History of agriculture in Papua New Guinea

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Introduction

The history of agriculture in PNG is about 10 000 years old. This history is reviewed here in the context of 50 000 years of human occupation of the Australia – New Guinea region.[1] More is known about what has happened nearer to the present, especially since 1870, than about the distant past. Much of the early history (prehistory) of PNG was unknown until about 50 years ago, but since 1959 there has been a lot of research on the prehistory of PNG, with a major focus on agriculture. However, this is a rapidly evolving field of study and our understanding of the history of agriculture in PNG is still incomplete. The information that is summarised here will be expanded and modified by future research.

Historical evidence is reviewed in a number of periods: the arrival of humans in New Guinea some 50 000 years ago; the beginnings of agriculture about 10 000 years ago; the appearance of Austronesian-speaking people from island South-East Asia about 3500 years ago, bringing with them more domesticated crops and animals;[2] the introduction of sweet potato about 300 years ago; permanent settlement by Europeans and other outsiders, with many introductions of plants and animals after 1870; and the period of rapid social and economic change that commenced about 70 years ago in 1940.

The peopling of New Guinea

When the first humans came to New Guinea about 50 000 years ago the climate was very different from now. Worldwide, temperatures were lower, the polar ice caps were larger, glaciers were more common, and sea levels were lower. As a result, the South-East Asia mainland extended as far east as Bali and Borneo to form a landmass that is known as Sunda. The Asian mainland (Sunda) and New Guinea were always separated by ocean but, at that time, New Guinea was not an island, but formed the northern part of a large continent that also included Australia and Tasmania, known as Sahul (Figure 1). The Bismarck Archipelago and the Solomon Islands chain have always been separated from the Sahul continent by ocean.

The world climate started to warm from about 18 000 years ago. The sea level began to rise from the melting of ice caps and glaciers and the tree line became higher. The extensive low-lying plains between New Guinea and Australia were flooded. By 10 000 years ago, only a narrow strip of land linked southern New Guinea with the Australian mainland. Around 8500 years ago this land bridge was broken

1 Prehistorians do not agree how long humans have occupied the Sahul continent (Australia, New Guinea and Tasmania). The figure of 50 000 years used here is a compromise between the shorter time period of about 45 000 years argued by some scholars and the longer one of 50 000–60 000 years argued by others.

2 See box on page 11 for a definition of domestication.

when Torres Strait became flooded and the northern part of the great Sahul continent became the island of New Guinea, with a coastline similar to the present.

The first people to settle the Sahul continent are likely to have come in small groups. They would have made scattered landings on the coastline following earlier movements from the Asian mainland via the eastern islands of the Indonesian archipelago. Following the initial colonisation, human settlement spread to different parts of what is now PNG.

People probably reached the islands of New Britain and New Ireland by 40 000 years ago, soon after the initial colonisation of the Sahul mainland.

By 28 000 years ago there were people on what is now Buka Island, at that time the northern end of a single island that included most of the Solomon Islands. The trip from New Ireland to Buka required some time at sea without view of the target land. Manus was settled by at least 20 000 years ago. Colonisation of Manus involved an open sea crossing of more than 200 km, of which 75 km would have been out of sight of land. Human settlement in the Pacific islands extended as far as the end of the Solomon Islands until about 3500 years ago.

Definitions of terms

Archaeology. The scientific study of a prehistoric culture by excavation and description of its remains.

Bismarck Archipelago. The islands of Manus, New Ireland and New Britain and smaller nearby islands, north-east of mainland PNG.

Domestication. The process whereby people transform a wild plant or animal population into one with more desirable characteristics, usually with an edible product such as a grain, tuber, fruit or nut (in the case of plants). This is done by selection and propagation of plants or animals with the desired characteristic.

Glacier. A river of ice. Small glaciers still exist at high altitudes in west New Guinea (Indonesian Papua), although these are disappearing as the climate warms (see Section 1.8). There were a number of glaciers in the mountains of east New Guinea up to about 18 000 years ago.

New Guinea. The second largest island in the world (after Greenland), lying just south of the equator. It is split into two national units. The eastern half is part of Papua New Guinea, an independent nation, while the western half (west of 141° E longitude) is the Indonesian province of Papua, formerly known as Irian Jaya. The term New Guinea is used here to refer to the island, not to a political unit.

Papua. This is a confusing term as it has a number of meanings. Papuan languages are a group of related languages spoken mainly on the island of New Guinea, but also by some groups in New Britain, New Ireland, the Solomon chain and the Timor and Halmahera areas of east Indonesia. Papua is the current name of the Indonesian province that occupies the western half of the island of New Guinea. It is also the name of the former Australian colony, now known as the Southern Region of PNG; and thus it has been incorporated into the name for the nation of Papua New Guinea.

Prehistory. The history of humans in the period before events were recorded in documents, known mainly through archaeological research.

Solomon Islands. A chain of islands lying south-east of New Britain, extending from Buka to San Cristobal. The two larger north-west islands (Buka and Bougainville) lie in PNG; the others in the political state of Solomon Islands. The term is used here in a geographic rather than political sense.

