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Explaining the "Underutilization Phenomena" of the Sago Palm in Papua New Guinea:

Evidence from Malalaua Area

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Abstract

This study reports the empirical results of 51 surveyed sago farmer households in three randomly selected villages: Keke/Tapala, Heatoare and Savaiviri in sago using agrarian societies (SUAS) in Malalaua District of Gulf Province, Papua New Guinea. Dissecting the socio-economic aspects of a plant genetic resource (PGR), the sago palm by drawing on its beneficial and adaptive role in these relatively underdeveloped rural agrarian areas, this paper attempts to transcend on its sublime nature so as to clarify the causal principal factors behind the "underutilization phenomena". About 3,072 sago palms are cut and processed for starch per annum in SUAS in Malalaua area. Of this total, about 70 percent of the sago starch is sold, while the remaining 30 percent is kept for household consumption. On average, it takes about 11.6 hours for 5.4 individuals in a group contributing about 62.98 manhours to process a bole of sago palm for starch therein. About 110 kg of starch is produced per bole of sago palm, which is a function of the traditional tool ("*movora*") used and the piths washing method applied in the process. This traditionally processed starch output in Malalaua area is comparatively lower than an expected optimal starch yield of more than 240 kg obtained from machine-operated sago factories in Sarawak, East Malaysia.

Key words: Malalaua area of Papua New Guinea, Sago Palm, Sago Using Agrarian Societies (SUAS)

I. Introduction

Papua New Guinea has over a million ha of sago palms (Flach 1997; Jong 2002); of which 300,000 ha are accessible and harvestable (Newcombe *et al.,* 1980). Flach (1997) postulates that there are about 400,000 ha of sago palms growing wildly, and about 5,000 ha semi-cultivated in Gulf Province. Sago palm, a staple food crop (Townsend 1982; Ulijaszek 1995), let alone, a renewable resource grows abundantly in Gulf Province of Papua New Guinea (Laufa 2001). Mature palms when harvested can fetch between 250 kg to 400 kg of sago starch per bole, if cultivated and managed as a horticultural crop as is practiced in Malaysia (Bujang & Ahmad 1999; Chew *et al.,* 1999; Power 2002) and Indonesia (Bintoro 2002; Oates *et al.,* 1999). Sago is widely consumed, depending on the methods of preparation used throughout Papua New Guinea and the Malalaua area is no exception (Sopade 1999; Laufa 2001). Sago making in Papua New Guinea is characterized as traditional (micro-scale) processing and

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correlates with "low starch productivity", owing to the manner of exploitation of this staple food crop (Oates *et al.,* 1999; Oates & Hicks 2002).

Against this beguiling scenario, this study takes a Kantian transcendental approach in pursuing two specific aims, which necessarily prescribes an aesthetic task of interpreting the sago palm situation in Papua New Guinea. Firstly, to provide an epistemological basis for this low starch productivity, of which, the author describes it as the "underutilization phenomena" of the sago palm in SUAS in Malalaua area of Papua New Guinea. Secondly, to formalise the concept of the "underutilization phenomena" of the sago palm, of which its inspiration is drawn from sago palm's sublime nature, how it intricately links with indigenous people, in what is best described as a symbiotic partnership of people and plants in distinctive communities. It shall be clarified at the outset that, SUAS[1] are collectively conceptualised as an attributive concept that supports the view that where sago palms grow, especially in the rural agrarian localities in Pacific Islands and Southeast Asia such as those in Papua New Guinea, Vanuatu, Indonesia, Malaysia, Philippines, among others, the indigenous people have established an interactive intimacy with sago palm, utilizing it as either a food or material source. The paper begins by exploring the nature of sago agriculture and characterises it; then dwells on conceptualising the "underutilization phenomena", of which the principal factors are described, measured and discusses some of the measures through policy prescriptions for addressing these in the sago palm industry in Papua New Guinea.

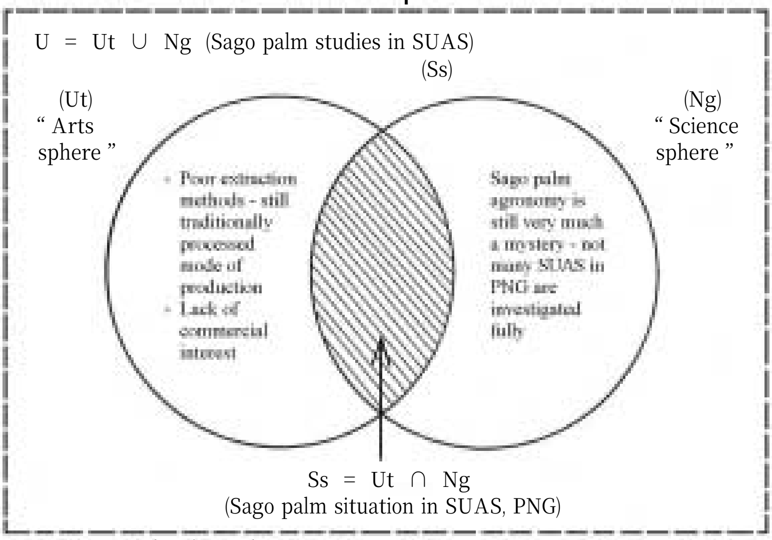
I .1 Is Sago Agriculture in Gulf Province Horticultural? Exploring Its nature

Horticultural practice in Gulf Province is characterised by mixing crop system, which typifies a risk aversion strategy for unforeseeable crop failure or bad harvest. On sago palm, it cannot be classified as a horticultural crop, as much of it is gathered and harvested from wild stands (Hide *et al.,* 1993; Vasey 1985). This is quite evident in Papua New Guinea, of which two well-documented studies by Carl Sauer (1952) and by a Japanese botanist, Sasuke Nakao (1966) highlights this view on explaining people's attitude towards agriculture; how they related to crops, as is cited by Toyoda (2002), on a comparative study on various crops affecting the anthropological and socio-economic relationships of people in Wenjeaka village in Sandaun Province, Papua New Guinea. Toyoda (2002) delineates the contribution by Nakao (1966) on the vegeculture concept; cited as the "Nakao theory", which describes at least three agricultural systems in the New World. The Nakao theory attributes the use of seeds as a horticultural practice; quite a recent phenomenon, compared to vegetative cropping patterns by people and how they have adapted in time. The Nakao theory describes the socio-cultural attitudes of people to sago palm cultivation for use as a food crop and the technology used for sago starch extraction, as elements of the vegeculture concept. The vegeculture concept refers to a culture, in which plants are propagated as suckers rather than seeds. Sago cultivation is mainly through suckers than the seeds (Oates *et al.,* 1999), depending on whether sago palm management with respect to its rate of intensive exploitation focuses on leaves for thatch or subsistence by people in SUAS today.

Ⅰ.2 "Underutilization Phenomena" of the Sago Palm: What are the principal factors?

The Dutch agronomist Flach (1997) observes that the sago palm is still very much an "underutilized" and "neglected" plant. The author illustrates this bifurcation of sago palm studies[2] in

Figure 1 Venn diagram depicting the sago palm situation in SUAS in Malalaua Area of Papua New Guinea



Source: Drawn by the author.

Fig. 1 below, using a simple set notation so as to abstract from a complex reality. Some researchers have postulated that the sago palm not only has the latent potential for providing rural income source for sago farmers in SUAS, but can also meet the rising demands of other food industries and other industrial needs for biodegradable plastics (Allen & Hornung 2002; Chulavatnatol 2002; Doelle 1998) after repurchasing sago starch for reprocessing (Oates 1999; Oates & Hicks 2002). If people in SUAS have been subsisting on sago palm, adopted technologies and adapted these to their living conditions in the past, then surely there must be a way of improving and adapting to more advanced systems of starch production by articulating this traditional mode of production and utilization to a higher form of technology application for food and other industrial materials.

Critical aspects of developing the sago palm industry in SUAS in Malalaua area require careful articulation by deciding which areas need to be developed first in the technology adaptation process. Equally important, is the need to articulate the production and management systems to suit an appropriate level of technology where practicable. How to "negate" these labels of "underutilized" and "neglected" associated with the sago palm, is a task that is conceived very much an art, rather than a science. Thus how to improve sago palm productivity by negating the principal morbid symptoms so as to promote a threshold of new opportunities, remains unresolved. Science provides solid research on sago palm's general and specific genetic properties, among other things; however, much of the agronomic management science of sago palm is still left wanting. Moreover, these scientific studies are only confined to specific locations, of interest to those researchers, even to this day. Science's positivist extrapolations and explanations, it can be argued, partly share the reprehensibility for the "knowledge gaps; hence the ensuing debate about sago palm's "negligence" in essence. Meanwhile, the 'art' sphere is also blamed for not taking concrete steps to commercialize sago palm so as to realize the potentials that science has investigated and reported for commercial and industrial uses, which is manifested in Papua New Guinea. Superior qualities of the sago palm are emphatically promoted (Allen & Hornung 2002; Stanton 1993), yet affirmative actions to bring these aspirations into reality remains unfulfilled. Nonetheless, these artificial scientific and socialists enterprises are merely half travelling the journey of sago palms' full utilization.

II. Methodology of the Present Study

The present study drew from three main sources: (1) from the author's sago survey results; (2) actual on site observations during field surveys in 2000 and 2002 and (3) relevant literatures, which are used for analytical purposes herein.

