Chapter 6

An Overview of Sago Industry Development, 1980s–2015

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Abstract The major world commercial sago producers are Malaysia and Indonesia. In Malaysia, sago was mainly produced in family-owned small factories (<100 mt/month) before the 1980s. There were over 40 such sago factories along the Mukah and Dalat Rivers. Modernized sago-processing factories (500–1000 mt/month) mushroomed in the 1980s, largely replacing the small factories by late 1980 to early 1990. Processing technologies in these larger factories were mostly adopted from cassava processing with innovations to tackle the structural differences between sago and cassava. Malaysian's annual sago export is around 47,000 mt. Sago palms were mostly cultivated in a semi-wild state by smallholders. This is still the mainstream cultivation practice by most smallholders today. A large-scale sago plantation was initiated in the mid-1980s, but the outcome was disappointing.

In Indonesia, the hub of commercial sago production is at Selat Panjang. About 80,000–90,000 mt of dried sago is produced annually. Processing is mostly done in the 50–60 small factories with capacity ranging from 50 to 200 mt/month. In 2010, a 3000 mt/month modern sago factory was built at Selat Panjang and is in operation. In the late 1980s, medium-sized factories were also established in Halmahera (Maluku) and Arandai (West Papua) but were subsequently closed down. A new sago factory (3000 mt/month) is currently under establishment at West Papua.

At Selat Panjang, sago palms are mainly cultivated in a semi-wild manner in smallholdings, similar to those practiced in Malaysia. A 12,000 ha sago plantation employing improved agronomic/management practices was initiated in 1996. It is still in production though not all the palms are in optimal growth conditions. Development of natural sago forest at West Papua initiated at around 2010. Harvesting of existing mature palms followed by systematic rehabilitation was planned and is ongoing.

Marketing of sago starch was mainly confined to meet domestic demands in Malaysia and Indonesia. The sago starch is mainly used in food industries like vermicelli and glass noodles.

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In this paper, more detailed reports are given with specific reference to technological innovation in cultivation and processing. Potentials and challenges in plantation development, processing, and marketing are also discussed.

6.1 Sago Production in Malaysia

6.1.1 *Transition Between Traditional and Modernized Processing*

The Mukah and Dalat regions of Sarawak are the major sago production areas in Malaysia. Before the 1980s, most of the sago produced was from traditional small mills, and the starch was dried in the sun. Many such mills processed a few palms per day with a yield of less than 1 mt dry starch per day. In the mid-1980s, there were over 40 such sago factories along the Mukah and Dalat Rivers, together with a few relatively modernized mills that produced refined sago starch. Crude wet starch produced by some of the traditional mills was sent to these larger mills for refining.

By the late 1980s, there were about ten such modernized sago-processing factories each with production capacities of about 500–1000 mt dry sago per month. Most modern and traditional factories did not own sago palm plantation to support their raw material needs and had to outsource from smallholders. With the increase in the number of modernized factories, competition for sago logs in the limited pool became intense. Many small mills were outcompeted by the more efficient modern mills and had to shut down. By the early 1990s, nearly all the traditional mills were closed, and many of the modern mills were unable to get sufficient quantities of raw materials for full operation.

To encourage sago palm cultivation, the Department of Agriculture introduced a *sago subsidy scheme* to smallholders, but they were hardly able to meet the demand for raw material supplies. As of 2015, there are still about ten modern sago factories in operation in Sarawak, producing a total of about 47,000 mt/month of refined sago. At Batu Pahat in Peninsular Malaysia, there were about seven factories (producing a few hundred mt/month) in the mid-1980s. Some of these factories purchased wet starch from Riau for refining. With the opening up of the Batu Pahat area for oil palm and other developments, as well as the cost increase to import crude sago, only three factories remained in 2012, and probably only one is still in production, producing about 100–200 mt/month of refined sago.

