t/a where exported from Brazil and Colombia to the USA and Europe. However, this market collapsed due to changes in market structure and destructive harvest (Balick & Gershoff, 1981). There is currently an enormous interest in developing the market for *Oenocarpus* oil, and the commercial potential is generally considered as high, even for regional and national markets (Mejía, 1992). In Peru, it is regarded as one of the most promising palms from a commercial point of view (Kahn, 1988, 1991). In 1996, the unrefined oil sold for 10–11.66 US$/liter and the purified oil for 32.50–40 US$/liter in Ecuador (Miller, 2002). The net value of the total amount of unrefined oil that can be obtained from a one hectare grove in 1 year varies between 500 US$ and 1,166 US$ and for the refined oil it may be as high as 4,000 US$ (in 1996 prices). The total market value of the *Oenocarpus* fruits themselves was estimated to be 115.92 US$/ha/a (Pyhälä et al., 2006). A study of one hectare of forest at Mishana, RNAM, Peru recognized *Oenocarpus* fruits as the single most important non-timber forest product, accounting for 35% of the household income (Pyhälä et al., 2006).

Cosmetics containing *Oenocarpus* oil are being marketed at a minor scale via the internet and on organic markets (*Bio ferias*) in Lima (www.mishkiperu.com, accessed 20.10.2010). In Bolivia, there are several projects dealing with industrial processing of *Oenocarpus bataua* fruits (Miranda et al., 2008). One of the areas with a well developed market for *Oenocarpus bataua* fruits is Riberalta in Bolivia. Collectors here sell 12–90 kg of fruits per day at a price of 0.26 US$/kg (Ortiz Camargo, 2007). According to different sources, 25–37 kg of fruits are required to obtain one liter of filtered oil (Madre Tierra de amazonia/IPHAE, pers. com.). The fruit required costs up to 9.5 US$/liter when purchased on the local market, and the overall production costs are estimated at 26 US$/liter (Miranda et al., 2008). Retail prices for the oil in La Paz are around 78 US$/liter, which means that the costs of the raw material make up less than 12% of the retail price of the finished product.

Oenocarpus oil is a lucrative product for the national market, even when additional costs for packaging and transport are considered. In Colombia, the retail price of the oil is 1–1.25 US$/kg and thus much lower (Castaño et al., 2007). Ecuador has already engaged in exports of *Oenocarpus* oil to Europe, where it is used for cosmetic purposes (www.eza.cc, accessed 20.11.2010), mainly in haircare products (www.aromandina.com, accessed 10.11.2010; www.rahua.com, accessed 20.11.2010; www.eza.cc, accessed 20.11.2010; www.ainy.fr, accessed 20.11.2010).

The cake that remains after oil extraction of palms is highly nutritious, with elevated levels of protein (nearly 20% in *Attalea speciosa*) and/or carbohydrates (nearly 85% in *Bactris gasipaes*). The cake is commonly traded locally as animal fodder. Animal nutrition is under-developed in many South American countries and programmes focussing on the dual use of palm fruits for the extraction of palm oil and processing of the press-cake into high-quality animal fodder could have high socio-economic impact.

Improvement of the industrial processes involved in the oil extraction may contribute to reducing production cost. The high vitamin contents of some native palm oils may also be of importance on the domestic markets, due to serious problems with malnutrition and vitamin deficiency especially in the poorer part of the population. Nevertheless, the prospects for a large scale export of native palm oils for human consumption are not promising, since it is unlikely that they will be competitive in price and quality, compared to numerous established vegetable oils. Current prices for native palm oils are not competitive on the international market for food and food ingredients (Table 2).