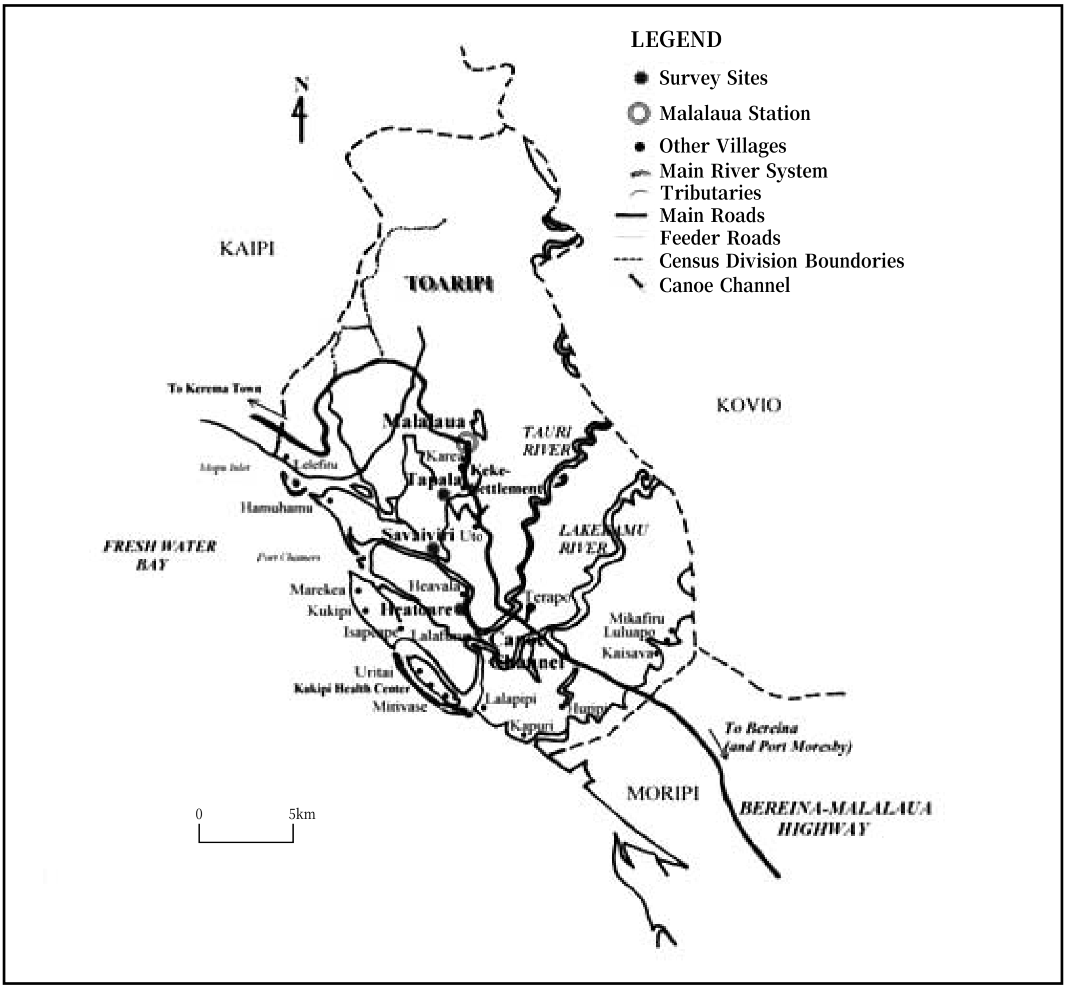
II. 1 Brief description of the research sites

The research sites showing the three villages: Heatoare, Keke/Tapala and Savaiviri in Malalaua District of Gulf Province are featured on the map (Fig. 2), whilst demographic details are presented in Table 1. Malalaua district covers 402,700 ha, of which the surveyed sites in Toaripi census division cover an area of 62,500 ha and has abundance of sago stands in semi-wild condition clustered around the Taure and Lakekamu river basins, covering about 15,000 ha of this census division. From district level assessment, only 4% (15,000 ha of the 402,700) of the total area is covered by sago stands, thus alluding to the possibility that there is scope for establishing sago plantations on some of the available marshy peat soils. Meanwhile Keke is a settlement within Malalaua District headquarters whereby her inhabitants are from the main Tapala village, thus for this study, it is labelled as Keke/Tapala. Prior to the 1995 provincial government reforms, the administrative region for these villages was called Mailovera constituency, now referred to as Taure/Lakekamu Local Level Government (LLG) area in the post-reform period henceforth (Laufa 2001).

II. 2 Materials for the Study

Relevant literature from other sago palm studies were used for comparative purposes, whilst provincial information on census divisions, indicating the district boundaries for the surveyed villages, including mapped information was retrieved and modified after the *1978-79 Provincial Data Systems (PDS) Rural Community Register*. Demographic data for the research sites were obtained from the

Figure 2 Map Showing the research sites of sago using agrarian societies (SUAS) in Malalaua District, Gulf Province of Papua New Guinea.



Source: Drawn by the author.

National Statistical Office. These materials were supplemented, for comparative purposes, with text summaries, maps, code lists and village identification for Gulf Province. Topographic survey maps for Malalaua District were obtained from National Mapping Bureau GPS survey (2000); redrawn and modified for the purposes of this study.

Table 1 Basic Demographic Details of the research sites

Census Units (CU)	No. of house holds	Population as at 1990 Census		
		Male	Female	Total
Keke stmnt	26	82	86	168
Tapala	45	152	113	265
Heatoare	171	513	457	970
Savaiviri	67	191	192	383
TOTAL	309	938	848	1,786

Source: National Statistical Office, PNG.

II. 3 Data collection methods

Data were collected in two socio-economic surveys in 2000 and 2002 (Table 2), using prepared questionnaires and semi-structured interviews in selected SUAS. The surveys focused on: (1) “stock of sago palm” (existing number of sago palms owned); (2) “flow of sago palm” (sago starch production situation in SUAS; (3) productivity (manhours per sago bole) in sago making process in SUAS and (4) rural income from sale of sago starch; a function of parameters (2) and (3). Secondly, actual observation of sago making process, utilizing the Rapid Rural Appraisal (RRA) method was undertaken in complementing the data collection efforts for map drawing and Venn diagrams of observed phenomena, through personal communication with “key informants” cognizant of traditional knowledge on the intricacies of sago palm in Savaiviri village. This provided the basis for reporting some of the underlying subtleties associated with aesthetic interpretations of the sago palm situation in the Malalaua area.

Table 2 Showing sampled sago farmer households in SUAS

Year	Keke/Tapala	Heatoare	Savaiviri	Total
2000	12	7	0	19
2002	8	0	24	32
Subtotal	20	7	24	51

Notes: Let Sample (I) be data collected in 2000
Let Sample (II) be data collected in 2002
Let the Population (N) be Samples (I) and (II) combined.
Source: Author 's sago surveys.

Table 3 Showing Percentage of Sago Farmer Households

Village	Total no. of households	Total no. of sago farmer households	Sampled no. of sago farmer household	Sago farmer household interviewed (%)	Sago Farmer household (%)
Heatoare	171	16	n= 7	43.7	9.4
Keke/Tapala	71	36	n= 20	55.5	50.7
Savaiviri	67	42	n= 24	57.1	62.6
TOTAL	309	94	N= 51		

Notes: Information on households was obtained from National Statistical Office, which was complemented by author 's field surveys and personal communication with key informants in Malalaua District.

II. 4 Specification of the principal issues for measurement and analysis

There are at least three principal issues worth studying the forms of interaction among explicit, implicit and embodied ideas pertinent with the “underutilization phenomena” of the sago palm in the study area, which are specified, measured, and analyzed in the discussion to follow: They are: (a) land tenure arrangements; (b) sago palm ownership and mode of acquisition and (c) sago starch production and utilization systems in SUAS.

(a) Land tenure arrangements

Land tenure arrangements in SUAS in Malalaua area are predominantly characterized by collectivism, through which available natural resource base is determined. Identifying the landowner groups by establishing their use rights and evidence of physical occupation, let alone other traditionally identified landmarks, have all been used as criteria in land mediation tribunals, after land disputes arose between various clan groups. Thus, sustainable and commercial exploitation of natural resources anywhere in Papua New Guinea; unequivocally, rests on dealing with the sensitive matter related to land use rights.

(b) Sago palm ownership and modes of acquisition

Sago palm ownership and its modes of acquisition are critical determinants of the production and social relations in SUAS, thereby influencing the overall consumption situation in the Malalaua area. To cut and process sago palm for starch at the outset, one has to at least own sago palm, or be invited to exploit it, therefore implicit or embodied ideas about sago palm proprietorship has a bearing on how much can be produced, and if there are conflicts about proprietorship, then it may have negative social consequences such as miserable conditions of poverty and hunger. Rural development initiatives for promoting more commercially oriented sago production and utilization of its starch; thereby moving the sago palm industry from that of traditionally oriented system to a more mechanised system is dependent on reducing social conflicts and enhancing social relations within SUAS. Modes of acquisition of these sago palms were investigated to clarify the ownership structure so as to determine how this influences overall sago starch production and utilization systems.

(c) Sago starch production and utilization system

Sago starch production and utilization system was investigated through the socio-economic surveys to establish two key determinants. Firstly, on the labour and effort expenditure to ascertain the prevailing sago starch productivity, using the unit manhours per sago bole. Secondly, drawing on from the production aspect is to establish the purpose of starch utilisation thereafter. Utilization system of sago starch is a critical area of inquiry to assess whether the utilization of starch's orientation is on sale at local markets or for self-consumption at the household level. The determined sale and self-consumption ratio, to an extent, indicates the supply conditions, which could be further developed by articulating the relations among the factors of production used to produce more commercially oriented sago starch for domestic and the international markets in future.

II. 5 Income Analysis

Income analysis for SUAS with respect to the three villages covered, are calculated using the results obtained from sago starch production and utilization parameters as specified. The number of sago palms cut and processed per month annually and the mean of sago palms owned by each village are extrapolated in the results section. The aggregated results of the income analysis for SUAS are used for determining individual sago farmer households' income in Malalaua area.

III. Empirical Results of the Study

III. 1 Land tenure arrangements

Based on the sago surveys and personal communications with key informants, it was established that land tenure arrangements in SUAS in Malalaua area still practice collectivism for defining land use hitherto and do influence sago starch production and utilization. Sago farmers have an equal right to ownership of a parcel of land; however, primogeniture rights apply wherein the elder sons in different clans wield more power over land use in ancestral lands in Malalaua District. Throughout the Malalaua area, the customary practice of land acquisition and taking decisions on behalf of a clan is still the province of the eldest sons; reflective of a patrilineal society.