Sago starch-processing technologies in the larger factories in Malaysia were mostly adopted from cassava processing, with modifications to accommodate the structural differences between sago and cassava starch. In the last 30 years, continuous improvements have been made and innovative equipment fabricated by individual factories or by local engineering workshops. The following are some examples:

6.1.2 Debarking Sago Logs

Sago starch is stored in the pith tissue of the sago palm trunk (stem). The trunk has a length ranging from 5 to 18 m and a diameter of about 25–70 cm. The starch-rich pith is enclosed in an outer layer of *bark*, and this highly lignified bark is normally removed before sago can be extracted from the soft pith. The sago trunk is normally cut into sections about 0.9–1.2 m long and the bark removed manually or mechanically. In traditional processing, bark removal is done manually by an axe or heavy knife (Fig. 6.1). A skilled worker can debark 100 sections per day, but the average is about 50. In the 1980s, mechanized debarking was developed. The trunk section, together with the bark, is split lengthwise into a few pieces. The pith side of the split trunk is placed downward on a rotary nail-studded rasper to remove the pith, leaving the hard outer bark. At around the same time, a pith chopper and scraper was also developed. In this procedure, the split trunk is placed on a conveyor with the pith side upward and carried to a set of mechanically operated choppers to cut the pith into small pieces. The depth of chopping action is adjusted so that only the pith is chopped while avoiding cutting through the hard bark. The chopped pith is then scraped out by a rotary scraper thereby removing the pith from the bark. This technique was used at Arandai, West Papua, Indonesia, but discarded after being found inefficient.

The pith scraper was replaced by the *screw mill* (Fig. 6.2a), whereby the split trunk is fed with the bark sideways onto rotary screw-like blades to cut and scrape the pith in a continuous motion. In all the above debarking operations, the capacity was small. More energy has to be used in subsequent hammer milling of the large amount of pith removed by scraper and screw mill. In the 2000s, veneer peeling machines used in the timber and plywood industries were tested to peel off the hard bark but met with little success as the soft pith made log gripping difficult. Slipping occurred if insufficient pressure is applied, and breakage happened when too much pressure is applied at the ends. Peeling machines were not adopted in any of the Sarawak sago factories.

A bark scraper (Fig. 6.2b) for timber logs was also tested in 2000. In view of the much harder outer bark and shorter length of sago log sections, various modifications to the scraper were made. The entire sago log section was successfully debarked without the need for splitting (Fig. 6.2c). Despite the bulkiness and high power consumption of the modified bark scraper, it was successfully adopted and

Fig. 6.1 (a) Manual sago trunk debarking. (b) Using an axe. (c) Using a knife

Fig. 6.2 (a) Screw mill. (b) Bark scraper. (c) Debarked section

is now in use in most of the sizable sago factories in Sarawak. A skilled operator can debark about 60–70 m per hour of trunk sections with this machine. Innovation continues, and in late 2000, a light-weight *ring debarker* operated by a hydraulic jack was fabricated by a local engineering workshop. A set of ring knives with different diameters to debark sago logs of different diameters was constructed to move on a rail. With the end of trunk section aligned to the desired ring knife, the sago log section is then pushed by a hydraulic jack against the ring knife so that the bark is cut and separated from the pith. A second-generation ring debarker was fabricated in 2013 with different ring knives fixed on a rotating wheel instead of a sliding rail. The ring debarker has a capacity similar to a bark scraper but is much less bulky and much more energy efficient. A hydraulically operated free-size ring debarker is currently being fabricated and under trial. It is aimed at simplifying and replacing the set of five rings with a single expandable ring to remove bark from sago logs of different diameters.

6.1.3 Pith Milling

Pith milling using steel nails manually fixed to a wooden drumlike rasper powered by a motor to rotate at high speed was common in the 1980s. Pieces of split sago pith are pressed against a rotary rasper to pulverize the pith and release the starch granules. Gradually, larger rasps were made to increase the rasping capacity but were limited by the use of a wooden drum for nail studding. When modernized mills employing the cassava-processing technology were adopted, a saw-blade rasper typically used for milling tapioca was tested but quickly rejected. Unlike tapioca, sago pith needs to be chipped before feeding it into the saw-blade rasper. The much higher content of fiber together with its hardness and structure/shape made saw-blade rasping inefficient. Among the drawbacks reported were fast wear and tear of saw blades as well as frequent sieve clogging. Steel drums with a quick-fit nail-studded case were then introduced and further modified to rasp the entire pith section without the need to split the pith into batons. Powered by a 60–75 KW motor, this is the most common sago pith milling equipment in Sarawak. Such a rasper is normally paired with the debarker to handle 60–70 m of sago log sections per hour. Pith rasping by a nail rasper offers the advantage of producing fine pith for