Vegetable Ivory

Vegetable ivory is the collective term for the hard endosperm of palms, which is rich in hemicelluloses and oil. In South America this product is obtained from species of *Phytelephas*, especially: *P. macrocarpa* (Peru and Bolivia), *P. aequatorialis* (Ecuador) and *P. seemannii* (Colombia). Vegetable ivory or *tagua* has a long history in international trade. Exports started in the 19th century and were mainly directed to Europe (Acosta-Solís, 1948; Pérez-Arbeláez, 1956; Barfod, 1989; Barfod et al., 1990; Borgtoft Pedersen & Balslev, 1990, 1993). *Tagua* was among the five most important export commodities from both Colombia and Ecuador in the second half of the 19th century (Acosta-Solís, 1948; Bernal, 1992). Vegetable ivory can be readily turned, carved, polished and stained (Hofmann, 1995) and used for handicrafts (Fig. 3d) and buttons. In Colombia, *tagua* trade started to decline around 1920 and by 1935 the industry had virtually disappeared. In Ecuador, exports peaked around 1929 reaching 25,000 t/a, valued at over 1.2 Mio US$, equivalent to about 15 Mio US$ in present day prices (Borchsenius & Moraes-R., 2006). Similarly, 1,000–2,000 tonnes of *Phytelephas macrocarpa* were exported from Peru between 1920 and 1940, mainly for the manufacture of buttons (Anonymous, 2002). During and after World War II the international demand for *tagua* dropped dramatically, because it was replaced by plastics (Barfod, 1989). Lately, since the 1990ies, the *tagua* trade is increasing again (Borgtoft Pedersen & Balslev, 1990, 1993; Pülschen, 2000). In 1991 the overall value of the vegetable ivory products in Ecuador was estimated at 4.2 Mio US$ (Borgtoft Pedersen & Balslev, 1990, 1993) and *tagua* is now exported from Ecuador, Colombia and Peru, mainly for the button industry. Manufacture of *tagua* buttons is usually wasteful since only 5–7% of the dry weight of the palm endosperm is retrieved in the finished product. Traditional fabrication (late 19th century) of *tagua* buttons was less wasteful and 3 kg of raw material went into the production of 1 kg of buttons (Hofmann, 1995).

In 1995, Ecuadorian harvesters received 4.35–6.25 US$ for one *quintal* (ca. 50 kg) of *tagua* and derived 40% of their monthly income from this product alone (Velásquez-R., 1998). *Phytelephas aequatorialis* is the most important palm in terms of availability and accessibility, sustainability of the harvest as well as present and future commercial value (Borgtoft Pedersen & Skov, 2001). In Peru, there is an incipient market for *tagua,* based on *P. macrocarpa*. Peru exported 1.45 tonnes in 2002 increasing to 5.73 tonnes in 2005. The dehusked endocarps containing the seed are bought from village communities at 0.1–0.2 US$/kg depending on size (Navarro, 2006) and they are resold for more than 12 US$/kg, which is 60–110 times the price paid to the primary producer. The retail price for dried, unprocessed nuts in Ecuador is roughly 4–7 US$/kg depending on size (www.nayanayon.com, accessed 20.11.2010). On the German retail market individual *tagua* nuts weighing 30 g are sold for 3.5 US$, which corresponds to 115 US$/kg (www.taguagalerie.de, accessed 20.11.2010) or 600 times the price paid to the primary producer. In Europe, buttons made from *tagua* are gaining market shares in designer clothing. Individual *tagua* buttons (slice of nut with 2 holes, otherwise unprocessed) are sold at retail prices of 0.9–2.5 US$ in Germany, more elaborate designs for 6.75 US$ or more. In Ecuador, simple beads are sold for up to 90 US$/kg, more elaborate designs are sold for up to 929 US$/kg. On the German retail market carved figurines and boxes may fetch over 4,000 US$/kg (www.taguagalerie.de, accessed 20.11.2010), which is more than 30,000 times the value of the raw material in Peru and Ecuador.

Phytelephas stands vary in density and productivity (Navarro, 2006). *Phytelephas aequatorialis* produces 4 t/ha/a in Ecuador, *Phytelephas seemannii* groves produce 2.25–12 t/ha/a in Colombia. In a forest reserve of 394 ha near Iquitos, Peru, vast populations of *Phytelephas macrocarpa* produce 0.77–1.67 t/ha/a. A conservative estimate for the average productivity of the entire area is 1.22 t/ha/a (Navarro, 2006). Thus, the resource available to the local communities can, under ideal circumstances, generate more than 60,000 US$ worth of raw material every year, corresponding to a potential export value of ca. 6 Mio US$ (in 2005 prices). The seeds are collected from the ground after rodents have eaten the mesocarp which represents sustainable harvest. If harvested before full maturity the vegetable ivory will be of inferior quality and lacks the characteristic colour and lustre (Borgtoft Pedersen, pers. comm.).