While this view and customary practice is still applicable and enforced by established mores, there are few exceptions to these modes of acquisition on a case-by-case basis, wherein, a clansman who has occupied and worked a parcel of land for many years, may acquire more underutilized land for one's self-interest, based on mutual agreement with clan elders. This proviso is a source of conflict amongst other clan members, who may envy this particular person and dispute any ownership claims, especially during the negotiation phase with other stakeholders for natural resource development purposes. Land tenure disputes are mainly triggered by economic interests; for instance, the proposal to invite investors to commercially exploit natural resources such as sago palm for starch for either domestic or international markets. While seniority in land acquisition along the lines of favouring male-dominated exercise and control of customarily owned land is explicitly acknowledged, the onus is on individuals to utilize the land by making gardens or undertake other land use activities to sustain their livelihoods. In principle, the female gender's rights to land use and its subsequent acquisition after marriage is restricted to making gardens only and not to permanently occupy the land and wrestle claim from the male folk.

Restricted rights to land use from gender-based perspective has been the established and practiced more in the area since prehistoric times up to the present time. Therefore, exercising control over land and its mode of acquisition, presents a diachronic perception that long time series on information on one locality with respect to traditional knowledge dissemination and practice in land acquisition in these societies characterises its spatiotemporal transition as opposed to synchronic view, which covers short time series over a large area, considering time frame and coverage between indigenous knowledge and international knowledge (Mathias-Mundy 1996 citing Wolfe *et al.,* 1991).

Combining indigenous knowledge and international knowledge in view of land tenure arrangements in Papua New Guinea, at a level of generality, requires finding a creative response (Goava 1996: 65), in counter arguing why there is strong perception that customary land tenure appears to be the biggest obstacle to development in Papua New Guinea. The Land (Tenure Conversion) Act (1963) enabled the Land Titles Commission to convert customary tenure into freeholds. One of the purposes was to enable guaranteed individual titles to be issued to citizens to promote agricultural development (Goava 1996; Manda 1996). Another important piece of legislation for clear demarcation of land tenure purposes is the Land Groups Incorporation Act (1974), wherein landowners groups can voluntarily register their parcels of land and develop it further themselves or allow foreign investors to develop it through joint venture arrangements. This effectively applies to landowner groups in SUAS in the Malalaua area to exercise that option for more secure participation in resource exploitation from commercially oriented standpoint.

From socio-cultural contexts, Rhoads (1980: 19) argues that the degree of sago palm management is equally important in explaining land use patterns of SUAS in Papua New Guinea. Three patterns of land use strategies are reported by Rhoads (1980: 94-96). Firstly, there is extensive resource exploitation either from nuclear settlements, or dispersed hamlets. Secondly, the seasonal resource exploitation, which takes advantage of dry season hunting opportunities and thirdly, localized resource exploitation by sedentary groups who are able to subsist on resources very close to their settlements. The situation in Malalaua area ascribes to the first and third types mentioned by Rhoads (1980).

III. 2 Sago palm ownership and modes of acquisition

Sago palm ownership and its modes of acquisition mirrors the aesthetics of the sago palm from its traditional and contemporary management practices, which transcends on the interactive intimacy established between the indigenous peoples, the sago palm and the land. The percentage of sago palm ownership and modes of acquisition for the three surveyed villages are presented in Table 4. Moreover, Tables 5, 6, 7 and 8 give insights to the subsequent discussion on sago palm production and utilization in Malalaua District. There are three ownership types, namely: (1) from heritage entirely; (2) acquired via both heritage and self-cultivated and (3) entirely self-cultivated. Firstly, from heritage alone, that is claims made by ancestors and passed on from one generation to the next by way of folklore and physically showing one where their sago palms to be harvested are located, with reference to distinguishing landmarks. This is to differentiate from other people, who may have ownership claims to adjacent sago palm groves nearby.

Secondly, from partially inherited and self-cultivated methods as a mode of ownership means that whilst using sago palms accessed or acquired on the basis of genealogical claims, sago users also grow their own sago palms, either through vegeculture or seed planting to replenish stock of sago palms for future consumption. This mode of sago palm acquisition generally reflects the ownership structure of sago palm in SUAS in Malalaua District, and could well explain the situation elsewhere within the province. Thirdly, the “self-planted” ownership type is relatively small and is a recent phenomenon, which widely appeals to sago farmers who have been cultivating small sago palm groves within the sago palm forests (*cf.* Huber 1978) or near their houses and are gradually departing from the other cited types.

From the data (Table 4), the third type may not face problems in the future, as proprietorship is clearly demonstrated, unlike the other two modes of acquisition, which may encounter difficulties, arising out of commercial interests from a speculative viewpoint. The situation for the third type of exercising control over sago palms in the Malalaua area also reflects propinquities of the Malaysian experience, in that the latter is predominantly managed sago gardens (Flach 1981; Oates *et al.,* 1999; Power 2002), which means that asserting control over sago palms for subsequent commercial purposes is manageable. Conflicts emanating from proprietorship issues over sago palms would aptly reflect social struggles and relations among the production factors of labour and the existing stock of sago palm itself, be it semi-cultivated or from harvesting from wild stands (*op.cit.* Hide *et al.,* 1993; Vasey 1985).

By and large, the main mode of acquisition (mixture type) of sago palm for starch as food and is closely correlated with high incidence of claiming ownership through kinship ties. Therefore, ownership of sago palm stands arising out of heritage claims is synonymous with harvesting from wild stands. Frequent interactive intimacy with the existing stock of sago palms for either harvesting for food or for thatch for roofing materials on particular sago groves, to an extent, indicates management of the sago palm. Therefore a subtle ownership type, with specific reference to genealogical claims can be measured and characterised with some assurance. Social mapping for showing clear ownership claims, as is pointed out by Power (2002) appears to be an effective medium through which to identify and organize sago starch utilization on a more commercially oriented basis.

Table 4 Percentage of Determination of Sago Palm Ownership by types

Sample size (n)	Village	Heritage (%)	Part from heritage and part grown by sago farmer (%)	Grown by sago farmer (%)
n= 7	Heatoare	—	100	—
n= 20	Keke/Tapala	45	45	10
n= 24	Savaiviri	62.5	37.5	—

Source: Author 's questionnaires surveys of 2000 and 2002.

Traditional knowledge on sago palm management studies in Papua New Guinea is well documented in the literature. For instance, (Rhoads 1981: 48-49, 1982: 24) delineates three levels of sago palm management practiced in different parts of Papua New Guinea. Firstly, at the simplest level, repeated exploitation of palms is a kind of ‘unintentional’ management, which helps maintain the stand in good condition. The second level of management is horticulture, which involves planting seedlings or suckers. The third level is palm cultivation, which involves modifying the environment by clearing the rainforest canopy or creating artificial swamps. In a study on the Angorr with respect to sago forest clearing by Huber (1978: 165), reported that the labour input in this activity was regarded as a transfer of ownership of the palm to the person who cleared the garden. Forest clearing, to an extent, encourages the growth of the palms (Huber 1978) by increasing access to sunlight and air (Flach 1981). Having briefly surveyed the nature of land use strategies and traditional sago palm management from a three perspectives by reviewing (Huber 1978), attention is shifted to issue of sago palm ownership in SUAS in Malalaua area.

Table 5 shows the number of sago palms owned by each village. These totals are aggregated estimates provided by sago farmers interviewed during the surveys. There is no correlation between the number of sago palms owned and the number of sago palms processed per annum. This presents a peculiar difficulty in measuring the exact number of the existing stock of sago palms in semi-cultivated conditions as many sago farmers can only indicate how many palms they own by giving estimates. Accessibility to the sago palm groves is quite difficult; only those near the river are harvested frequently, while the rest tend to be neglected and left to undergo natural processes of forest rehabilitation. Evidently, ownership of sago palms is implicit to the mode of acquisition and that a "non-horticultural" practice defines its exploitation in every respect.

Table 5 Stock of Sago Palms Owned per village

Sago Farmers	Village	Sago palms
7	Heatoare	320
20	Keke/Tapala	5,589
24	Savaiviri	9,472
51	TOTAL	15,381

Notes: Total number of observations N=51
Cf. the raw data in Table A-1 in the appendices.
Source: Author 's sago surveys.

III. 3 Sago starch production and utilization system

Table 6 shows the number of sago palms cut and processed by sago farmers in each village surveyed and typify the production possibility of sago palm starch production of SUAS within the Malalaua area in any given year. Table 7 shows the number of sago palms processed per month, as disaggregated from Table 6. The monthly mean of the mean number of the sago palms processed in SUAS stands at 4.9 palms; hence, about 5 sago palms are cut per month by a sago farmer for starch processing for either food at household consumption or for sale at local markets.

Table 6 Sago Palms processed (flow) per annum

Sago Farmers	Village	Sago palms
7	Heatoare	150
20	Keke/Tapala	1,580
24	Savaiviri	1,342
51	TOTAL	3,072

Notes: Cf. the raw data in Table A-2 in the appendices.
Source: Author 's sago surveys.

Table 7 Sago Palms Processed on a monthly basis per annum for each village

Village	Number of sago palms processed per month												
	January	February	March	April	May	June	July	August	September	October	November	December	Annual Total
Heatoare	14	10	10	7	11	14	16	16	12	15	17	8	150
Keke/Tapala	132	130	127	127	129	136	129	133	130	136	130	141	1,580
Savaiviri	117	108	101	101	110	104	114	112	113	111	122	129	1,342
Monthly total	263	248	238	235	250	254	259	261	255	262	269	278	3,072
Mean	5.1	4.8	4.6	4.6	4.9	4.9	5.0	5.1	5.0	5.1	5.2	5.4	1,042

Notes: The mean no. of sago palms per month were divided by population; N=51 cases.
Cf. the raw data in Table A-2 in the appendices for individual sago farmer's output per month.
Source: Author 's sago surveys.

For the number of sago palms traditionally processed per annum by each village as per Table 6 and Table 7 respectively, the following can be compared. Heatoare village processes about 150 sago palms per annum, a mean of 21.4 sago palms; a standard deviation of 8.36. Keke/Tapala processes about 1,580 sago palms per annum; a mean of 79 sago palms, and standard deviation of 44.0. Finally, Savaiviri processes about 1,342 sago palms per annum; mean was 55.9 sago palms, and standard deviation of 47.47.

Sago Palm Processing for Starch in SUAS in Malalaua Area

Main phases of sago palm processing for starch are described here beginning with selection of sago palm stands occurring in semi-cultivated condition in SUAS in Malalaua area. Before the onset of flower initiation, sago stands are selected at a particular location; then felled using a steel axe. Immature sago suckers near the felled sago palm are either uprooted or pruned to clear the place for cutting off sago leaves from the felled palm for pith extraction from the trunk. Depending on the size of the group for sago making on a given day, the tasks are normally divided among individuals, reflective of the social make up of the group and demonstrably underlies the importance of burden sharing of tasks for much-needed food as a staple for either self-consumption or for sale at local markets.