Tree line. The distance above sea level, or altitude, above which trees do not grow because the temperature is too low. In PNG at present the tree line is around 3800 m above sea level.

The earliest indications of human activity in the mountains of New Guinea are thought to be 35 000 years old and are evidence of disturbance of the vegetation by burning. This may have been caused by hunting and exploitation of seasonal foods, especially pandanus nuts, rather than long-term occupation. From about 18 000 years ago, as the climate became warmer, the vegetation in the highlands changed and there was greater use of the highland valleys by people.

Around 3500 years ago a group of people came to the New Guinea area. They were pottery-making agriculturalists and possessed what archaeologists call the 'Lapita culture', named after a style of pottery that they made. Over the next 500 years 'Lapita' people moved beyond the limit of previous settlement at the end of the Solomon Islands and reached New Caledonia, Fiji, Tonga and Samoa. They spoke languages known as Austronesian, which may have originated in Taiwan. These languages are now found

Figure 1 The Sunda and Sahul landmasses at about 50 000 years ago when people first came to Sahul.
Note: Some modern islands were connected to the two large landmasses and others, such as New Britain, New Ireland and the Solomon chain, were always separate. Source: Cartographic Services, ANU.

over a very large area in the Pacific, Indonesia, parts of mainland South-East Asia, and Madagascar in the western Indian Ocean. In PNG they are much better represented in the Bismarck Archipelago and other islands than on the New Guinea mainland, where they are scattered around the coast, particularly in the north and east. Austronesian speakers later spread throughout the Pacific as far as Easter Island, New Zealand and Hawaii. Some of their Polynesian descendents came back to settle on small islands in the New Guinea region within the last 1000 years.

The history of the New Guinea region is made up of many movements of people and Papua New Guineans are heirs to a long and varied genetic, linguistic and cultural history. Most details of the early settlement history are unknown and may never be known. The early colonisation of Sahul would have been made up of small independent movements from different starting points to different places on the coast. Similar movements would have continued after initial colonisation, as illustrated by the transport of plants, animals and raw materials described below.

Subsistence for the first settlers (50 000 to 10 000 years ago)

The first settlers in New Guinea and nearby islands obtained their food from hunting, fishing and gathering. The animals hunted included giant marsupials, now extinct and possibly hunted out of existence by the migrants. The people would have exploited local plants for food, including sago. It is probable that sago was domesticated by the selection of plants with a high content of starch in the trunk. Human populations were probably very small.

Stone tools, dated to some 40 000 years ago, have been found on terraces on the north side of the Huon Peninsula of Morobe Province. These tools were possibly used to thin, trim and ringbark trees to assist the growth of desirable plants that provided food or to obtain starchy food from sago or cycad trees.

It is likely that very early people started to use trees that had, for example, larger edible nuts, and to cut down trees that had smaller nuts. If this was done over a long period, the best-yielding trees will now dominate the forests where people are living. *Galip* nut (*Canarium* species) provides evidence for this practice. Seed remains of *galip* nut have been dated as early as 17 000 years ago in archaeological excavations in the middle Sepik area. They have been dated at 15 500 years ago on Manus, at 11 500 years ago on Buka and 9000 years ago on New Ireland. It seems that *galip* was domesticated by people on the north coast of New Guinea and then introduced to the Bismarck Archipelago and Solomon Islands.

Edible nuts of one pandanus species (*Pandanus antaresensis*) have probably been used for about 30 000 years, and the high-altitude pandanus nut (*P. brosimos*) was possibly first used about 10 000 years ago. The form of nut pandanus that is common at 1800–2600 m altitude in the highlands now (*P. julianettii*) appears to have been domesticated from *P. brosimos*, possibly about 2000 years ago (see Section 3.4). It is likely that people were domesticating other plants at this time, even before they used agriculture as we now know it. Such plants could have included *marita* pandanus and other nut- and fruit-bearing plants. People may also have been exploiting wild taro plants a long time before the beginning of agriculture: taro starch has been found on stone tools from Buka Island that were used as long as 28 000 years ago.

We also know that people were trading obsidian (a black, glass-like stone formed in volcanoes that was used to make sharp cutting tools) a long time ago. Obsidian from Talasea on the north coast of New Britain first appeared in New Ireland about 23 000 years ago and has been found as far away as Borneo. We also know that people were moving wild animals such as the cuscus and bandicoot from the New Guinea mainland to the islands, with the first movement as early as 23 000 years ago. Presumably, wild animals were transported so they could be hunted for food. The cassowary is the only indigenous animal that has undergone some degree of domestication. People hunt it and rear captured chicks. It is not known for how long people have done this.