Discussion

Trade

Colombia, Ecuador, Peru and Bolivia all have a considerable international trade in palm products, and although exact figures are lacking, it is clear, that the two main products are palm heart *(palmito)* and vegetable ivory *(tagua)*. For each country export values of these commodities amount to several million US$. The fruit of *Mauritia flexuosa* is the third most important palm product in terms of market volume. This is surprising, since it has a distinctly regional value chain and the trade is concentrated in the greater Iquitos region of Peru. Other South American palm products are subject to inreasing international trade. Oils derived from other native palm species are gaining importance but have a much smaller share of the international market. At present, Brazil is the key player on the rapidly growing market for *açaí* fruits and a key-player on the *aguaje* market, not least due to development of new products.

The remaining palm products are exported in much smaller amounts and trade is difficult to quantify, since they do not appear in export statistics or are included in wider categories, together with non-palm products (e.g., handicraft). Furthermore, trade at the national, regional and local levels is not usually captured in official statistical surveys.

The best example of a really well-developed and massive regional trade in palm products is the *Mauritia flexuosa* fruit market in Peru. A number of products derived from these fruits are traded in tremendous volumes throughout the year. The processing industry is diversified and value chains are often complex. *Mauritia flexuosa*, in both its crude and processed forms, is traded within Peru, with a growing market in cities far away from Iquitos, such as Lima. *Mauritia flexuosa* is the economically most important palm species in Peru. A complex evaluation system for fruit quality for different uses is in place, but technical sophistication of the industry is low. This is particularly true for harvesting techniques, which remain destructive and have caused and continue to cause a severe decline of the most valued palm populations.

There are also budding regional and national markets for several native palm oils such as those derived from *Oeonocarpus bataua, Mauritia flexuosa,* and various species of *Euterpe, Attalea,* and *Astrocaryum*. Extraction techniques are still primitive and inefficient. Production costs and prices are high, reaching more than 20 US$ per kg, so these palm oils may not develop into major commodities at national or international markets. However, native palm oils are increasingly used in cosmetics, both within the countries of origin and abroad. National markets in "native" cosmetics are rapidly growing. Perhaps as a consequence of rising prices, some companies have been able to meet acceptable quality standards.

Palm fruits are important at local and regional levels as food. They have high contents of oil, starch and protein and elevated carotenoid and tocol levels. This composition of nutrients makes them suited for both human consumption (staple diet, functional foods and food additives) and animal fodder, since malnutrition still constitutes a serious problem in north-western South America.

Palm thatch represents another flourishing regional market for palm products. Thatch is a locally important product that is sold outside the region of origin, generating considerable cash income for producers and middlemen in Iquitos. Whereas the value chain and technology are well understood, the overall volume of this trade remains poorly known. Like other palm products in the Amazonian region of north-western South America thatch often constitutes the most important cash income for individual small-holders or entire communities. Similarly, handicrafts made of palm fibres or palm fruits may play a minor role at the national level and a moderate role at the local and regional levels, but they are crucial for the livelihoods in the communities where they are harvested and processed. Thus, several palm products (*Astrocaryum chambira* fibre, *Oenocarpus bataua* and *Mauritia flexuosa* fruit, *Lepidocaryum* leaves, *Phytelephas* nuts, etc.) provide the only or most important sources of cash income (often >30% of the entire cash income) for numerous local communities and are crucial for local - and sometimes regional – economies. Trade volumes, as measured in metric tons and US$ and as captured in official statistics, therefore do not adequately reflect the socio-economic importance of these products and grossly underestimate their importance.

Value Chains

Value chains are heterogenous, depending on product type, market penetration and the number of middle men involved. Value chains may differ even within the same region and for the same product. The bulk of palm products is marketed directly, i.e., the family that harvests the product sells it directly to the consumer at the local market. If processing is involved (manufacture of handicraft, processing into oils, etc.), then this will typically be carried out by family members. The primary producer then receives the added value (gross benefit). For handicraft sold at the national level a relatively high proportion of the retail price percolates back to the primary producers (*Astrocaryum chambira* carrying bags, Ecuador: 50–60%; *Astrocaryum chambira* hammocks, Ecuador: 30–60%; thatch, Peru: 55%). The proportion of the price for the raw material for the domestic industry going back to the sourcing price for the raw material is still considerable (e.g., 12%, *Oenocarpus bataua* fruit for oil extraction, Bolivia). With increasing trade volumes and industrialization, the costs of raw material in relation to the retail price becomes increasingly reduced. For canned palm heart (Bolivia) and furniture from *Iriartea* timber (Ecuador) the corresponding figures are only 2–6%. In Peru, the price fetched by the primary producer of the unprocessed vegetable ivory nuts is only 1.6% of its export price (FOB) and 0.1% of the price for nuts sold on the German retail market. Most of the profit is thus typically generated further up in the value chain, and often abroad.