Gender-specific tasks are clearly shown whereby the men usually fell the palm with a steel axe, cut off the branches and mark intervals on the trunk. The first stage of processing sago pith to extract starch is to separate pith from the bark and this signifies the debarking process (Cecil 2002; Oates *et al.,* 1999). The intervals marked on the trunk are suggestive of division of labour during the sago pith extraction process, using a traditional tool called the "*movora*" (Photo A). The men folk take turns to extract the piths; an indispensable process in the entire sago making expedition, which then initiates piths washing. The women also participate in pith extraction process too, depending on the number of individuals in a sago-making group. An all female group of about three can work through the entire day or two to make sago for their families.

Traditionally speaking, men are not involved in sago piths washing, which constitutes an established more in SUAS in Malalaua area, thus piths washing (Photo B) is considered a woman's task. This division of labour aptly shows a gender-specific task in sago making with respect to washing, or kneading to extract starch. From actual site observations, while the men are involved in sago pith extraction process, the women simultaneously do the pith washing after someone rests to allow for another to assume the task. During resting time, the women collect the piths for pulverizing by kneading with the hands. For the kneading process, which utilizes water from a nearby river, a chute is prepared, using the bark of the sago palm to act as a transport vessel to permit the washed starch extracted from the pith to travel down and collect in a trough made of nipa palm fronds at the base of the chute. The pulverized pith percolates through a coconut frond, serving as a traditional filtering system. Some sago processors lately have adopted fly screen obtained from hardware stores to replace the coconut frond. In any case, the coconut frond is a natural filter and still performs the task satisfactorily.

Photo (A) showing a man extracting piths using adze-shaped tool called "*movora*" in Malalaua Area, Papua New Guinea

Photo (B) showing a woman in Malalaua area, Papua New Guinea squeezing the sago piths using her hands (kneading)

Source: Author's sago survey 2000 in Keke/Tapala village.

From selecting and felling of the sago palm to its eventual processing to obtain starch, the time taken during the following phases from cutting of sago palms, extraction of sago piths, kneading sago piths, precipitating sago powder and eventual packing of sago starch is provided in Table 8. The total and average times in hours are given and are used to calculate the required manhours, using data from two samples and comparing this with the total number of observations.

Table 8 Time taken (in hours) for micro-scale sago starch processing showing different Phases per sago palm bole

Parameters	Cutting of sago palms		Extraction of sago piths		Kneading sago piths		Precipitating sago powder		Packing sago starch	
	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean
Sample I	27.10	1.42	76	4.00	32.5	1.71	35.75	1.88	26.16	1.37
Sample II	15.86	0.49	151	4.71	186.0	5.81	19.79	0.61	20.23	0.63
Population	42.96	0.84	227	4.45	218.5	4.28	55.54	1.08	46.39	0.90

Notes: See the raw data presented in the appendices (*cf.* Table A-4) for Tables 8 and 9 respectively.
Source: Author's sago surveys

The total number of hours for the five phases is 590.39 hours by combining samples (I) and (II), has a mean of 11.6 hours for the entire duration of sago making on a given day in SUAS. The mean size of a group for sago making for the population is 5.43 individuals. Sample (I) obtained a total of 196.51 hours and mean of 10.34 hours; comparable to the mean of 10.64 hours reported in a study by (Ulijaszek & Poraituk 1993). Sample (I) had a mean of 7.31 individuals in a group. Sample (II) had a slightly higher total of 393.88 hours and recorded means of 12.3 hours and 4.31 individuals in a group respectively. Summarised results in Table 8 are used to calculate the number of manhours per sago bole provided in Table 9 below. The number of manhours was determined by multiplying the means of the number of hours taken in the entire sago making process with the mean of the number of individuals in a group. Here sample (I) shows that 75.58 manhours are required for sago starch to be produced per bole of sago palm; sample (II) requires 53.01 manhours per sago bole, while considering the population, 62.98 manhours are required per sago bole.

Table 9 Showing Manhours for traditional sago making in SUAS in Malalaua Area per sago palm bole

	TIME TAKEN (hours)		LABOUR (Number of individuals)		MANHOURS
	Total	Mean	Total	Mean	
Sample (I)	196.51	10.34	139	7.31	75.58
Sample (II)	393.88	12.30	138	4.31	53.01
Population	590.39	11.60	277	5.43	62.98

Source: Author's sago surveys

Purpose of sago starch Utilization in SUAS in Malalaua Area

Purpose and utilization of sago starch use in study area is based on two key aspects. They are either the traditionally processed sago starch is either for self-consumption at the household level or for sale at local markets, which essentially characterizes an income-generating activity. During actual sago making site observations, sago farmers were asked how many 10 kg bags of sago starch (in 10 kg discarded bags of rice/wheat flour) were produced per bole of sago palm. Based on the amounts aggregated for the number of 10 kg bags of sago starch per bole, sago farmers were further asked if there were ten bags at their disposal, how many would be sold at the markets and how many were to be kept for self-consumption. These two questions asked about sago starch utilization and their associated purposes are used as indices for measuring income derived from sago starch. Income analysis for SUAS is based on the two questions, which are related to amount of sago starch produced annually. Tables 10 and 11, both provide the results showing the number of 10 kg bags of sago starch per bole of sago palm and the utilisation of sago starch showing the ratio of every 10 bags of 10 kg sago starch for either sale or self-consumption respectively.

Table 10 Showing Number of 10 kg bags of sago starch per bole of sago palm

Parameters	Total (10 kg bags)	Mean (10 kg bags)
Sample (I)	225	11.84
Sample (II)	353	11.03
Population (N)	578	11.33

Source: Author 's sago surveys.

Table 11
Utilization of Sago Starch Showing ratio of every 10 bags of 10 kg sago for either sale or self-consumption

Parameters	Sale: Self-consumption Ratio
Sample (I) n = 19	7.30 : 2.70
Sample (II) n = 32	6.96 : 3.13
Population N = 51	7.25 : 3.02

Source: Author 's sago surveys.

The ratios expressed for the utilisation of sago starch for every 10 bags of 10 kg are quantitatively expressed in Table 12. Using the means computed based on the results presented in Tables 10, it could be stated that about 11 bags of 10 kg of sago starch are processed per bole, thus suggesting that on average 110 kg of sago starch is produced per sago bole during a sago making session in Malalaua area. Results in Table 11 also illustrate that for every 10 bags of sago starch packed in 10 kg bags, 7 are sold, while 3 are kept for household self-consumption in SUAS in Malalaua area. Taking the total of 3,072 sago palms processed per annum (Tables 6), and applying the sale and self-consumption ratios, sago starch quantity in Malalaua area can be extrapolated.

Table 12
Utilization of Sago Starch Showing Quantity of every 10 bags of 10 kg Sago for either sale or self-consumption (tonnes)

Mode of Utilisation Parameters	Approximated Quantity in (tonnes)	
I. Sale	(2150.4) X 0.11	236.5
II. Self-consumption	(921.6) X 0.11	101.5
TOTAL	(3,072) X 0.11	338.0

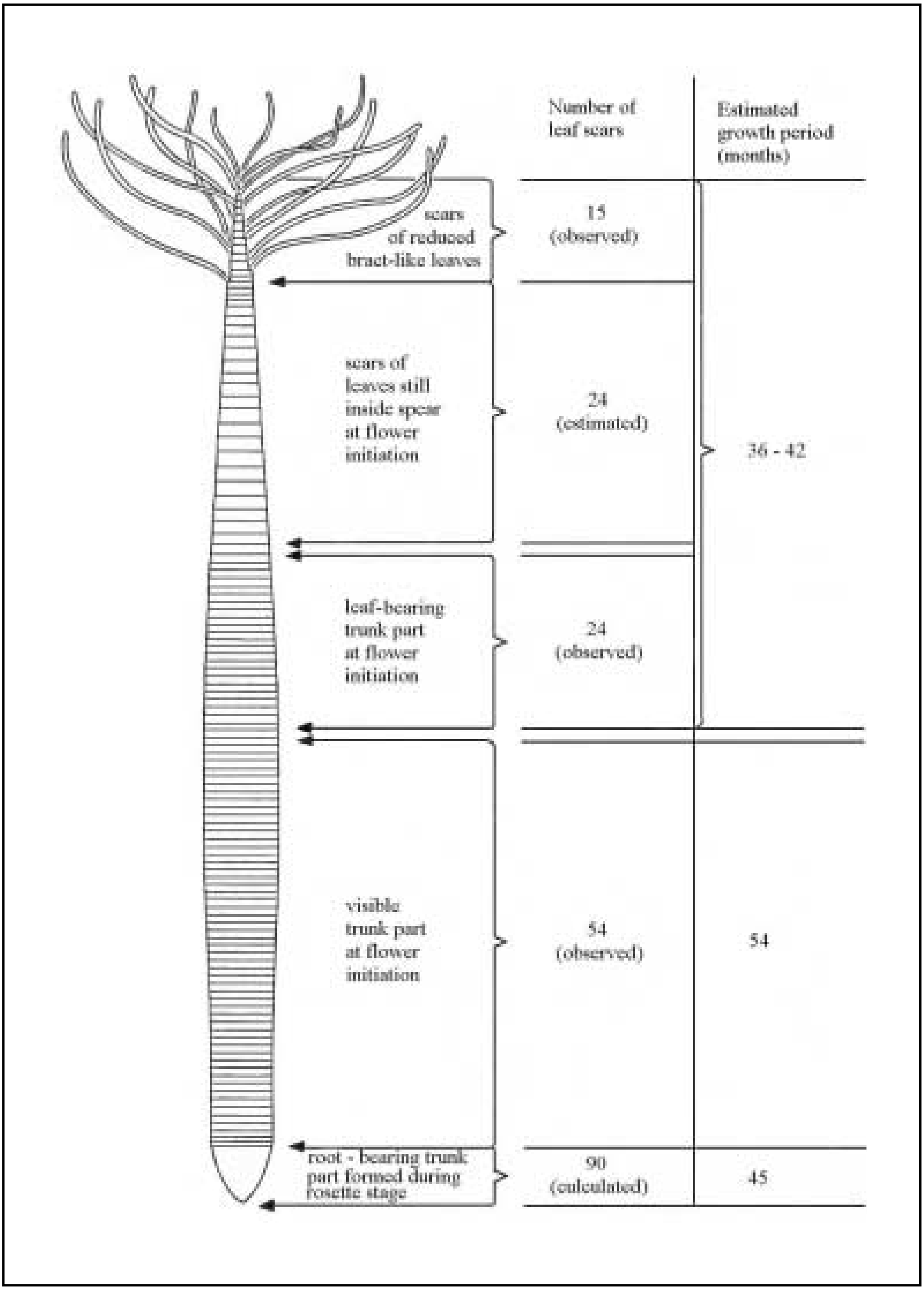
Notes: The index of 0.11 was derived from converting the 110 kg per bole mean of 11 bags of 10 kg of sago flour as projected in Table 10.
The total no. of sago palms to calculate the quantity was obtained from Table 6.
Source: Author 's sago surveys.