The beginning of agriculture (10 000 years ago)

By 10 000 years ago the climate had warmed to modern temperature levels. It seems that people started practising agriculture, at least in the New Guinea area, from about 10 000 years ago. Certainly, from 7000 years ago, the evidence for agriculture is very clear. It is also likely that agriculture was invented in the New Guinea highlands at about the same time as it appeared in other parts of the world,[3] and that the development of agriculture in New Guinea was independent of what happened elsewhere. The evidence comes from a site called Kuk in the upper Wahgi Valley in Western Highlands Province. Extensive research at Kuk over a 30-year period suggests that:

- Plants were being exploited and some cultivation was occurring about 10 000 years ago. Archaeological research has found features that indicate planting, digging and staking of plants, and possibly localised swamp drainage. Taro starch found on stone tools excavated at Kuk that are about 10 000 years old suggests that taro was being planted at Kuk at this time.
- A network of small island beds and associated basins had been constructed by 7000 years ago, so that water-tolerant plants could be cultivated in the basins and those requiring drier conditions could be planted on the island beds.
- Banana was intensively cultivated from 7000 years ago.
- From 4500 to 5000 years ago, swamp gardens were drained by straight line ditches dug at right angles to each other that drained into large channels.

[3] Apart from PNG, other centres of early agriculture were the Fertile Crescent of the Middle East and the Yangtze and Yellow river basins of central China, with dates of 11 000 and 9 000 years ago respectively.

Arrival of the Austronesians (3500 years ago)

The arrival of the Austronesians is associated with the appearance in the Bismarck Archipelago of the distinctive Lapita pottery and the first domesticated animals – the pig, chicken and dog. The newcomers were agriculturalists and brought many of their crops with them. Some of these were of the same species of plant that people had domesticated in the New Guinea region. Indeed, some of these crops may originally have been domesticated in New Guinea and carried back into South-East Asia.

European exploration and transfer of crops (late 1400s to 1870)

In the late 1400s, explorers, missionaries and traders from Spain and Portugal, and later the Netherlands, France and England, moved and settled around the globe. They took plants and domestic animals from one region and introduced them to other regions. Many of these plants became important economically in the new places. The production of important food and cash crops is now often greater in locations distant from where the crops were initially domesticated. For example, the most important palm oil-producing area is now South-East Asia (Malaysia, Indonesia and Thailand), but oil palm was domesticated in West Africa. Similarly, wheat was domesticated in the Middle East, but the main wheat-exporting nations are now the United States, Canada, Australia, France and Argentina. Sweet potato was domesticated by people in the American tropics, but today the major sweet potato-producing country is China. Sweet potato is now the most important staple food for people in the western Pacific (Solomon Islands, PNG and Indonesian Papua) and production has expanded greatly in that region in the last 60 years.

This major transfer of plant materials around the world by European explorers and colonists, which has had such a large impact on global agricultural production, occurred in the western Pacific later

than elsewhere. Europeans and other travellers made sporadic contact with Papua New Guineans from the early to mid 1500s, but there is no evidence that the early European explorers made any plant introductions into PNG at that time.

A small number of species from the Americas were introduced by Europeans into Indonesia and spread from there to PNG before 1870 (Table 1). The most important of these was sweet potato (see page 17). Another crop of American origin that became important in PNG is tobacco. Tobacco was introduced by Europeans to the Moluccas in eastern Indonesia before 1600, from where it spread to New Guinea. It is likely to have come into PNG at a number of locations. One of these is the Trans Fly area in the south of Western Province, where Moluccan traders probably introduced tobacco when they came to this area seeking dammar between 1645 and 1790.[4] The first written record for tobacco in New Guinea is by the Dutch explorer Schouten in 1616, who saw it on Arimoa Island in north-western Papua (Indonesia). Tobacco diffused through New Guinea over several centuries, but it had not reached south-east New Guinea (Oro, Central and Milne Bay provinces of PNG) by the time of first sustained contact with foreigners from the 1870s.

Lima bean was also probably transported from east Indonesia to New Guinea some time between 1700 and 1870. It had been introduced to east Indonesia prior to 1650. Many villagers in the highlands believe that lima bean was used by distant ancestors, but others say it is an introduction (Table 1).

Cassava is another food crop that was probably introduced into parts of mainland PNG from west New Guinea some time after 1800. People in the western part of PNG, in particular Western and Sandaun provinces, consider it to be a 'traditional' crop. It seems that cassava was introduced directly to some islands by European sailors around the same time.

Bixa, a plant used as a bright red dye and body paint, also reached PNG before 1870. Some villagers consider bixa to be a traditional plant, but others do not. It is likely that bixa seed was also spread from Indonesia, where it had been introduced by Europeans from the Americas (Table 1).

Table 1 Proportion of villagers who consider five crops of American origin to be post-European introductions[a]

Crop	Number of locations surveyed	Post-European introduction (%)	Pre-European introduction (%)
Bixa	32	31	69
Cassava	65	63	37
Lima bean	25	20	80
Sweet potato	52	54	46
Tobacco	52	17	83

[a] These crops were introduced to PNG between 1600 and 1870.

Sources: Extracted from published reports and author surveys in various locations in the PNG lowlands and highlands.

Plants used for agriculture until 300 years ago

Prior to permanent settlement by foreigners in the 1870s, more than 170 plant species were used by Papua New Guineans for food. As well, hundreds of other species provided materials for shade, firewood, medicine, tools, weapons, house and fence construction, decoration, rope, string, food wrappings, bark cloth, dress, personal adornment, canoe and raft construction, and ritual and magic purposes. The most important staple (carbohydrate) foods were taro, banana, sago and yam (Figure 3.1.2).