subsequent starch extraction. With a well-designed rasper, subsequent hammer milling may be circumvented to save machinery investment and energy costs. Even if a hammer mill is desired to improve extraction efficiency, less energy will be required to pulverize the fine rather than the coarse sago pith.

6.1.4 Starch Extraction

After pith pulverizing, the starch must be separated from undesired debris like fiber and cell masses. In traditional practice, coarse debris is commonly removed by sieving and finer debris separated by starch sedimentation. Starch granules are heavier and normally sink faster than debris. Before modern factories were established, rotary wooden-framed barrel sieves were used (Fig. 6.3a). These are cheap and efficient and require reduced power to run and experience little wear and tear (low speed rotation). One drawback is its bulkiness which requires a larger space for installation. When modernized sago factories were first established, using cassava extraction technology, various problems were encountered with the extractors (Fig. 6.3b) used for separating starch from fibers. Sago palms have somewhat more fiber than tapioca. Furthermore, the hardness, structure, and water-absorbing capability of sago fiber are different from those of tapioca fiber.

Adopting cassava-processing technology for sago processing without modification resulted in greatly decreased efficiency/capacity. However, problems were not uncommon because extractors were often clogged, overloaded, vibrated severely, and tore the sieves in the extractor. Sieve damage in the extractor often resulted in malfunctioning of subsequent refining equipment such as nozzle clogging in the disc separators. Fungal growth at the back screen can occur if it is not cleaned regularly and lead to fungal spore contamination of the starch. To improve extraction capacity, and reduce starch loss, more extractors (compared with cassava processing) were installed but increased the equipment investment and energy consumption. Today, extractors are being phased out, except in some factories where they are used in combination with other starch extraction equipment.

Fig. 6.3 (a) Rotary barrel sieves. (b) Vertical extractors

Some sago factories chose sieve bends instead of extractors. According to one factory operator, significant starch is also lost in discharged fiber owing to sieve clogging. The sieve bend requires regular backwash to remove clogging by the long spindle-shaped sago fibers. As compared with corn starch processing, relatively more sieve bends (repeated steps) are required to reduce starch loss. A few sago factories in Sarawak are currently using sieve bends to separate sago starch from fiber. Extractors or sieve bends are expensive equipment and consume high energy. A local engineering workshop developed the rotary sieves about 2010; improved stainless rotary sieves were fabricated to partially or totally replace extractors or sieve bends. This is now used in a few sago factories replacing or in combination with extractors.

6.1.5 Separation of Starch and Fiber in Submerged Condition: A New Concept to Be Explored

In the abovementioned equipment used for starch and fiber separation, the starch separation by forced filtration occurs when fiber containing starch milk is sprayed onto a sieve under pressure (sieve bend). In an extractor, aqueous fiber/starch mixture is fed to a fast-rotating sieve (extractor) so that the smaller starch granules are pushed out by centrifugal force. In a rotary barrel sieve, water is sprayed onto the pulverized pith on the sieve screen to wash out the starch granules. The above separation techniques often resulted in starch being trapped and lost in the discarded fiber, especially in the absence of adequate water or when sieves are clogged. In the course of laboratory experiments to filter sago starch, it was noted that starch filtration is easier and more efficient when the sieve is placed in water (as compared with washing down the starch with sieves placed above the water). Further tests were carried out in 2012 by partially submerging a wooden rotary sieve so that the starch granules are separated from fiber in water (by gravity and moving water). Promising results prompted the fabrication of a commercial-size stainless sieve for more comprehensive trials in 2014, and preliminary results indicated that:

- (a) Starch separation is more efficient than the current commercially used rotary sieves of the same size. Relatively clean fiber is discharged in a single step.
- (b) There is a significant saving in consumption of processing water because continuous spraying onto the macerated pith is not necessary. Also, water can be partially recycled to further reduce both water consumption and effluent treatment volume.
- (c) The rotary sieve, partially submerged, is powered by a 2 KW motor, and thus power consumption is greatly reduced as compared with extractors.
- (d) Minimal fiber clogging occurs as clogged fibers are automatically removed by backwashing when the drum screen rotates in water.

With further R&D, submerged starch-fiber separation may contribute significantly to the advancement of sago starch processing, with the potential of replacing existing rotary sieves, extractors, and sieve bends. It may also be applicable to other starch-processing industries.

6.1.6 Starch Slurry Concentration, Refining, and Drying

After starch extraction, the steps of refining, concentration of starch slurry, starch dewatering, and drying are almost identical to cassava processing. Disc separators are mostly used in starch refining and concentration, some in combination with decanters or hydro-cyclones to produce better-quality starch. Few issues were reported with these processing steps, and so they are not discussed further.

6.2 Sago Production in Indonesia

In Indonesia, the hub of commercial sago production is Selat Panjang, Riau Island. About 7000–8000 mt of dried sago is produced monthly. Processing is mostly done in the 50–60 small factories with capacities ranging from 50 to 200 mt/month (Jong 2000a). Sago-processing technology varies from the very traditional sago pith chopping using metal-capped wooden implement in Eastern Indonesia to modernized processing technology in large factories in Riau. Debarking is very much manually done using a heavy-duty knife. The screw mill, described earlier, is becoming popular in several factories in Selat Panjang. When the screw mill is used, the resulting pith is fed into a hammer mill for further pulverizing. In factories not using a screw mill, debarked pith batons are rasped using nail-studded wooden drum rasps. No hammer milling is carried out. Usually, a considerable amount of starch is lost because of coarse rasping which is relatively inefficient in breaking down the pith tissue. In the small factories, starch extraction is almost totally carried out using wood-framed rotary barrel sieves. Normally this is a one-step operation, two sieves in parallel for removing coarse fibers and one or two sieves for removing fine fibers (Fig. 6.3a). Starch is recovered by sedimentation in concrete tanks (Fig. 6.4a). Normally in a factory, several concrete sedimentation tanks are built, and filtered starch slurry is channeled into these tanks. Heavier starch granules sink to the bottom, and most of the lighter fibrous wastes are discharged in the overflow.

When all the tanks are filled (a few days to a week), the water is drained out. The starch cake can either be dug out manually or pumped to another tank after water is added to make concentrated slurry. The starch cake or slurry is then refined, again using sedimentation, in wooden or concrete troughs with slurry flow controlled manually by a skilled operator. The refined crude starch that settles in the trough is dug out, crushed into finer particle sizes, and mostly sun-dried. Some factories use a centrifuge de-watering device to remove water from refined crude slurry before

Fig. 6.4 (a) Sedimentation tanks. (b) Sun-drying sago starch

sun-drying. Crushed starch is spread out on a rainproof sheet measuring about 3 m × 3 m. When rain is approaching, the starch is gathered at the center, and the sides of the sheet are folded over the starch to keep off the rainwater (Fig. 6.4b).

In 2010, a 3000 mt/month modern sago factory was built at Selat Panjang and is currently in operation. In the late 1980s, medium-sized factories were also established in Halmahera (Maluku) and Arandai (West Papua) but were subsequently closed. A new sago factory (3000 mt/month) is currently being built in West Papua.