Table 12 indicates that approximately 338 tonnes of sago starch are produced annually in SUAS in the Malalaua area. About 236.5 tonnes of sago starch are sold at local markets for cash income, while 101.5 tonnes are consumed within households in SUAS in Malalaua area. Taking 110 kg of sago starch produced per bole and dividing by the population mean of 5 individuals per group, it suggests that 22 kg of sago starch is produced per person. This output (22 kg) of starch produced per individual divided by the mean of 11 hours per day of sago making indicates the probability that about 2.0 kg of sago starch is produced per hour in SUAS in Malalaua area. This 2.0 kg/hr of sago starch produced reflects similar output reported by Ohtsuka (1977), on the Oriomo people of Western Province. Other research results reported on sago starch production output per hour in different localities in Papua New Guinea are within the range of 1.9 kg/hr and 3.7 kg/hr of sago starch. Hyndman (1979: 207), on the Wopkaimin of Western Province reported 1.9 kg/hr; Schindlbeck (1980: 88), on the Sawos of East Sepik Province reported 3.66 kg/hr; Ulijaszek and Poraituk (1981: 29), on the Koravake of Gulf Province reported 3.5 kg/hr; whilst Suda (1995: 5), on the Siuhamason of Western Province reported 2.95 kg/hr of sago starch produced. On sago starch productivity in SUAS in Malalaua area starch quantity assessments are correlated with vernacular classifications, which provides the epistemological basis that sago farmers are cognizant of different sago palm varieties in the research areas.

Vernacular classifications of sago starch productivity in Malalaua Area

Vernacular classifications giving some estimates of improved varieties of sago palm in SUAS in Malalaua area presented here based on interviews with key informants in Savaiviri village during the sago survey in 2002. There are four identified types of sago palm varieties in the Malalaua area, of which "*Poi*" is the generic *Toaripi* word for sago. The four noted vernacular classifications of sago palm in the *Toaripi language* and their respective dried sago starch quantities packed in discarded 10 kg rice bags are: "*Mita poi*", produces between 180 to 200 kg (18 to 20 bags); "*Sere poi*", produces about 110 kg (11 bags); "*Aris poi*", produces about 150 to 160 kg (15 to 16 bags) and "*Kovukavu poi*", produces about the same amounts as compared to the "*Aris poi*" (S. Haro 2002, Savaiviri, pers. comm.). Harvesting of matured sago palms normally produces 80 kg (8 bags); meanwhile, less sago starch between 30 to 40 kg (3 to 4 bags) are produced from premature harvests (K. Ivahau 2002, Savaiviri, pers. comm.). Low yields from premature sago palm stands allude to the probability that sago starch utilization is driven by market motives and arbitrariness defines its method of exploitation. In a sense, this "arbitrariness", undoubtedly violates the bioethics[3] of sago palm management, in that sago palm exploitation, though harvested for an economic need might result in loss of germplasms within natural sago forests. Thus knowledge of when to harvest from wild stands must be carefully weighed against germplasm depletion based on proper knowledge of harvesting time for sustainable harvesting practices. Optimal time for harvest should be based on starch content, but starch quality is an unresolved issue as well (Oates *et al.,* 1999). On starch content measures, it is often argued that the amount of pith in a trunk is related to the volume of the trunk and the height of the trunk is related to the age of the trunk, as probably one leaf per month is being produced and each leaf has its own internodes, the distance between the two leaf scars (Fig. 3). More so, the circumference of a trunk is more important for its volume[4] than height.

Figure 3 Model of Molat-type trunk



Source: Flach (1993), p.12; originally after Flach & Schuiling (1989).

Flach (1993: 13) suggested developing a correlation matrix between starch content on the one hand and measured trunk volume combined with percentage of trunk diameter submerged in water. Holmes *et al.,* (1984), reviewing earlier studies by a Dutch starch manufacturer on sago starch productivity on the island of Salawati, Irian Jaya from 1950-1957 on wild stands, (cited by Flach 1993, 1997), found a statistical average of 1.2 m^3 per 1000 kg of pith, thus a pith starch density of 167 kgm^{-3} (weight over volume) on a (w/v) basis can be calculated. The Salawatian wild trunks had an average weight of 1000 kg, bark 250 kg and fresh piths 750 kg. From the fresh piths (750 kg), dry starch was 150 kg, other dry matter was 105 kg and moisture was 495 kg.

Computed results on sago starch productivity per bole in SUAS in Malalaua has closer output of 110 kg of dry sago starch, compared with the Salawatian case (1950-1957), cited in the study by Holmes *et al.,* (1984) of 150 kg of dry sago starch. The wild stands in either Malalaua, Papua New Guinea or in Salawati, Irian Jaya, are still found on clayish soils that are flooded for part of the year. Other studies done on different SUAS such as Alubijid in Northern Mindanao, the Philippines suggests that waterlogged conditions may be a probable cause for lack of trunk formation, which serves as one of the main determinants of starch yield (Celiz *et al.,* 2002), apart from other interactive management practice such as frequent harvesting of sago leaves for thatching roofs. By and large, the four vernacular types mentioned for SUAS in Malalaua area could be of the Molat-type (*Metroxylon sagu* Rottb.). Further studies are required to distinguish each type, based on morphological characteristics, such as leaf formation and longevity, among other agronomic measures, and watertable requirement aspects. On sago palm starch productivity, Flach (1981: 10) pioneering agronomic study on sago palms in the lower Sepik area can be used as a yardstick, which suggests that the highest starch yields per trunk, are correlated with:

1. At least 50 leaf scars on the trunk;
2. Short internodes between the leaf scars; and
3. Higher circumference

Furthermore, Flach (1981: 11-12) suggests several agronomic management measures that could be undertaken to increase starch yields in Papua New Guinea, in a sharp contrast he made to the Malaysian sago plantations, which are carefully managed for optimal starch yields. These include:

1. Killing of all other trees.
2. Thinning to 275 palms per hectare to increase spacing between clumps.
3. Pruning excess suckers so that each clump consists of three trunks of different ages.
4. Clearing away dead leaves from the trunks.

The Model of Molat-type trunk by Flach (1993: 12) in Fig. 3 illustrates that the leaves are produced at an approximate rate of one leaf per month (Flach 1981: 6). After the trunk formation in its initial stage, the fallen leaves produce a leaf scar on the trunk. Under poor growing conditions, the palm spends more of its years in the rosette stage (without a trunk), hence, ends up having fewer scars and lower starch content. In any case, Flach (1981: 5) observes that sago stands that were planted by ancestors are no different in starch quantity output compared to the wild stands, with the noted exception that planted trunks have larger trunks.

III. 4 Results of the Income Analysis for SUAS

The index for measuring income for SUAS was derived from the sale: self-consumption ratio (Table 11), which focused on the number of 10 kg bags of sago starch produced per bole (Table 10) and sold at a market venue, either locally within the village, Malalaua government station, or even in Port Moresby city. Table 13 provides the results of the income analysis below, using the aggregated quantity of sago palms cut and processed per annum as is depicted (Tables 6 and 7) respectively. Of the total quantity processed per annum, which is approximately 338 tonnes, 236.5 tonnes (70% of the total) in SUAS in Malalaua area is probably designated for sale.

Table 13
Comparative Market and Income Analysis on sago starch for SUAS Per annum showing gross income

Market Venue (Parameters)	Total Quantity processed in kg	Quantity sold in empty rice or wheat/flour bags in kg	Unit Price (per 10 kg bag of sago starch)	Annual gross income from sale of sago starch
			PNG Kina (K)	PNG Kina (K)
I. Within the village	236,500	10	15.00	354,750
II. Malalaua Station	236,500	10	20.00	473,000
III. Port Moresby city	236,500	10	30.00	709,500

Notes: The quantity produced per annum for sale was divided by 10 and multiplied by unit price to determine comparative annual gross income for SUAS.
Source: Author's sago surveys.

Comparative market and income analysis for SUAS shows that it is more profitable to sell the sago starch in Port Moresby city market, then the other two local markets per annum, given the assumption that all the sago starch were sold there. Because it was noted earlier that each sago farmer processes about five sago palms per month, thus applying the sale: self-consumption ratio of 7:3 (see Table 11), it suggests that of the 550 kg of sago starch produced, the farmer sells 385 kg (38 bags) and keeps 165 kg (16 bags) for household self-consumption. Using the unit price of 30 PNG Kina for a 10 kg of sago starch bag sold at a market outlet in Port Moresby city, a sago farmer earns about 1,140 PNG Kina per month. Assuming that a sago farmer is constant in supplying the same amount of sago starch for sale, then the annual income per farmer household in SUAS could fetch a gross sum of 13,680 PNG Kina.