Many plant species that today provide carbohydrate food, vegetables, fruit and nuts were either domesticated in the New Guinea area or were introduced into PNG thousands of years ago (Table 2). Other species were domesticated in Asia or elsewhere in the Pacific and then introduced into PNG somewhere between several hundred to several thousand years ago (Table 3). Many other minor foods in PNG are likely to have been important in the past, but have been displaced by more recent introductions.

4 Dammar is a resin that comes from a number of trees, including *Vatica papuana*, which grows in south-west PNG (Swadling et al. 1996:157–65). It was used for lighting, as well as for coating and sealing pottery.

Most of the species listed in Table 3 were domesticated in Asia, but two came from the Pacific. The first is *pao* nut (*Barringtonia procera*), which was probably domesticated in the Solomon Islands and introduced into New Ireland and the Admiralty group relatively recently, perhaps less than 1000 years ago. It was taken by migrants from southern New Ireland to the Gazelle Peninsula of New Britain about 400 years ago. It has spread to mainland New Guinea and elsewhere in New Britain over the past 50 years.[5] Kava was probably also domesticated in the Pacific, in Vanuatu, and introduced before 1870 into a limited number of locations in PNG including the Madang area, some islands off Manus Island, and parts of Western Province (see Section 3.5).

[5] Related species (*B. novae-hiberniae* and *B. edulis*) with edible nuts are found on New Guinea as well as the Bismarck Archipelago, Solomon Islands and Vanuatu.

Table 2 Crops domesticated in the New Guinea area, or very ancient introductions

Staple (carbohydrate) foods
*Banana
Coconut
*Cordyline
Kudzu (Pueraria)
Polynesian arrowroot
*Sago
*Sugar cane
*Taro (*Colocasia*)
Taro (*Alocasia*)
Taro, swamp
*Yam, greater
Yam, aerial
Yam (*Dioscorea nummularia*)
Yam (*Dioscorea pentaphylla*)
Vegetables
**Dicliptera papuana*
**Ficus wassa*
*Highland *kapiak*
Job's tears
**Kumu musong*
*Oenanthe
**Pitpit*, highland
**Pitpit*, lowland
*Rorippa
*Rungia
Trichosanthes pulleana
Tulip
Wandering Jew
Fruit
**Bukabuk*
Coastal pandanus
Golden apple
Mango (*Mangifera minor*)
**Marita* pandanus
Mon
**Parartocarpus venenosa*
**Pouteria maclayana*
Raspberry, red (*Rubus moluccanus*)
Raspberry, red (*Rubus rosifolius*)
**Ton*
Nuts
*Breadfruit
Candle nut
Castanopsis
Dausia
**Elaeocarpus womersleyi*
*Finschia
**Galip* (*Canarium decumanum*)
**Galip* (*Canarium indicum*)
**Galip* (*Canarium lamii*)
**Karuka*, planted (*Pandanus julianettii*)
**Karuka*, wild (*Pandanus antaresensis*)
**Karuka*, wild (*Pandanus brosimos*)
**Okari* (*Terminalia impediens*)
**Okari* (*Terminalia kaernbachii*)
**Omphalea gageana*
Polynesian chestnut (*aila*)
Sea almond (*talis*)
Sis (solomon)
Stimulants
Betel nut, highland
Betel pepper, highland

Note: Species with an asterisk (*) are likely to have been domesticated by people in the New Guinea area. The other species in this table may have been domesticated in the New Guinea area, but the evidence is less clear.

The adoption of sweet potato in the highlands (about 300 years ago)

Sweet potato was taken from its American homeland by Polynesians who introduced it into many Pacific islands and New Zealand about 1000 years ago. However, it came to PNG from Indonesia. Sweet potato was taken back to Europe from the West Indies after the first voyage in 1492 by Christopher Columbus, an Italian navigator and maritime explorer who crossed the Atlantic Ocean under Spanish sponsorship. Portuguese explorers then took sweet potato to Africa, India and their colony in the Moluccas in eastern Indonesia. From there it was traded by local people into New Guinea. Oral history research from the Tari basin in Southern Highlands Province and archaeological research at Kuk in Western Highlands Province indicates that sweet potato was adopted in the highlands some decades after the major volcanic eruption of Long Island off the north coast of New Guinea. This blanketed the highlands in ash which leaves a record in the soil as well as in oral history (related as the 'Time of Darkness'). The eruption has been dated to 1665. Further oral history research shows sweet potato was traded into the Lagaip Valley of northern Enga from the Sepik area. It may have been adopted into the highlands of Indonesian Papua somewhat earlier than 1700.

Table 3 Crops introduced into PNG from Asia or the Pacific several hundred to several thousand years ago

Staple (carbohydrate) foods
Yam, lesser
Vegetables
Aibika
Amaranthus tricolor
Bean, lablab
Bean, winged
Castor
Coral tree
Cucumber
Ginger
Gourd, bottle
Gourd, wax
Lemon grass
Fruit
Malay apple
Rukam
Nuts
Pao (*Barringtonia procera*)
Stimulants
Betel nut
Betel pepper, lowland
Kava

Note: Kava was probably domesticated in Vanuatu. *Pao* was probably domesticated in Solomon Islands. The other crops in this list most likely came to PNG from Asia.