6.3 Sago Palm Cultivation in Malaysia and Indonesia

In Malaysia, sago palms are mostly cultivated in a semi-wild state by smallholders with varying plant densities. This is still the mainstream cultivation practice by most smallholders today. The total sago-growing area is difficult to estimate but is roughly 30,000–40,000 ha, with less than 20,000 ha in sustainable production. Owing mainly to non-intensive cultivation, the average starch yield is low, about 2 mt/ha/year as estimated from the export figures. The first large-scale sago plantation (7700 ha) in Malaysia was initiated in the mid-1980s at Mukah. Palms were planted rather semi-intensively on raw deep peat. The plantation was expanded to over 21,000 ha (Hassan 2002) at two nearby locations in the following two decades or so. Despite great effort to improve sago palm cultivation in the mid-2000s, the growth of most palms is suboptimal, and starch yield is generally low.

In Indonesia, sago palms are mainly cultivated in a semi-wild manner in smallholdings, similar to the practices in Malaysia. The planting density also varies greatly but on average is about 30 palms/ha (Jong 2000a). Yields also vary with some good gardens achieving about 10 mt/ha/y in some intensive sago farms (Yamamoto et al. 2008). At Selat Panjang, a 12,000 ha sago plantation (Fig. 6.5) employing improved agronomic and management practices, somewhat similar to oil palm cultivations, was initiated in 1996 on rather mature deep peat (Jong 2000b). In this plantation, sago palms were cultivated in 50-ha blocks surrounded by canals.

Fig. 6.5 (a) A commercial sago plantation at Selat Panjang, Riau, showing road made from canal dugout. (b) Nearly mature palms

The canals are used to transport farm inputs and harvested sago logs and for fire prevention/fighting, as well as for water table control. To facilitate management and reduce travel time, a base camp was built for every 1000 ha and a 10-man worker's quarter constructed for each 200 ha within the plantation. Excavated material from digging the canals was compacted to form roads for light vehicles and motorcycles to expedite supervisory work. Started in 1996, some palms reached maturity (flowering) in 9–10 years, but most palms matured in about 11 years in this plantation. It is still in production although not all the palms are in optimal growth conditions.

6.4 Natural Sago Forest Development

There are reportedly about 2 million ha of naturally occurring sago forests on New Guinea Island, consisting of Papua New Guinea in the east and the Indonesian West Papua (formerly Irian Jaya) and Papua on the west (Flach 1983). In the late 2000s, licenses were granted by local government to a few companies to develop some of the natural sago forests in Irian Jaya (West Papua). Until today, field development was observed in a private company. Prior to finalizing a development plan, aerial and ground surveys were carried out to determine the sago palm distribution, palm density, variety, morphology, as well as their starch content (Jong 2011 unpublished). Based on the aerial surveys around Timika and South Sorong, high density or nearly pure sago stands (Fig. 6.6a) were rather limited, occurring only in isolated patches. Most of the sago palms were mixed with other indigenous tree species with variable sago palm densities (Fig. 6.6b). The diameter of sago palms varied from 25 to 60 cm, normally with thick bark and a small trunk diameter at the lower trunk portion to a height of about 3–4 m, under heavily shaded conditions. The palms are tall, with trunk lengths (excluding leaves) ranging from 10 to 18 m. The starch content also varied greatly from a few percent to about 17% (dry starch: fresh trunk); the average around 10–11%. Higher starch contents were found in inhabited and more open areas leading to the conclusion that low starch content was mainly

Fig. 6.6 (a) A natural sago forest at West Papua: pure sago stands. (b) Aerial photo showing sago palms (*shorter*) mixed with other tree species

attributed to the environment (overcrowding and shading by sago palms and other trees) (data is not shown).

The varieties of sago palms found in different regions varied greatly. Over 18 varieties were reported at Sentani, Papua (Widjono et al. 2000), and over 10 on Salawati Island (Schuiling et al. 1992). Around South Sorong and Bintuni, West Papua, nearly all the naturally occurring wild sago palms are apparently of the same variety (Jong, pers. obs). Harvesting of existing mature palms followed by systematic rehabilitation is planned, and this project is ongoing by a company.