IV. Discussion

IV. 1 Sago Agriculture in Malalaua Area - Where do we go from here?

Sago agriculture in the Malalaua area has received some attention through previous socio-economic studies (Laufa 2001, 2004; Power 2002), especially from prescriptive and descriptive assertions on management of the palm for secure livelihood of populace in marginal SUAS. Here it is observed that, "what rural people already know, must be the logical way and perhaps the only correct starting point for any intervention" (Fielding & Kirsopp-Reed 1995: 135). One unique and rich source of knowledge on sago palm varieties and characteristics is 'vernacular classification' of the sago palm (Flach & Schuiling 1989; Kraalingen 1986; Yoshida 1980), if applied well, can be of immense help to rural development management officers (Townsend 1982), in working collaboratively in ensuring that development programmes designed for improving rural lifestyle is not comprised, let alone fed with delusions of sorts by local recipients (Chambers 1983). From vernacular classification of the four types of sago palm varieties in Malalaua area, one can approximate, which type produces high quantity of starch, thus cross-breeding programmes for high-yielding sago starch, based on genotypic or phenotypic manipulation can be tested through collaborative research networks between local and international research scientists or development specialists. This participatory learning process, as is suggested by Brookfield (1996), "requires empathy on the part of practitioners and openness on the part of local people; in short, it sets a bond of trust that will need hours of dialogue to build".

IV. 2 Strategies for Agricultural Rural Development in SUAS

Some strategies to be employed for agricultural rural development in SUAS to bring about desired results, for example, increase in food production for addressing issues related to food security, food self-sufficiency and community income generating activities in these peasant agrarian communities are explored here. Although the concept of 'strategy' has gained currency recently in development economics, few attempts have been made to define it. A general definition offered is "a strategy is a mix of policies and programmes that influence the pattern and the rate of growth" (Johnson & Kilby 1995: 110). Therefore any strategy for agricultural development should embrace some combinations of (a) programmes of institution building related to such activities as agricultural research and rural education and farmer training, (b) programmes of investment in infrastructure, including irrigation and drainage facilities and rural roads, (c) programmes to improve product marketing and distribution of inputs, and (d) policies related to prices, taxation, and land tenure. Its efficiency will depend on promoting optimal use of available resources, and still more on modifying existing constraints. The sago palm situation in SUAS in the Malalaua area typifies existing constraints of the four-strategy enhancing mechanisms, which must be incorporated from a holistic viewpoint. To promote agro-based rural development in SUAS, this necessarily calls for coordinated efforts towards effectively articulating the mode of sago palm starch production to improve and sustain secure livelihood systems.

IV. 3 Replacing the "Plant and forget" mentality with a more "Cultivation-centred Approach" Argument Revisited

Harvesting from wild stands to extract sago starch will require a drastic change in attitude in effectively replacing the 'plant and forget' mentality and adopting a more cultivation-centred approach to sago palm (Oates *et al.,* 1999). Results of this study still indicate that sago palm starch is still underutilized, owing to three possible reasons. Firstly, there is no clear social mapping of ethnic groups to whom sago palm ownership and methods of acquisition is to be identified with. This is still an unresolved matter, which requires more time to forge cooperative links between all stakeholders. Secondly, the method of pith extraction and piths washing to collect starch is quite inefficient, thus results in significantly lower yields. Sago starch produced per bole with a mean output of 110 kg shows that sago starch processing is still predominantly underutilized in the surveyed SUAS. After all the "underutilization phenomena" of the sago palm is equated with the practice of harvesting sago starch from wild stands, which goes to show that sago harvesting either for self-consumption or for sale at local markets is very much a gathering activity, as opposed to a horticultural activity. Moving away from gathering activity to horticultural practices with respect to cultivation of sago palms would then facilitate an important rural agrarian change, that is, providing the basis for sago agriculture organised along the lines of sago estates, which is reflective of a monoculture. This requires knowledge of land use management, so as to attain higher productivity of starch per hectare per tonne in future. SUAS in Malalaua may have the comparative advantage and fulfil the requirements of the 'export theory'; however, judging from present starch productivity level of 0.02 t/ha/yr, this is meagre compared to outputs in more commercially oriented sago plantations in Malaysia and Indonesia. Thirdly, another critical problem associated with estate management of sago palms is agronomic management; still an unresolved issue in sago palm research. Further research is required for sago agronomic practice, let alone for exploring the scope and nature of land use management practice in Malalaua area, so as determine best cultivation and cropping patterns, if monoculture and intercropping systems were to be introduced, as schemes for improving not only food production on a large scale, but also for rural income generation activities too.

IV. 4 Two-pronged Approach for Economic and Social Inclusion Policy Formulation

Negation of the "underutilization phenomena" in SUAS in Malalaua area requires a two-pronged approach from relevant authorities with respect to developing appropriate social and economic inclusion policy responses so as to forge cooperative links with interested foreign firms and local entrepreneurs in the sago industry. The question of how to implement this two-pronged approach becomes increasingly important for rural agrarian societal transformation process to take place at this juncture. To address this necessary transformation process would require addressing both the “bioethics” and “biodiplomacy”[5] of the sago palm, which necessarily prescribes the parameters, or the ontological nature for effectively promoting sago commercialization process on a more grand scale. Articulating the sago palm mode of production is a relative function of how best to combine bioethics and biodiplomacy issues.

Addressing the bioethics of the sago palm in SUAS in Malalaua area prescribes the need for resolving sago palm tenure issues, which could be addressed through social mapping of ethnic groups, in conjunction with voluntary land registration, so as to militate against the social conflicts, let alone struggles arising from traditional use or commercial exploitation of a natural resource, the sago palm. It will be quite necessary for landowning groups to register their traditional land[6] under the Land (Group Incorporation) Act (1974), as important first step towards the underutilization negation process of the sago palm. This will strengthen the weak ‘inter-linkages’ between sago palm ownership and technology application, in that, the absence of a defined ownership structure outside the scope of the aforementioned piece of legislation, there is no commitment to improve land for commercial purposes, though another important piece of legislation, the Land (Tenure Conversion) Act (1963), provides the mechanisms for developing agricultural and rural pastoral land[7].

Economic inclusion for participating in the sago commercialization process rests on the land issues meaning that resource exploitation cannot proceed, until and unless resource owners in SUAS in Malalaua area collectively resolve these legal issues. Legally defined ownership structure in place, could not only effectively change the ‘plant and forget’ mentality and move it towards horticultural management of sago palm, but could also awaken societal consciousness to proactively ponder means to adopt better pith and starch extraction technologies. Change in management system of sago palm processing and utilization from that of traditional arbitrary exploitation from wild stands to horticultural management so as to comply with logic of the market for commercial purposes rests on recreating mutually a “win-win situation” within the confines of existing pieces of legislation. This would facilitate coordinated control and management of sago palm, whereby resource owners and resource developers could be better off through constant dialogue for sustaining and improving the sago palm industry to a viably self-sustaining rural industry, thereby negating the myth of economic exclusion, and in its place, economic inclusion of benefit sharing in SUAS.

The ‘technology factor’ has been lagging behind, owing to ineffective, or rather inefficient extraction technologies. Thus, addressing the efficiency aspect of sago palm commercialization by developing technologies for sago starch extraction for critical stages is an important structural transformation process for sago agricultural development in underdeveloped SUAS in Malalaua area, so as to negate the “underutilization phenomena”. The *modus operandi* and the technologies used for sago pith extraction and washing to obtain starch, considering the present situation, is quite inefficient and further reinforces the underutilization phenomena in one way or another. Application of an intermediate technology such as grater could not only save time; likewise, contribute to improvement in starch productivity. The corollary of that argument is that articulating the mode of sago palm production is required for enhancing the relation between extraction technologies and labour applied to obtain optimal sago starch yields.

The two key modes of pith extraction and starch extraction come under critical scrutiny here. Firstly, the traditional tool, "*movora*" for sago piths extraction is not producing fine grains; uneven granules tend to make it difficult for kneading out the starch from the supposedly spent sago pith. Secondly, much of the starch is evidently lost because of irregular washing rhythm, using hands; perhaps more critically, some of the starch escapes into the river system. Another critical factor could be that some sago piths are lost during inefficient debarking process (Cecil 1986, 2002; Flach 1993; Stanton 1993). Therefore, the sago starch extraction methods employed from debarking to washing needs appropriate technology to optimize the level of starch output. The debarking process needs a system of careful felling of a sago trunk and separation of the bark from the piths per bole and a sago factory and transportation system could fill this void, while the washing of the piths requires advanced washing treatment from manual operation to an automated washing system, with water treatment plant for monitoring falling levels of water pH values, which affects coloration of the starch, thereby having an effect on the quality of starch produced. Abdullah *et al.,* (2002) on a study on improving sago starch quality reported that traditional practices, for instance, that of SUAS in Malalaua area suffers from low extraction rate and inferior quality in terms of purity and colour. This relative weakness can be improved through enzymatic treatment by combining mechanical and chemical processes (Abdullah *et al.,* 2002), which may control microbial activity for quality control purposes (Cecil 2002; Doelle 1998).

In a study on sago starch production in Asia and the Pacific, (Oates *et al.,* 1999; Oates & Hicks 2002) investigated and analysed the level of technology applied and scale of operation used in different SUAS in Indonesia, Malaysia, Thailand and Papua New Guinea and reported its main problems, prospects and main salient features as occurring in a four-stage developmental model from traditional starch processing to fully-mechanised technology or modern-factory-based starch processing. Oates and Hicks (2002) main conclusions stress that the needs and demands of the traditional systems of sago starch processing need to be carefully weighed against industrial exploitation. Critical to sago starch commercialization in SUAS in Malalaua area also needs to address the biodiplomacy aspects of the sago palm. Forging cooperative links for knowledge sharing underpins the biodiplomacy of the sago palm, taken from compromise seeking initiatives and promoting development of sago; dubbed as "starch crop of the 21st century" (Tarimo *et al.,* 2002; citing Jong 1995). A case in point is that of tripartite arrangement between Hasanundin University of Indonesia, Kyoto University, Japan and

Sokoine University of Agriculture, Tanzania for trial planting of sago palm *(Metroxylon sagu L.)* in Tanzania, which met peculiar difficulties to climate adjustment and bureaucratic procedures and was unsuccessful then; however, the quest for introducing sago palm into the African continent is still strong and that further trials are being planned for the future (Tarimo *et al.,* 2002). Similarly, though with different considerations, Papua New Guinean research scientists on sago palm agronomic management can also work closely with other scientists from Japan, or even from Sarawak, Malaysia through rigorous research on different sago species for future optimal gains to sago starch productivity in Papua New Guinea. Knowledge sharing for optimal strategies (Johnson & Kilby 1995) for developing the fledging sago palm industry in Papua New Guinea hinges upon strengthening the biodiplomacy aspect further, without which, it could be quite difficult to advance the commercialisation effort, owing to the apparent ‘knowledge gap’, which borders on obeying the laws of biology, botany and agronomy of the sago palm in essence (Stanton 1993). Nonetheless, Brookfield (1996) asserts that it is critically essential to strive for larger incorporation of results of good research into diagnosis, management and development does border on promoting biodiplomacy aspect of the sago palm. Finally, sago palm research and development in Papua New Guinea with special reference to its agronomic management needs to further develop and strengthen the biodiplomacy of the sago palm further, of which its comparative advantage lies in the “centre of diversity phenomenon”, bordering on genetic diversity and genetic variability of this natural resource (Kjaer *et al.,* 2002). Such knowledge sharing and acquisition is essential for adopting adaptive research and development on breeding programmes for commercialization of the sago palm in Papua New Guinea (Allen & Hornung 2002; Kjaer *et al.,* 2002).