Prior to the adoption of sweet potato in the New Guinea highlands, people depended on taro as their main food, supplemented by banana and yam (*Dioscorea alata*). The adoption of sweet potato brought major changes in highland societies. First, sweet potato makes good pig fodder, and can be fed to pigs raw, whereas taro must be cooked.[6] The adoption of sweet potato gave an advantage: people could produce more pigs, thus becoming wealthier than their neighbours. Also, their diet possibly improved. Second, sweet potato will grow at higher altitudes than taro. The adoption of sweet potato meant that people could occupy higher altitude land on a permanent basis. Settlements spread from around 2200 m up to 2800 m above sea level. Third, the adoption of the new crop resulted in significant changes in the social organisation. Some of these changes are known from oral history research in Enga Province.

By the time that Europeans penetrated the highlands of PNG in the 1920s and 1930s, sweet potato was the main food for almost all highlanders. There were some exceptions. West of the Strickland River, in the Oksapmin and Telefomin areas, taro remained the

[6] Taro contains crystals of oxalic acid that cause severe irritation to the mouth and throat of humans and pigs. Cooking destroys these crystals and makes taro edible.

most important food. Several groups of people living in the Lamari and Imani valleys south of Kainantu still depended on a mix of taro, yam and sweet potato. People in these two valleys changed to a diet based on sweet potato after about 1980. At the time of contact with outsiders, sweet potato was present at a number of locations along the north coast of New Guinea as far east as the Huon Peninsula. It was not present in the Bismarck Archipelago and Solomon Islands until the early to late 1800s, where it was introduced by European traders and settlers.

Some people in the PNG highlands, for example in the Tari basin, have stories about the time when they did not have sweet potato and taro was their staple food. But most highlanders think that their ancestors have always lived on sweet potato. In fact, it has been the most important food in the highlands only for about 10–12 generations, or 300 years. The changes brought about by its adoption are still occurring today, for example, in the continuing intensification of land use (see Section 3.6).

Settlement by foreigners and introduction of many new crops (since 1870)

The settlement in PNG by foreigners first occurred in the early 1870s. Europeans, Asians and other Pacific islanders settled in many coastal locations,[7] bringing with them new plant species. The Russian scientist Nikolai Miklouho-Maclay lived on the Rai Coast near Madang for several years from 1871. In the same year, the London Missionary Society (LMS) placed teachers on three islands in the Torres Strait near PNG. In the following year (1872), the LMS established stations west of Port Moresby and on the coast of Western Province. Also in 1872, a trading post was established on the Duke of York Islands between New Britain and New Ireland. In 1873, the German firm Godeffroy set up trading stations in Blanche Bay on New Britain. Methodist missionaries established a station on the Duke of York Islands in 1875.

Records of crop introductions are limited, although some early accounts exist. French Marist missionaries introduced a number of food crops to Woodlark Island in Milne Bay Province in 1847, including beans, pumpkin, corn (maize) and watermelon. Miklouho-Maclay introduced pumpkin, watermelon, corn and pawpaw (papaya) to the Rai Coast in 1871 with seed brought from Tahiti. He noted that the pawpaw, watermelon and corn 'became the favourites and were soon introduced in the plantations [gardens] and the villages on the coast'. In 1873 he introduced mangosteen, durian, orange, lemon, coffee and other species with seed from east Indonesia.[8] Methodist missionaries introduced a number of food crops to the Duke of York Islands in 1875, including orange, lemon, lime, custard apple, guava and new varieties of banana. Many of the early introductions in PNG were made by Pacific island missionaries, as well as by Europeans and Asians.

When many of these introductions occurred is not known, but it is known which species have been introduced since 1870. These include hundreds of potential cash crops, as well as fodder plants (grasses and legumes), shade crops, decorative plants and weeds.[9] Many food crops were introduced into PNG

7 Prior to 1870 there were a few scattered and generally short-lived settlements in the New Guinea region. From 1793 to 1794 there was a British settlement at Restoration Bay near Manokwari in west New Guinea. The Dutch made a settlement on the south coast of west New Guinea at Triton Bay in 1828–36. Both locations are a long way from PNG, so it is unlikely that crops introduced by the British or Dutch settlers were transported to PNG, but it is possible. A mission station was established at Guasopa on Woodlark Island in Milne Bay Province by French (and later Italian) Marist Catholic missionaries between 1847 and 1855. The Marists established a settlement on Umboi Island between New Britain and New Guinea in 1848–49. These settlements had limited and local impacts.

8 Villagers at Bongu village and nearby locations still use their version of Russian names for some of the plants and items introduced by Miklouho-Maclay, including watermelon, corn, pumpkin, cucumber, knife and axe. The term for corn (*gugurus*), derived from the Russian word for maize (*kukuruz*), is used elsewhere in coastal Madang Province.