Sustainability

Colombia, Ecuador, Peru and Bolivia have all implemented legislation for prohibiting “non-sustainable” use of forest resources (De la Torre et al., in press). There is, however, little evidence that these laws have a noticeable effect on how resources are managed. Legislation is largely ineffective, because the bulk of the trade in palm raw materials is informal. One positive example, however, is the apparently effective legal protection of species of *Ceroxylon* against overharvesting of leaves for ceremonial purposes (Galeano & Bernal, 2010). Also, vegetable ivory is being marketed based on presumably sustainable management practices to make it more attractive to the incresasingly large segment of ecologically conscientious consumers. In spite of the marginal percentage of the retail price being returned to the primary producers, there is a rising awareness of the value of this resource and the importance of protecting it against overharvesting. *Lepidocaryum* leaves for thatch are increasingly being harvested using sustainable management practices. Fibre extraction from *Astrocaryum* is also increasingly managed sustainably instead of destructively. However, contrary to the intentions of legislation, the bulk of the trade in native palm products in north-western South America is still largely based on destructive harvest of wild populations, even in cases where this is not necessary (Bernal et al., in press).

A rough estimate based on the scattered annual production figures suggests that a minimum of several tens of million palm trees are cut down annually and, for the main part, unnecessarily to obtain fruits or leaves. Rising prices and reduced availability of raw materials is already widespread in a range of products such as timber and *Oenocarpus* and *Mauritia* fruits. Much of the palm extraction is therefore based on shifting extraction practices. New areas are harvested every year and the resources are already depleted near villages and urban areas.

The palm heart industry provides a particularly well-researched example of non-sustainable resource exploitation. Currently, tens of millions of palms are destroyed every year to deliver a limited quantity of a specialty vegetable. In terms of biomass destroyed in relation to biomass used, palm heart harvest is inherently destructive and wasteful. It is difficult to envisage how sustainable wild harvest should be managed, without causing a massive increase in the price of the raw material. Sustainable wild harvest is likely not an economically viable alternative. Replacing wild palm heart with palm heart from plantations may be desirable from a conservation point of view, since it reduces the pressure on native stands. However, large-scale cultivation has negative side effects such as clearance of forest and loss of income for local farmers involved in the wild harvest. Furthermore most of the profits generated by palm heart plantations typically end up in the hands of large land owners and private companies.

Unless destructive harvest is replaced by non-destructive practices, which are available for all species, even the most common palms such as *Mauritia flexuosa, Oeonocarpus bataua* and *Euterpe* spp. will face commercial extinction. Since destructive harvest is often selective, the best-quality trees are lost from the gene pool. As a consequence, genetic resources rapidly degrade and reduce the options for future resource development. Figures concerning the relative abundance of destructive harvest as opposed to sustainable harvest for other major palm products are not available, but are urgently needed for adequate resource management. There is a growing understanding of the negative impacts of destructive harvest and progress has been made in several regions towards implementing more sustainable harvest techniques. Small enterprises, such as “Madre Tierra de Amazonia (supported by IPHAE)” and “Indelcusi” in Bolivia and “Mishki” in Peru make an effort to ensure the sustainability of the palm products that they sell. Behind these enterprises are often NGOs, such as the “Fundación de amigos de la naturaleza” (FAN), WWF in Bolivia, or the “Rainforest Conservation Fund” (RCF) in the Iquitos region in Peru.