6.5 Sago Marketing

In Malaysia, about 42,000–50,000 mt of refined sago were produced annually from 2004 to 2013. Sago is mainly sold to West Malaysia and added (at 20–30%) to rice flour in the production of flat rice noodle and rice vermicelli. Despite the higher prices, as compared with cassava or corn starch, sago is preferred as it is reported by some users to have superior properties over corn or cassava starches to create rice noodles and vermicelli less brittle to handle and chewier in texture. In Indonesia, a total of about 100,000 mt/year is produced in Riau and nearby areas and sent to Cirebon, West Java (unpublished company data), for further processing or redistribution to other regions of Indonesia. Sago produces clear starch when cooked, and this property is ideal for the production of glass noodle (*so-hun*). A private company survey in 2009 found that over 90% of the sago produced in Indonesia is used for the production of glass noodles. Marketing of sago starch is mainly confined to meeting domestic demands in Malaysia and Indonesia. Apart from domestic consumption, Malaysia also exports some sago starch to Japan, reportedly for use in coating noodles. Commercial production of sago in other countries like Papua New Guinea, Thailand, and the Philippines is relatively small and mainly for local markets.

6.6 Potential and Challenges in Future Development

6.6.1 *Potential of Sago Palms*

Sago palm is a high energy-yielding crop, and estimated yields of 25 mt/ha/year of dry starch have been reported (Flach 1983). An intensively cultivated sago farm, harvesting over 100 mature palms per ha (about 20–30 mt dry starch), is achievable in a particular year, but palm yield will decrease in subsequent harvests, dragging the average yield down significantly over a longer period. Recent studies by Yamamoto et al. (2008) indicated that a sustainable dry starch yield of 10 mt/ha/year is achievable on a relatively good farm.

Other advantages of sago palm cultivation are:

- (a) It has a perpetual economic life owing to its sucker (offshoots) regeneration capability. The offshoots produced by sago palms have very strong growth vigor. In sago-growing areas in Sarawak, most sago gardens have been passed down for generations with minimal maintenance or replanting and are still in sustainable production.
- (b) Sago palms can tolerate flood conditions very well. Aerial roots are produced under continuously inundated conditions enabling them to outcompete most other plants in swamp lands.
- (c) They are very adaptable to a wide range of soil pH. Sago palms are found growing from acidic to limestone areas.

The major disadvantage of cultivating sago palms is the long juvenile phase of about 10 years. Because of this, financial institutions are unwilling to support sago plantation projects.

6.6.2 *Sago Starch Potentials*

Starch is in demand as a commodity for both food and industrial applications. As such, sago starch should be able to gain a share in the huge world starch market. Sago has unique properties that render it ideal in specific applications (Hamanishi et al. 1999). Among these properties are large starch granules, clear gel, high swelling power, non-gluten, and slow in releasing sugar. Currently, its gel clarity property is utilized in the glass noodle and vermicelli industries, and other properties have yet to be commercially exploited. On the other hand, sago starch can be used as a multipurpose raw material for both food and nonfood applications such as in the fermentation industry. Because of its high yield and other advantages over most other crops, sago could be competitively produced for such applications.

6.6.3 Market Challenges

Sago starch is relatively unknown to the international starch markets owing to its limited production for domestic demands in major producing countries like Malaysia and Indonesia. Currently selling at about USD 700/mt FOB Sarawak, refined sago is, respectively, about 35 and 20% more expensive than cassava and corn starches. As such, corn or cassava starch buyers are not willing to consider sago for their existing uses. Because of its unique properties, refined sago starch could be used in more specific applications. However, potential new buyers that require such starch properties are unfamiliar with sago and need to be educated and convinced through further R&D before being considered together with other factors like cost advantages, quantity and constancy of supply, as well as suitability/modification of the existing setup if sago were to be used. Thus, before refined sago can be readily marketed internationally, more R&D on its properties and applications, followed by aggressive product promotions, need to be looked into. A more plausible way is to market sago as a raw material for fermentation and modified starch industries. Crude sago without refining could be produced more competitively than refined sago especially in areas where the sago palms are plentiful and cheap, e.g., from the million hectares of natural sago forests in Papua New Guinea and West Papua. A commercial processing line to produce sago without added water would be ideal to produce sago at a competitive price for the fermentation as well as health-food industries. In such a process, proteins, minerals, sugar, polyphenols, and other nutrients will be retained. There will be no effluent, and all by-products will be utilized in the process (e.g., bark for fuel, fiber for feed and biofuel).