9 For example, the Experiment Station at Rabaul had planting material of 115 species available for distribution in 1926. Most were introduced species and included fruits, vegetables, other food crops, cover crops, fodder grasses and actual or potential cash

after 1870 (Table 4). The Department of Agriculture, Stock and Fisheries introduced more than 2200 varieties of 90 food crop species between 1950 and 1975. Many of these species were already in PNG by then; further introductions were made to identify varieties with superior qualities.[10]

Foreign settlement, particularly the introduction of new crops and cash cropping, resulted in an important new era in PNG agriculture. Some of the new crops were adopted by villagers and had a significant impact on village agriculture. For example, the anthropologist Malinowski, who conducted fieldwork in the Trobriand Islands in Milne Bay from 1915 to 1918, noted that, since the adoption of sweet potato (in the 1890s) and the availability of imported rice, there had not been a famine. Sweet potato, and later cassava, were widely adopted throughout the islands of Milne Bay Province and greatly improved food security. At a village in the Aiyura basin in Eastern Highlands Province in 1980, villagers grew 87 species of food and cash crops. Almost 60% of these (51 species) had been introduced and adopted during the previous 50 years, including some grown in significant quantities such as peanut, coffee, common bean, Chinese taro, corn and pak choi.

Some introduced crops moved inland ahead of European colonisation. Corn was widely grown in Eastern Highlands, Simbu and Western Highlands provinces when the first European explorers and missionaries visited those areas in the 1930s. It was spread by villagers after being introduced to the Madang area by Miklouho-Maclay. The naturalist MacGillivray further distributed corn in Milne Bay in 1849. Corn was present on some other islands when first visited by European explorers in the 1870s. Similarly, some people in the highlands were growing common bean by the 1930s. It also seems to have been introduced into some coastal locations in the 1870s or 1880s and to have spread into the highlands over the next 40–50 years. Another crop that was adopted quickly in the highlands was pumpkin. Villagers in some locations in the Sepik River area believe *kangkong* to be a traditional crop, which suggests that it was possibly introduced to that area some decades before 1870.

Foreign cash cropping (1880s onwards)

Individual foreigners and overseas companies have been involved in PNG agriculture since the 1880s. This history is partially covered in a number of publications and is reviewed only briefly here. Some of the first foreign settlers in PNG came to trade for coconut to make copra. Villagers in many coastal locations in the islands and on the New Guinea mainland responded by planting significantly more palms. Copra was the most important cash crop in PNG from the 1880s to the early 1970s. Foreigners in both New Guinea and Papua produced and exported a wide range of cash crops from the 1880s onwards, generally in small quantities. These included tobacco, cotton, kapok, rubber, cocoa, sisal and coffee. Cattle and rice were grown for the local market. Other agricultural exports collected from natural stands of trees or the sea included ivory nut (the seed of a palm related to sago), sandalwood, bêche de mer (sea cucumber), trochus shell and pearl shell.

Prior to 1940 experimental plantings were made of a wide range of other crops including sugar cane, corn, castor, tea, cinchona (for quinine), teak, oil palm, vanilla, ginger and peanut, with a view to developing export industries. During the 1950s copra remained the most important export crop, supplemented by rubber, cocoa and coffee. Coffee and cocoa increased in significance in the 1960s and 1970s (Figure 5.2.3). Oil palm, tea, tobacco, corn, sorghum and peanut were also grown by individual foreign settlers and large plantation companies. Village cash cropping increased in significance from the 1950s and the plantation sector declined after 1980. Smallholders now dominate production of all cash crops except oil palm (Table 5.2.1).

crops. The cash crops included those producing fibres, oils, spices, rubber, West African oil palm, bixa, coffee and cocoa. There were a number of varieties of some species (Hopkins 1926).

10 Rice (627 varieties) and wheat (272 varieties) accounted for 40% of the varieties of food plants introduced between 1950 and 1975 (Charles 1976). This was part of a significant but unsuccessful research effort by the Department of Agriculture, Stock and Fisheries to make PNG self-sufficient in rice production (see Section 2.5).

Table 4 Some of the food crops introduced into PNG after 1870

Staple (carbohydrate) foods
Corn (maize)
Irish potato
Queensland arrowroot
Rice
Taro, Chinese
Wheat
Vegetables
Amaranthus blitum
Amaranthus caudatus
Amaranthus cruentus
Bean, broad
Bean, common
Bean, snake
Beetroot
Broccoli
Cabbage, Chinese
Cabbage, head
Capsicum
Carrot
Cauliflower
Celery
Chilli
Choko
Eggplant
Garlic
Kangkong
Kohlrabi
Leek
Lettuce
Onion
Pak choi
Parsley
Pea
Peanut
Pumpkin
Radish
Rhubarb
Shallot
Silverbeet
Soya bean
Spring onion
Tomato
Turnip
Watercress
Yam bean
Zucchini
Fruit
Apple
Avocado
Brazil cherry
Bullock's heart
Cape gooseberry
Carambola
Cherimoya
Cumquat
Custard apple
Durian
Elder
Governor's plum
Granadilla
Grapefruit
Guava
Guava, cherry
Jackfruit
Langsat
Lemon
Lime
Loquat
Mandarin
Mango (*Mangifera indica*)
Mangosteen
Mulberry
Naranjilla
Nectarine
Orange
Passionfruit, banana
Passionfruit, lowland yellow
Passionfruit, purple
Pawpaw
Peach
Persimmon
Pineapple
Plum, Japanese
Pomegranate
Pomelo
Pulasan
Rambutan
Raspberry, black
Rockmelon
Santol
Soursop
Star apple
Strawberry
Suga prut (highland yellow passionfruit)
Tamarillo (tree tomato)
Tamarind
Watermelon
Watery rose apple
Nuts
Cashew
Macadamia integrifolia
Macadamia tetraphylla
Pecan