Conservation through Use

Many palm products have developed markets at various economic levels. Products such as timber, fibre, fruit and vegetable ivory, could likely increase their market share under adequate management of the resources, the value chains and the market. High productivity per area and local abundance of palms delivering a range of raw materials make them ideally suited for “conservation through use”. Overall, the development, establishment and control of sustainable harvest techniques are probably the most important requirements for positive mid-term developments. Possible threats against this scenario are bad governance, corruption, and uncertainty of land tenure. Serious impediments in both policy making, law enforcement, and research will have to be overcome to develop the full potential on an ecologically and economically sustainable basis. Also, the value chains will need to be adjusted, so as to ensure that primary producers receive an adequate share of the overall benefits. This has to go hand in hand with strict policing and the clarification of contentious issues such as land tenure and ownership of the resources—otherwise higher profits will be an incentive for the informal and destructive harvest.

Conclusions and Recommendations

A wealth of studies exists on trade of native palm species in north-western South America, here used as a collective term for Bolivia, Colombia, Ecuador and Peru. In this review we focused on palm products of major economic importance on the local, regional, national, and international markets, attempting to cover major use categories. It is surprising that details on trade volumes and value chains remain incompletely documented, considering the socio-economic impact of palms to the livelihoods of millions of rural dwellers in South America. North-western South American palms provide a range of products that potentially could sustain flourishing industries. Many palm species are suited for production of vegetable oils, food supplements (high vitamin contents) and animal fodder (high protein and carbohydrate contents) and several species deliver valuable timber for construction, tool making and handicrafts.

The future of markets for native palm products is difficult to predict. Palms that were recently considered of marginal importance now deliver international commodities such as *açaí* fruits. Vegetable ivory once played a major role on the world market, but was substituted by plastics. Recently, this unique material has been rediscovered and now forms the basis of a booming industry. Resource depletion may, however, present a serious future impediment. Already with present trade volumes wild stands of several palm species cannot sustainably satisfy the demand. Another challenge is the ability of the primary producers to deliver raw material in predictable quantities and uniform qualities. Large-scale production for food, food additives and animal fodder will require preselection and propagation of cultivars with desirable characteristics. There will be an increasing pressure to move from extractivism to agricultural production with increasing trade volumes, either via agroforestry or plantations. This is particularly true for smaller and more densely populated countries, such as Ecuador.

We foresee that an increasing demand for any given palm product will not lead to a *proportional* increase of the income and hence increased socio-economic benefits in rural areas. It should be noted that destructive harvest and value chains are intricately linked: the commerical value of palm products inadequately reflects the true value of the raw material in terms of availability and sustainability of harvest. Unfortunately, the benefit obtained by the primary producers is often so small that they are not encouraged to engage in sustainable (and more laborious) management and harvesting techniques.

Although market developments for timber and fibre have not been fully researched, our research suggests that technological innovation is needed to develop the industry beyond handicrafts. As for palm products used for food and cosmetics the problems are equally clear. Since most palm fruits perish quickly, the time of transportation between the harvesting and proccessing sites should be minimized, which is often difficult in the Amazon region and represents a serious logistic problem. Extraction of native palm oils is still carried out in technically unsophisticated ways, with fluctuating yields and poor-quality oils as a result. There have been numerous attempts to develop state-of-the-art extraction techniques, but an overall coordination is missing. Fruit production is mostly seasonal, which means that processing facilities can only be used part of the year, which in turn makes it difficult to recoup investments. The obvious solution to this problem is making the manufacturing plants more flexible, so that they are able to process several kinds of palm fruits (and possibly other crops). A major development of national and international markets will remain impossible as long as production and transport costs are as high as they are at present. The rapidly growing market for *açaí* fruit somewhat contradicts this, but we believe that prices are currently inflated by overstated health claims. Concerted action should be taken to ensure stable supply and uniform quality of native palm products at all levels of commercialization. Growing markets can only be served by the formation of cooperatives or direct-sourcing partnerships. Fair-trading could be an efficient marketing instrument to assure that benefits are funneled back to the primary producers and harvest occurs on a sustainable basis.

Fierce competition within South America represents a major obstacle for the countries included in this review in their attempts to obtain market shares. Brazil has already taken the lead, and is a serious competitor regarding all major palm products exported from Peru, Bolivia, Ecuador and Colombia. The low prices for vegetable ivory on the world market are at least partly due to competition between different north-western South American countries. A similar situation will probably arise as new products are developed – and rapidly copied elsewhere.

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