V. Conclusions

Welfare considerations for communities such as SUAS in Malalaua area of Papua New Guinea are largely determined by the interactive intercourse between available lands, its land use functions, tenure arrangements and, more important of them all, the decisions taken to determine proprietorship of this plant genetic resource (PGR), the sago palm at its disposal. Further articulation of the sago palm mode of production from more subsistence oriented to one of commercial nature as is showcased in Malaysia and Indonesia, so as to negate the principal factors behind the “underutilization phenomena” depends on forming a creative alliance between the bioethical and biodiplomatic aspects as discussed in this study. Further collaborative research; especially, related to agronomic management and taxonomic studies are quite necessary to ascertain the genotypic and phenotypic aspects of sago palm in the Malalaua area so as to provide more deeper knowledge of this staple food crop and determine the commercialization process in this study area.

Notes

1. SUAS is the acronym used for sago using agrarian societies cited throughout the text of this study.
2. John Pollock's book, *Technical Methods in Philosophy* (1990), cogently expresses what a literary scholar needs in formulating theoretical propositions, mainly grounded in philosophy with respect to two methods: set theory and predicate calculus. The author, using former method, as outlined by Pollock (1990), presents the bifurcation of the sago palm studies as being contextually situated in the realm of "underutilized" and "neglected" sphere to explain the inherent causal factors, as illustrated in Fig.1. The "underutilized" relates to the arts aspects, which mirrors the lack of commercial interests, that is moving from the traditional mode of production and utilization system in SUAS, e.g. in Malalaua area to a more systematically managed sago plantation, which appeals more to horticultural oriented sago palm management. The neglected aspect has connotations for the lack of advances made to scientific research, of which the positivism sphere as a knowledge building system appears to project, for instance, in sago agronomy. To review the existing sago palm situation in SUAS in Malalaua area of Papua New Guinea, (Fig. 1) applying the concepts underlying the usefulness of set notations is used for illustration purposes. Let the universal set $U = U_t \cup N_g$ denote the sago palm studies in SUAS, which explains that "underutilization" (U_t) union "neglected" N_g. More specifically, the sago palm situation in SUAS in PNG is best represented by "underutilization" intersect "neglected" $Ss = U_t \cup N_g$. Given the set notations in words, this study attempts to address the "underutilization" phenomena, which characterises the nature of 'arts sphere', which underscores at least two key elements. Firstly, poor extraction methods, meaning pith extraction and starch washing are relatively inefficient, thus resulting in lower dry starch yields during sago making in SUAS, which pointedly, means lack of technological advancement. Secondly, and perhaps more critically, is the apparent lack of commercial interest in developing the sago palm industry so as to transform this industry to an agribusiness-oriented industry, among other commercially viable rural agricultural products to support other rural development efforts, thereby supporting and creating the potential for enhancing sustainable rural development in SUAS. Lack of commercial interest in developing the sago palm industry in PNG has many contextual dimensions taken from absence of assigning property rights; which is implicitly made through genealogical claims, thus, interested foreign and local investors, facing high risks of not being supplied enough sago logs periodically, will not entertain financial loses as well as lengthy litigation over tenure matters, compounded by traditional landowners not voluntarily registering their parcels of customary land in the first place. Therefore a prisoner's dilemma situation here captures the essence of both resource owners and resource developers embraced in a mutual fear of loosing, or rather denied access to benefit sharing from the commercial exploitation of the sago palm.
3. See J.O. Urmson & Jonathan Ree 1989. *The Concise Encyclopaedia of Western Philosophy and Philosophers.* London: Unwin Hyman Ltd., p.18. Bioethics is the sub-speciality in applied ethics at the moment. Although this term was originally coined to refer to an ethical approach to the whole biosphere, it has come to be used much more narrowly, as a label for studies in ethical issues arising from medicine and biological sciences.

4. See Flach 1993, p.13. wherein, he denotes: "In volume, calculated as: $\pi \times r^2 \times h$, the radius (r) has a quadratic expression, where the height (h) only has a linear contribution".
5. The United Nations University/Institute for Advanced Studies (UNU/IAS) through its thematic research centers e.g. Environment and Sustainable Development Programme (ESD) has been promoting the biodiplomacy concept for mutual and cost-effective means for enhancing problem solving issues through collaborative research networking. (See URL: http://www.unu.edu/)
6. op.cit., see Goava 1996; cf. Manda 1996.
7. Ibid, see footnote 6.

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APPENDICES

Table A-1 Showing Sago Palms Owned (stock) by a Sago Farmer in SUAS and cut and processed per annum (flow)

Sago Farmer	Village	District	Sago palms (flow)	Sago palms (stock)
1	Keke/Tapala	Malalaua	60	11
2	Keke/Tapala	Malalaua	60	60
3	Keke/Tapala	Malalaua	60	70
4	Keke/Tapala	Malalaua	60	155
5	Keke/Tapala	Malalaua	84	n/g
6	Keke/Tapala	Malalaua	72	100
7	Keke/Tapala	Malalaua	72	100
8	Keke/Tapala	Malalaua	48	100
9	Keke/Tapala	Malalaua	120	200
10	Keke/Tapala	Malalaua	120	220
11	Keke/Tapala	Malalaua	44	40
12	Keke/Tapala	Malalaua	36	33
13	Heatoare	Malalaua	38	40
14	Heatoare	Malalaua	30	30
15	Heatoare	Malalaua	15	40
16	Heatoare	Malalaua	17	46
17	Heatoare	Malalaua	17	100
18	Heatoare	Malalaua	19	38
19	Heatoare	Malalaua	14	26
20	Keke/Tapala	Malalaua	172	500
21	Keke/Tapala	Malalaua	172	600
22	Keke/Tapala	Malalaua	29	1,000
23	Keke/Tapala	Malalaua	154	400
24	Keke/Tapala	Malalaua	43	300
25	Keke/Tapala	Malalaua	48	400
26	Keke/Tapala	Malalaua	30	1,000
27	Keke/Tapala	Malalaua	96	300
28	Savaiviri	Malalaua	31	100
29	Savaiviri	Malalaua	31	1,000
30	Savaiviri	Malalaua	92	1,000
31	Savaiviri	Malalaua	68	1,000
32	Savaiviri	Malalaua	12	1,000
33	Savaiviri	Malalaua	192	1,300
34	Savaiviri	Malalaua	48	500
35	Savaiviri	Malalaua	132	100
36	Savaiviri	Malalaua	162	300
37	Savaiviri	Malalaua	37	1,000
38	Savaiviri	Malalaua	37	200
39	Savaiviri	Malalaua	43	200
40	Savaiviri	Malalaua	42	20
41	Savaiviri	Malalaua	43	30
42	Savaiviri	Malalaua	28	500
43	Savaiviri	Malalaua	36	300
44	Savaiviri	Malalaua	43	100
45	Savaiviri	Malalaua	31	40
46	Savaiviri	Malalaua	32	40
47	Savaiviri	Malalaua	47	600
48	Savaiviri	Malalaua	32	50
49	Savaiviri	Malalaua	34	35
50	Savaiviri	Malalaua	34	36
51	Savaiviri	Malalaua	55	21
Total			3,072	15,381

Notes: Heatoare n=7; Keke/Tapala n=20; Savaiviri n=24; Total N=51 observations. Sago farmers (1-19) were interviewed in 2000; whilst (20-51) in 2002.
Source: Author 's sago surveys of 2000 and 2002.