Changes in village agriculture since 1940

After 1940 the rate of change in PNG agriculture increased greatly. Factors driving these changes were:

- Population increase and pressure on land. The population of PNG rose from 2.2 million in 1966 to 5.2 million in 2000 (an increase of 138%) (Table 1.1.3).
- Alienation of land in some locations, resulting in increased land pressure. For example, in the Cape Hoskins to Talasea area of New Britain, land was alienated for growing oil palm (see Sections 5.7 and 6.1).
- Cash cropping by smallholders. Crops include cocoa, coffee and coconut (see Part 5).
- Plant diseases, especially taro blight, but also a root rot in Chinese taro.

The first major change since 1940 was the replacement of taro by sweet potato as the staple food in Bougainville and the rest of the Solomon Islands. This occurred because of the devastating impact of taro blight, which was introduced there in the early 1940s. Change did not occur evenly in all parts of the country. On the Gazelle Peninsula of East New Britain Province, for example, major changes in the food crops grown, production techniques used and the adoption of cocoa as a cash crop took place between 1945 and 1965, while in adjacent West New Britain Province the widespread planting of oil palm and changes in the main food crops grown did not take place until after 1970.

The responses people made to the new social and economic conditions include:

- Adoption of new crop species. Production of sweet potato and cassava in particular has expanded greatly since 1940 (Figures 2.2.1, 2.2.3). Other crops that have been widely adopted and become relatively important foods include corn, peanut and Chinese taro. Irish potato has become important above 2000 m altitude.
- Adoption of more productive varieties of some crops, including sweet potato and banana.
- More intensive land use characterised, for example, by shorter fallow periods and longer cropping periods (see Sections 3.6 and 3.8).
- Development or adoption of techniques to maintain soil fertility. These include managing fallow species composition by planting trees (especially casuarina in the highlands); crop rotations, especially of sweet potato and peanut; and green manuring (composting) (see Sections 3.7 to 3.12).
- Development of new agricultural systems by the integration of export cash crops into food crop systems. These systems include coffee–casuarina–food crops in the highlands and cocoa–food crops–leucaena–banana on the Gazelle Peninsula.

Agricultural techniques

Villagers use a variety of agricultural techniques in the cultivation of food and cash crops (see Sections 3.7 to 3.12). These techniques are used in different combinations, depending on climate, soil type, fallow vegetation and pressure on land. Archaeological research provides evidence as to how long some of these techniques have been practised.

- **Stone tools** were used as early as 40 000 years ago. Stone tools were used for clearing trees until the late 1800s, when they were replaced by introduced steel tools. In some highlands locations, stone tools were used until about 1950. In some places stone tools are still used to extract sago starch.
- **Burning** has a very long history in PNG and has been used for clearing land for at least 30 000 years (see Section 3.8).
- **Drainage** of agricultural land is widespread in PNG (see Section 3.12). Field drains have been dug in the highlands to remove excess water from food gardens for 4500–5000 years.

- **Mounding** is a widespread technique in PNG (see Section 3.11) and has been observed from 7000 years ago at Kuk.
- **Fences** are commonly built to exclude domestic and wild pigs from food gardens (see Section 3.12). This technique has not been dated, but presumably it was only adopted after pigs were introduced into PNG about 3500 years ago.[11]
- **Green manuring (composting)** was widespread in large areas of Enga, Southern Highlands and Western Highlands provinces when Europeans first visited the region in the 1930s (see Section 3.11). It is possible that the technique was invented in this form about 150 years ago.[12]
- **Planting trees** in fallow land to improve soil fertility is a technique used in a limited number of locations (see Section 3.10). This technique has increased in importance since the 1920s, but it is not known when it first developed. An examination of swamp deposits in a number of highlands locations has shown that at around 1200 years ago there was a marked increase in the numbers of casuarina pollen grains compared to older levels. This has been interpreted to mean that people began deliberately planting casuarina trees around this time, perhaps to provide timber as natural stands were depleted.

11 Pigs were introduced into the Bismarck Archipelago about 3500 years ago. The earliest record for pigs on the New Guinea mainland is 2000 years ago and the first record for the highlands is 1000 years ago.

12 The practice of placing organic matter in large mounds or beds to form compost was still spreading in recent decades (early 1960s to late 1980s) on the edge of the 'composting zone'. This suggests that adoption of the technique was as recent as the nineteenth century. Given the initial boost that sweet potato would have given to food production, there would not have been a need to adopt such a technique immediately after adoption of sweet potato. Development of the large composted mounds in Enga probably occurred in central or western Enga some years after the initial introduction of sweet potato (Wiessner and Tumu 1998:115).