6.6.4 Development Challenges

Large-scale commercial cultivation of sago palms is limited mainly because of its long growth period of about 10 years before being ready for harvest. In fertile soil and with good care, some sago palms in mine tailing areas at Timika (Papua, Indonesia) reached maturity (flowering initiation) about 8 years from planting. On poor soil, such as deep peat in Sarawak, palms may take 15 years or longer to reach maturity (Tie et al. 1987). In Riau where a large-scale sago plantation was established on semi-decomposed deep peat, about 30% of the palms attained harvesting stage in about 11 years (Jong, unpublished). The long juvenile phase of sago palm is extremely unfavorable for project financing from commercial banks, and thus large-scale sago plantations are very rare. In the 2 million ha of natural sago forests, young sago palms are continuously generated either from offshoots or from seeds to

replenish the older palms. The palms are in various stages of growth, from seedlings to overgrown/dead palms. In a census done in 2009–2012, there were on average 32 mature and harvestable palms per ha. The highest category is actually represented by overmatured palms, about 50/ha (Jong, unpublished). In a dense sago forest (>70% sago palms) at South Sorong, an estimated 5 mt of dry starch per ha can be harvested immediately by cutting mature palms. It appears to be quite a simple task to harvest the mature palms and rehabilitate the younger follower palms into sustainable sago plantations because no waiting time and planting costs are involved. However, in reality, as personally experienced in 2010–2012, there are several challenges to the harvesting and developing of these natural sago forests into sustainable plantations:

- (a) Geographical remoteness: this makes mobilization and logistical costs very high for personnel, equipment, farm inputs, as well as transporting finished products.
- (b) Lack of technical expertise: sago cultivation, rehabilitation, and processing are new to most investors, and there is limited expertise in this field.
- (c) High infrastructure development costs: sago forests are normally located in swampy areas, and costly infrastructure has to be developed to facilitate harvesting and mobilization operations.
- (d) Sago palm ownership and compensation: this is a rather complicated matter. All the land and sago palms belong to the local communities (by virtue of native customary rights), and negotiation has to be made with regard to royalty and other fees for any development. It is also a time-consuming process involving multiple meetings with local communities and governmental authorities.
- (e) Social and security issues: this may be one of the biggest challenges of all. Issues may frequently arise from unforeseen land ownership disputes among family members, clans or tribes, absentee owners, or unexpected requests by local people. Misunderstandings or miscommunications between investors and local people may result in temporary protests or blockage of operations.

Despite the above challenges, it is not impossible to solve them. With time and innovative approaches, as experienced in the development of other projects, sago forests are expected to be sustainably developed to supply an alternative source of starch to benefit local people and consumers.

6.7 Conclusion

Commercial development of the sago industry is slow. Despite the great potential of sago palms, and contributions from 11 international sago symposia to create awareness and promote sago in the last 40 years, little realization has been achieved in cultivation, production, and marketing. Since the First International Sago Symposium in 1976, improved sago processing did gain momentum in the mid-1980s in Sarawak and the late 2000s in Indonesia. More efficient sago-processing equipment was developed and adopted by sago factory owners or local workshops. However, all these were at a relatively small scale, and total commercial sago productions today remain relatively unchanged. Apart from the two sago plantations mentioned, there have been no new and large-scale developments. Established on deep peat soils, palm growth in both of the two plantations are not in optimal condition owing mostly to the poor soil conditions. Cultivation of sago palms should be avoided on deep peat unless they are for noncommercial purposes. Commercial-scale development of natural sago forests in West Papua began in 2010, and its progress has yet to be followed. Only a success story will convince other investors to participate. The abovementioned challenges in cultivation, shortage in expertise, sago forest development, processing, and marketing need to be critically addressed in order to improve, promote, and attract investors to expedite the development of the sago industries.

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