Table A-2 Sago Palms Processed per month annually

	Village	Number of sago palms processed per month by each farmer											
		January	February	March	April	May	June	July	August	September	October	November	December
1	Keke/Tapala	5	5	5	5	5	5	5	5	5	5	5	5
2	Keke/Tapala	5	5	5	5	5	5	5	5	5	5	5	5
3	Keke/Tapala	5	5	5	5	5	5	5	5	5	5	5	5
4	Keke/Tapala	5	5	5	5	5	5	5	5	5	5	5	5
5	Keke/Tapala	7	7	7	7	7	7	7	7	7	7	7	7
6	Keke/Tapala	6	6	6	6	6	6	6	6	6	6	6	6
7	Keke/Tapala	6	6	6	6	6	6	6	6	6	6	6	6
8	Keke/Tapala	4	4	4	4	4	4	4	4	4	4	4	4
9	Keke/Tapala	10	10	10	10	10	10	10	10	10	10	10	10
10	Keke/Tapala	8	7	8	10	8	7	8	10	9	15	15	15
11	Keke/Tapala	3	2	3	2	4	3	2	2	6	6	5	6
12	Keke/Tapala	3	4	5	1	2	3	4	2	3	1	2	6
13	Heatoare	3	2	3	2	6	3	2	3	2	3	6	3
14	Heatoare	3	2	2	3	4	3	2	1	1	2	3	4
15	Heatoare	1	1	0	0	0	3	3	1	1	3	2	0
16	Heatoare	3	2	1	1	0	0	2	1	3	2	1	1
17	Heatoare	0	0	0	0	0	3	2	6	3	2	1	0
18	Heatoare	2	2	2	1	1	2	3	2	1	1	2	0
19	Heatoare	2	1	2	0	0	0	2	2	1	2	2	0
20	Keke/Tapala	16	15	12	16	12	16	15	16	15	12	12	15
21	Keke/Tapala	15	16	12	12	16	15	15	16	12	15	12	16
22	Keke/Tapala	3	2	2	3	2	3	2	3	2	3	2	2
23	Keke/Tapala	12	12	13	12	14	16	12	13	14	12	12	12
24	Keke/Tapala	4	4	3	4	4	3	4	3	3	4	4	3
25	Keke/Tapala	4	5	5	4	4	6	4	4	3	4	3	2
26	Keke/Tapala	3	2	3	2	2	3	2	3	2	3	2	3
27	Keke/Tapala	8	8	8	8	8	8	8	8	8	8	8	8
28	Savaiviri	3	3	2	3	2	3	2	3	2	3	2	3
29	Savaiviri	2	3	2	2	3	2	2	3	2	3	2	3
30	Savaiviri	13	10	9	5	7	3	11	8	5	2	4	15
31	Savaiviri	7	4	8	6	5	2	1	3	8	5	9	10
32	Savaiviri	1	1	1	1	1	1	1	1	1	1	1	1
33	Savaiviri	16	16	16	16	16	16	16	16	16	16	16	16
34	Savaiviri	4	4	4	4	4	4	4	4	4	4	4	4
35	Savaiviri	10	5	6	7	8	15	16	14	9	13	17	12
36	Savaiviri	10	15	10	12	10	16	12	16	20	10	16	15
37	Savaiviri	3	3	3	4	3	2	4	3	2	3	4	3
38	Savaiviri	3	4	3	4	4	3	4	2	3	2	3	2
39	Savaiviri	3	4	3	4	4	3	4	3	4	4	3	4
40	Savaiviri	4	2	3	4	3	4	3	4	3	4	4	4
41	Savaiviri	4	3	4	3	4	4	3	4	3	4	3	4
42	Savaiviri	2	3	2	3	3	2	4	3	2	4	3	2
43	Savaiviri	3	3	3	3	3	3	3	3	3	3	3	3
44	Savaiviri	4	3	4	3	4	4	3	3	4	3	4	4
45	Savaiviri	1	3	2	1	4	3	1	4	4	1	3	4
46	Savaiviri	1	2	4	4	4	1	3	1	3	4	4	3
47	Savaiviri	8	5	4	3	2	3	4	6	5	4	2	1
48	Savaiviri	1	4	1	3	4	5	4	1	3	1	3	2
49	Savaiviri	3	1	4	3	4	1	5	3	1	4	3	2
50	Savaiviri	4	3	1	2	4	1	2	3	1	4	3	1
51	Savaiviri	7	4	2	1	4	3	2	1	5	9	6	11
Total		263	248	238	235	250	254	259	261	255	262	269	278
Average		5.1	4.8	4.6	4.6	4.9	4.9	5.0	5.1	5.0	5.1	5.2	5.4

Source: Author 's sago surveys of 2000 and 2002.

Table A-3 Showing Modes of Ownership and Sago Starch Utilization Ratios

Sago Farmer	Mode of land tenure	Mode of sago palm Ownership	10 kg Bags of sago starch per bole	Sago starch utilization (either for self-consumption or sale at local markets)	Sale ratio of every 10 bags processed
1	Communal	Inheritance	16	Self-consumption & sale	4:1
2	Communal	Self-planted	12.5	Self-consumption & sale	4:1
3	Communal	Heritage & self-planted	15	All for sale	10:0
4	Communal	Heritage & self-planted	11	All for sale	10:0
5	Communal	Heritage & self-planted	12	Self-consumption & sale	9:1
6	Communal	Inheritance	2	Self-consumption & sale	1:1
7	Communal	Self-planted	6	Self-consumption & sale	7:3
8	Communal	Heritage & self-planted	20	Self-consumption & sale	4:1
9	Communal	Heritage & self-planted	10	Self-consumption & sale	4:1
10	Communal	Heritage & self-planted	12.5	Self-consumption & sale	7:3
11	Communal	Heritage & self-planted	9	Self-consumption & sale	3:2
12	Communal	Heritage & self-planted	12	Self-consumption & sale	3:2
13	Communal	Heritage & self-planted	12	Self-consumption & sale	3:2
14	Communal	Heritage & self-planted	15	Self-consumption & sale	7:3
15	Communal	Heritage & self-planted	12	Self-consumption & sale	3:2
16	Communal	Heritage & self-planted	12	Self-consumption & sale	7:3
17	Communal	Heritage & self-planted	12	Self-consumption & sale	7:3
18	Communal	Heritage & self-planted	12	Self-consumption & sale	7:3
19	Communal	Heritage & self-planted	12	Self-consumption & sale	7:3
20	Communal	Inheritance	10	Self-consumption & sale	1:1
21	Communal	Inheritance	10	Self-consumption & sale	3:2
22	Communal	Inheritance	15	Self-consumption & sale	2:3
23	Communal	Inheritance	9	Self-consumption & sale	1:1
24	Communal	Inheritance	9	Self-consumption & sale	3:2
25	Communal	Inheritance	8	Self-consumption & sale	1:1
26	Communal	By other means	16	Self-consumption & sale	3:7
27	Communal	Heritage & self-planted	9	Self-consumption & sale	4:1
28	Communal	Heritage & self-planted	20	Only self-consumption	0:10
29	Communal	Inheritance	8	Self-consumption & sale	1:1
30	Communal	Inheritance	6	Self-consumption & sale	1:1
31	Communal	Inheritance	6	Self-consumption & sale	3:2
32	Communal	Heritage & self-planted	8	Self-consumption & sale	2:3
33	Communal	Heritage & self-planted	8	Self-consumption & sale	4:1
34	Communal	Heritage & self-planted	14	Self-consumption & sale	4:1
35	Communal	Heritage & self-planted	12	Self-consumption & sale	7:3
36	Communal	Heritage & self-planted	12	Self-consumption & sale	4:1
37	Communal	Inheritance	8	Self-consumption & sale	4:1
38	Communal	Inheritance	12	Self-consumption & sale	9:1
39	Communal	Heritage & self-planted	16	Self-consumption & sale	1:1
40	Communal	Inheritance	6	Self-consumption & sale	3:2
41	Communal	Inheritance	8	Self-consumption & sale	3:2
42	Communal	Heritage & self-planted	21	Self-consumption & sale	9:1
43	Communal	Inheritance	11	Self-consumption & sale	4:1
44	Communal	Inheritance	10	Self-consumption & sale	1:1
45	Communal	Heritage & self-planted	12	Sell all of it	10:0
46	Communal	Inheritance	12	Self-consumption & sale	4:1
47	Communal	Inheritance	16	Self-consumption & sale	1:1
48	Communal	Inheritance	10	Sell all of it	10:0
49	Communal	Inheritance	11	Sell all of it	10:0
50	Communal	Inheritance	10	Self-consumption & sale	7:3
51	Communal	Inheritance	10	Sell all of it	10:0
		Total	578	AVERAGE	7:3

Source: Author 's sago surveys of 2000 and 2002.

Table A-4 Showing Time taken in hours for Sago Making Activities and Manhours per Sago palm bole

Sago farmer	Cutting sago palm	Pounding/ crushing sago piths	Kneading sago piths	Drying sago starch	Packing sago powder	Total time taken	No. of individuals	Manhours
1	1	5	2	2	2	12	10	120
2	0.5	2	1	1	1	5.5	5	27.5
3	1	4	2	2	2	11	10	110
4	2	6	2	2	2	14	7	98
5	1	5	1	6	0.5	13.5	6	81
6	1	6	2	3	1	13	3	39
7	2	4	0.5	0.5	0.5	7.5	6	45
8	0.1	6	1	0.25	0.16	7.51	6	45.06
9	2	6	1	1	1	11	10	110
10	2.5	6	2	6	6	22.5	10	225
11	1	4	2	3	1	11	12	132
12	2	4	1	1	1	9	10	90
13	2	2	3	1	1	9	6	54
14	2	3	1	1	2	9	6	54
15	1	3	3	1	1	9	7	63
16	1	3	2	1	1	8	6	48
17	2	2	1	1	1	7	6	42
18	1	2	3	2	1	9	6	54
19	1	3	2	1	1	8	7	56
20	0.5	6	6	0.5	0.33	13.33	3	39.99
21	0.5	6	6	0.5	0.33	13.33	7	93.31
22	0.5	6	6	1	1	14.5	6	87
23	0.5	6	6	0.5	0.33	13.33	4	53.32
24	0.5	6	6	0.5	0.33	13.33	5	66.65
25	0.5	6	6	0.5	0.33	13.33	7	93.31
26	0.5	6	6	0.5	0.33	13.33	6	79.98
27	0.33	4	4	0.33	0.33	8.99	5	44.95
28	0.5	6	6	0.5	0.33	13.33	4	53.32
29	0.25	4	4	0.25	1	9.5	2	19
30	0.25	6	6	0.1	0.25	12.6	3	37.8
31	0.25	6	6	0.1	0.25	12.6	6	75.6
32	0.5	3	8	0.33	0.25	12.08	4	48.32
33	0.5	3	8	0.33	0.25	12.08	5	60.4
34	0.5	1	6	3	2	12.5	6	75
35	2	6	7	7	7	29	3	87
36	1	6	2	1	0.5	10.5	3	31.5
37	1	6	6	0.25	0.33	13.58	3	40.74
38	0.25	6	6	0.1	0.33	12.68	2	25.36
39	0.25	6	6	0.1	1	13.35	2	26.7
40	0.25	6	6	0.1	1	13.35	3	40.05
41	0.5	6	6	0.1	0.33	12.93	4	51.72
42	1	5	5	0.1	0.5	11.6	6	69.6
43	1	6	6	1	0.5	14.5	7	101.5
44	0.5	6	6	0.1	0.25	12.85	3	38.55
45	0.42	0.25	5	0.1	0.1	5.87	5	29.35
46	0.42	0.25	5	0.1	0.1	5.87	4	23.48
47	0.5	6	9	0.1	0.1	15.7	6	94.2
48	0.42	0.25	5	0.1	0.25	6.02	2	12.04
49	0.42	0.25	5	0.25	0.1	6.02	3	18.06
50	0.25	4	5	0.25	0.1	9.6	6	57.6
51	0.1	6	6	0.1	0.1	12.3	3	36.9
Total	42.96	227	218.5	55.54	46.39	590.39	277	2628.46
Mean	0.84	4.45	4.28	1.08	0.90	11.6	5.43	51.53