Summary

People were in what is now the island of New Guinea about 50 000 years ago and in the Bismarck Archipelago and the Solomon Islands around 40 000 and 30 000 years ago respectively. We do not know who the earliest occupants of New Guinea were, nor their relationship to modern populations. The final period of prehistoric settlement is associated with the arrival of Austronesian speakers from island South-East Asia. They entered the Bismarck Archipelago and the Solomon Islands over the period 3500 to 3000 years ago and had a marked influence on the subsequent history of those regions. Austronesian impact on the New Guinea mainland was later, more uneven, largely restricted to the coast and intensive only in particular places. Settlement by Europeans, Asians and other Pacific islanders from 1870 onwards caused major changes in agricultural production.

The very early New Guineans depended on hunting and gathering, but it is probable that they began to manage nut-producing trees to encourage better production. There is evidence from starch grains on stone tools for use of taro 28 000 years ago on Buka Island. It is likely that early migrants domesticated sago, *galip* nut and other native species. Agriculture was invented in New Guinea independently of developments elsewhere in the world but at a similar time to its beginnings in the Middle East and central China.

It is now generally accepted that many of the PNG food crops that were important before 1870 were domesticated in New Guinea or nearby areas, including the Bismarck Archipelago, as well as in Asia. Important foods probably domesticated in the New Guinea area are taro, some yam species, banana, breadfruit, sago, many plants used as green vegetables, and some fruits and nuts. Some species were domesticated in both the New Guinea area and Asia independently. In contrast to the important food crops, the most important domestic animal species – the pig, chicken and dog – were introduced into New Guinea after being domesticated elsewhere.

The indigenous PNG cassowary has been hunted and captured chicks reared in captivity, so it could be said to be partially domesticated.

There is a long but poorly known history of adoption and domestication of new crop species. It is likely that a number of new species were introduced by Austronesian-speaking migrants from about 3500 years ago. The overall direction has been replacement of crops by others that have higher productivity, can cope better with environmental or disease problems, and have superior eating properties. For example, it is likely that people once ate wild yam with poor eating properties. Some of these species were domesticated and the quality of the tubers improved. There are indications that some species of yam, such as *Dioscorea pentaphylla* and *D. nummularia*, are very ancient crops in PNG, perhaps introduced from elsewhere but most likely domesticated in the New Guinea area. Tubers of *D. pentaphylla*, for example, have inferior eating qualities and yields appear to be poor, yet people still grow the occasional plant, probably for its cultural value ('*bilong tumbuna*') rather than for food. It is likely that superior varieties of the greater yam (*D. alata*) were developed and that greater yam became the most important species of yam before the introduction of lesser yam (*D. esculenta*).

Lesser yam is likely to have been a later introduction into PNG.[13] It is agronomically superior to other yam species in PNG, including greater yam, has fewer disease problems, a greater yield per plant and tubers that are more easily prepared for cooking than those of most yam species. More people grow greater yam than lesser yam, although greater yam is not usually an important food (Tables 3.1.1, 2.2.1). *Dioscorea esculenta* is less important for ritual purposes than the other yam species, particularly greater yam. All of this suggests that lesser yam has been adopted because of its ability to provide food energy, while the other species have been retained for different reasons.

The many minor species of green vegetables used in PNG may also be what the ethnobotanist Jacques Barrau calls 'witnesses of the past'. That is, their continuing use tells us that they were once important foods, but have been superseded by superior species. The displacement of older species by ones with superior characteristics has continued into recent times. For example, sweet potato replaced taro as the main food in the highlands about 300 years ago. In the lowlands, food crops of American origin, particularly sweet potato and to a lesser extent cassava and Chinese taro, have displaced the older Asia–Pacific crops of taro, yam, banana and sago (Figure 3.1.2).

The adoption of sweet potato in the New Guinea highlands led to significant changes in the social and economic conditions, as well as allowing settlement at higher altitudes. Sweet potato and tobacco were the first of a wave of new crop introductions. They reached PNG between 300 and 400 years ago. Since permanent settlement by foreigners in the 1870s, a large number of food crops, cash crops, other plant species and domestic animals have been introduced. The new food species, the growing importance of export commodity markets and other social and economic changes have resulted in many important changes to agricultural systems since the 1940s.

Agriculture has had a long and successful history in PNG. The history of agriculture has been one of continuous change and evolution, with the rate of change increasing towards the present. The outcome has been agricultural systems which, despite significant social and economic change in other sectors of the economy, still feed more than 80% of the PNG population. The adoption of new crops and the invention of new techniques to cope with changing environmental conditions, increasing population pressure and social change has been carried out with great skill and imagination. People will have to continue to adapt to different circumstances, including to the HIV/AIDS epidemic, climate change and new economic conditions. There is every reason to believe that they will continue to do so as they have done for the past 50 000 years.

[13] Lesser yam may have been introduced 1000–3000 years ago, but this is a crude estimate. Austronesian migrants possibly introduced it 3500 years ago. However, linguists have not been able to reconstruct a word for this species in Proto-Oceanic, the language spoken by the Austronesian migrants (Malcolm Ross, pers. comm.). This suggests that lesser yam may have arrived in PNG some time after 3500 years ago.

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